ASYMMETRY AND MUSCLE PROPORTION IN PORK CARCASSES

82

by

YIE-SHIUNG CHEN

B. S., Chung Hsing University, 1962

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Approved by:

D. H. Kropf

Major Professor

THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING BEING SKEWED DIFFERENTLY FROM THE TOP OF THE PAGE TO THE BOTTOM.

THIS IS AS RECEIVED FROM THE CUSTOMER.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation and thanks to Dr. Donald H. Kropf, major professor, for his interest, patience, guidance and encouragement during this study.

Appreciation is also extended to Dr. Arthur Dayton for his assistance in the statistical analysis of the data.

The author wishes to extend a special thanks to Mr. Tom Yu, chief of Animal Industry Division, JCRR, Taiwan, R.O.C., who offered the opportunity to study at Kansas State University.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

CHAPTER I

INTRODUCTION

The validity of assuming that data collected from only one side of an animal carcass are representative of the entire carcass is subject to question. It is not clear whether appreciable differences between carcass sides are attributable to bilateral asymmetry or whether apparent differences arise mainly from errors in cutting.

Considerable time and effort has been spent by the livestock industry in an attempt to increase the proportion of some of the "high priced" cuts within the carcass. Proportion of muscular cuts is increased by reducing carcass fatness, but limited evidence seems to show that proportion of any single muscle of total carcass musculature cannot be appreciably altered.

This project was undertaken to determine whether differences exist between right and left sides of pork carcasses for some precisely measured physical traits. The information was collected on swine that showed apparent visual asymmetry in both live and carcass form.

Secondary, individual muscle weights and proportions were determined for two groups of carcasses with apparent visual differences of carcass balance (proportion), namely some selected to be heavy in muscling of front versus rear carcass parts.

CHAPTER II

LITERATURE REVIEW

ASYMMETRY

Lasley and Kline (1957) studied right and left sides of 222 pork carcasses and reported that errors in splitting the carcass may contribute to differences in wholesale cut weights. The average difference between sides was not significant for loin eye area, although left sides averaged heavier and yielded heavier loins, hams, picnics, lean cuts and primal cuts but lighter bellies and Boston butts. They expressed the opinion that such differences were not an expression of bilateral asymmetry. This was similar to the report of Bowman et al. (1962), who also reported that the greatest splitting errors were made in the shoulder area and the smallest in the ham.

Breidenstein et al. (1964) reported that of nine major pork muscles from the pelvic limb, back and thoracic limb, the supraspinatus, semitendinosus and adductor muscles differed most between left and right sides but averages were not significantly different. Right sides averaged 0.5 cm longer and yielded loins weighing 0.5 kg less than left sides. They suggested that an "off-center split permitted the side with less skeletal support to stretch more during chilling. Consequently, that side would be longer and would yield a lighter weight wholesale loin." They also concluded that sex, live weight and carcass side had no significant effect on differences of characteristics determined between right and left sides. Thus, bilateral asymmetry was not detected, and the difference from left to right side (up to approximately 8%) was attributed to experimental error. Osinska and Kielanowski (1958) had reported similar results.

MUSCLE PROPORTION

Butterfield (1963b) stated that it is generally believed that what is regarded as good beef conformation produces a relatively high proportion of most valuable meat cuts. Exponents of many beef breeds believe that their breed has the most meat "in the right places." If these claims are sound, we must assume that the differences of conformation between breeds are brought about largely by variation in the distribution of muscle, or fat, or both.

Effect of Breeding and Selection

Reports dating back many years make it appear very doubtful if any major differences between breeds are likely to be found, as little difference in the yield of high-priced cuts was demonstrated between beef and dairy cattle. The similarity in the yield of commercial cuts of beef from cattle has been recorded for many years but has had little effect on the beliefs of beef producers.

Butterfield (1963b), cited Garn (undated) who claimed that selection in cattle yielded a larger proportion of desirable cuts of meat through emphasis on certain muscle groups, but presented no evidence to support this claim.

Warwick (1958) concluded a review of investigations on the yield of high-priced cuts by stating that "it, thus, appears to be quite definite that if hereditary differences in the percent of high-priced cuts do in fact exist, they are not closely related to the factors most of us have been taught to look for in evaluating the external appearance of beef cattle."

Butterfield (1963b) reported, apart from indicating that the differences of muscle weight distribution are probably small, studies on yields of meat cuts show limited value in clearly defining the part which fat and muscle play in producing differences.

The distribution of muscle weight over the carcass of cattle is the result of response to functional demands by the animal to meet the challenges of its environment as stated by Butterfield (1963b). This vital anatomical response is capable of strongly resisting change animal breeders would like to force upon it. Efforts to increase the total amount of muscle per animal have been more productive than attempts to upset intrinsic muscle relationships of this functional locomotor system.

Christian (1968) reported that efforts of a producer who practices continuous selection for traits of high heritability such as backfat thickness and muscling traits, with the major emphasis upon individual performance, will be rewarded by consistent improvement.

Effect of Exercise

The work of Skjervold, Standal and Bruflot (1963), where pigs were forced to eat from elevated feeders to induce unusual muscular exercise, was unsuccessful in producing a higher proportion of ham muscles.

Effect of Nutrition

McMeekan (1940b) used twenty closely related inbred pigs and by quantitative control of the plane of nutrition, made them conform to one of four major variations in the shape of the growth curve from birth to 91 kg live weight. A high rate of nutrition throughout (High-High), a high followed by a low rate (High-Low), a low followed by a high rate (Low-High) and a low rate throughout the period (Low-Low) afforded comparison between animals of the same weight but with differently shaped growth curves. The plane of nutrition was changed at 45 kg live weight. The high plane section included addition of dried separated milk and free access to feed, the low plane rations consisted of addition of one-half amount of milk which was added to high plane and restricted intake.

In the Low-Low pigs, under continuing inadequate nutrition, bone and muscle continued to increase at the expense of fat. The long duration of the process (327 days to reach

91 kg) resulted in animals with more bone and muscle and less fat than under any other treatment. Butterfield (1963b) claimed selective depletion of body tissues during starvation, with latest-developing tissues first affected. This is in agreement with Pomeroy's (1941) finding, the later developing kidney fat reduced first, then the subcutaneous fat and lastly the early-developing inter-muscular, caul and mesenteric fat.

In the High-High treatment, ample nutrition throughout the growth period encouraged the growth of all three tissues and resulted in an animal with a "well-balanced composition." Rapid growth consequent on high nutrition had given full scope for the development of bone and muscle, and relatively short total period (165 days) had not permitted an excessive accumulation of the later developing fat. This agrees with Hiner and Bond (1971) who reported that weights of the muscles from full-fed steers were generally heavier than for limited-fed groups.

The change from a high to a lower level of nutrition in the High-Low treatment (211 days to 91 Kg) allowed the continued growth of bone and muscle--already well developed by the early good feeding and consequent rapid growth--at the expense of fat and resulted in pigs second only to the Low-Low in bone and muscle weight with but little more fat. Waldern (1964) used ninety-six Yorkshire pigs, reared during the growing period on high energy-high protein rations from weaning to 50 kg, followed with all combinations of two levels of protein (13 and 18%) and two levels of energy (67 and 80% TDN) in self-fed finishing rations, in a 2 x 2 factorial feeding experiment. The results on carcass traits from low protein and energy group agreed with those McMeekan (1940) had indicated above.

In the Low-High treatment (also 211 days to 91 kg) the change from inadequate to ample nutrition produced a marked recovery in the development of all three tissues, but this has been "so great in respect of fat that the pigs of this treatment exceed all others in their quantity of this tissue." This is in general agreement with Butterfield (1963b), who indicated "neither starvation nor recovery produced anything but very minor relative changes in 'expensive' and 'total' muscle." The same results were also suggested by Hiner and Bond (1971).

Brunstad and Fowler (1959) showed full-fed pigs were both thicker in backfat and larger in loin-eye on an adjusted weight basis. Full-fed pigs were bigger at the same age than the limited-fed pigs. Carcasses from the limited-fed gilts yielded an average of 1.5 kg more trimmed primal cuts than did the carcasses from full-fed gilts (P = 0.01) if slaughtered at a similar weight. Adjustment of the data to a constant age, however, reduced the difference in primal cut yield to a none significant 0.25 kg.

Greeley _et al._ (1964) indicated a significant linear trend toward increased pork backfat thickness with increasing tallow content (0, 4, 8 or 12 %) of diets when slaughtered at the average of 92 kg live weight. Neither cross-sectional area of the longissimus dorsi muscle, nor percent of trimmed ham and loin or of the four trimmed lean cuts of slaughter weight was significantly influenced by level of dietary tallow. None of the carcass characteristics studied was significantly influenced by protein content of the diets which contained 13, 15, 17 or 19% protein. The same results were also reported by Richmond and Berg (1972), who used 48 boars, barrows and gilts; the high protein diet contained 18% protein and was fed throughout the trial, the low protein diet consisted of a 16% protein growing ration and a 13% finishing ration. These results revealed that the level of protein in the diet had no effect on carcass composition. Many others have shown a ration protein level effect on carcass.

Muscle Weight

Butterfield (1963a) reported weight of muscle, bone and fat can be related to various simpler measurements or weights to test the validity of these measurements as indices of carcass composition. The weights of individual muscles and fat from various locations may be grouped to study changes of proportion of tissues. He suggested, for example, grouping muscles according to their tenderness rating, their color, their size, or any other characteristic but indicated that a most useful grouping for studies of muscle weight distribution is made according to their anatomical location.

Richmond and Berg (1972) used 14 sides of boars and gilts and dissected individual muscles. Those muscles representing the expensive carcass cuts were combined into three "expensive muscle groups." They were expressed as percentages of total side muscle in boars, barrows and gilts, respectively, with the following results: Ham, 32.5%, 32.5%, 33.4%; Ham + Loin, 49.7%, 51.0%, 51.6%; and Ham + Loin + Shoulder, 62.4%, 62.8%, 63.8%. They claimed sex had no significant effect on muscle distribution but slight differences among boars, barrows and gilts were noted. Gilts had a slightly greater proportion of muscle in the proximal hind limb muscles than either barrows or boars, and barrows had a greater proportion of spinal muscles than either boars or gilts. Boars had a slightly greater proportion of muscle in the neck, thorax and fore limb muscle groups than either barrows or gilts.

Some individual muscle weights reported by Hiner and Hankins (1939), Breidenstein _et al._ (1964) and Topel _et al._ (1965) are summarized in the following table.

	Hiner & Hankins	Breidenstein		Topel	
	Mean	Mean	S.D.	Mean	S.D.
Average live weight, Kg.	102.0	100.0		94.5	
Muscle, gm					
Adductor	171.8	212	28		
Biceps femoris		818	131	764.3	112.4
Psoas major				223.0	43.4
Quadriceps femoris		758	89		
Rectus femoris	238.7			282.9	38.2
Semimembranosus	480.6	653	93	623.4	79.1
Semitendinosus	219.4	313	50		
Longissimus dorsi		1514	235	1282.1	221.2
Supraspinatus		324	38		
Triceps brachii		533	52		

Specific Gravity

Average backfat thickness has been generally accepted as the simplest measure of carcass leanness, but Brown *et al.* (1951) found that specific gravity of the carcass was more highly related to cut-out and chemical analysis than was back-fat thickness. Brown *et al.* (1951) reported that carcass specific gravity was highly correlated with % lean cut (r = 0.84**), with backfat showing a correlation of -0.72** to % lean cuts. Whiteman *et al.* (1953) reported similar correlations of 0.87** and -0.79**; Pearson *et al.* (1956) reported 0.72 and -0.49 and Price *et al.* (1957) found correlations of 0.65** and -0.72**.

Brown et al. (1951) indicated that specific gravity showed a stronger relationship to chemical composition (ether extract, protein and moisture) than did backfat, with the correlation coefficients of -0.75**, 0.65**, 0.68** versus 0.48**, -0.51**, -0.45**. Price et al. (1957) also verified this with corresponding correlations of -0.85**, 0.82**, 0.83** versus 0.61**, -0.63**, -0.69**.

Whiteman et al. (1953) reported that specific gravity of the ham was closely related ($r = 0.95^{**}$) to that of the entire carcass. This was also verified by Pearson et al. (1956) with the correlation coefficient of 0.93**. They also agree that the specific gravity of either the rough loin or shoulder was not as closely related to measures of carcass leanness as was specific gravity of the ham.

Chine Bone Depth

Kauffman et al. (1959) used 304 pork carcasses and after adjusting for carcass weight differences, calculated correlations of 0.361 and 0.474 between lumbar lean depth and area versus loin eye area and of 0.544 between lumbar lean depth and lean cut yield. Pearson et al. (1959) used 142 carcasses and tested the relationship between several lumbar lean measurements and either % lean cuts or loin eye area. The following correlations were calculated with the above two factors: namely area of outer lumbar muscle 0.18 and 0.21, depth of outer lumbar muscle -0.02 and 0.02, depth of inner lumbar muscle 0.44 and 0.53 and depth of both muscles combined 0.42 and 0.59. Pearson _et al._ (1959) also tested the predictive value of total lumbar lean depth within more narrowly defined carcass weight groups of 120-139, 140-159 and 160-179 pounds; and reported correlations of 0.57, 0.57 and 0.26 with % lean cuts and of 0.57, 0.52 and 0.31 with loin eye area. Kropf (1962) compared vertebral chine bone measurements at the 1st, 7th and last rib locations and lumbar lean depth at the last lumbar vertebra and found that even the two most posterior of these measurements were relatively poor predictors of loin eye area, % lean cuts or carcass specific gravity. The last rib and last lumbar depths had correlations of 0.28** and 0.40** to loin eye area, 0.39** and 0.35** to % lean cuts and 0.18 and 0.38** to carcass specific gravity. A combination of all 4 depth measurements showed correlations of 0.24*, 0.40**, and 0.32** to loin eye area, % loin cuts and carcass specific gravity.

The above reports indicate that lumbar lean and more posterior chine bone depth measurement have a positive but some what limited predictive value of carcass muscling.

Backfat

Pork carcasses are difficult to evaluate because of the low relationship between some commonly used measurements and actual carcass leanness. Usually, average backfat thickness has been accepted as the simplest measure indicative of carcass leanness or fatness (Pearson _et al._, 1956).

The correlation coefficient between average backfat thickness and percent 4 lean cuts has been reported by numerous workers; namely Aunan and Winters (1949), -0.63**; Pearson et al. (1956,1959), -0.49, -0.80; Adams et al. (1972), -0.52; Brown et al. (1951), -0.70**; Price et al. (1957), -0.72**; and Whiteman et al. (1953), -0.79.

LITERATURE CITED

Adams, J. P., I. T. Omtvedt, J. V. Whiteman and L. E. Walters. 1972. Line and Carcass Measurements As Indicators of Lean Cut Yield in Swine. J. Animal Sci. 35:25.

Aunan, W. J. and L. M. Winters. 1949. Study of the Variations of Muscle, Fat and Bone of Swine Carcasses. J. Animal Sci. 8:182.

Bowman, G. H., J. A. Whatley, Jr. and L. E. Walters. 1962. Separation and Measuring Errors in Swine Carcasses. J. Animal Sci. 21:955.

Breidenstein, B. C., R. G. Kauffman, T. LaPlant and H. W. Norton. 1964. Bilateral Symmetry of the Pork Carcass. J. Animal Sci. 23:1054.

Brown, C. J., J. C. Hillier and J. A. Whatley. 1951. Specific Gravity As a Measure of the Fat Content of the Pork Carcass. J. Animal Sci. 10:97.

Brunstad, G. E. and S. H. Fowler. 1959. Some Carcass Characteristics of Swine in the Eighth Generation of Production Under Four Combination of Full and Limited Feeding. J. Animal Sci. 18:211.

Butterfield, R. M. 1963a. Estimation of Carcase Composition: The Anatomical Approach. Symposium Carcase Composition and Appraisal of Meat Animals. Melborne, Australia. 4-1.

Butterfield, R. M. 1963b. Relative Growth of the Musculature of the Ox. Symposium Carcase Composition and Appraisal of Meat Animals. Melborne, Australia. 7-1.

Christian, L. L. 1968. Limits for Rapidity of Genetic Improvement for Fat, Muscle and Quantitative Traits. The Pork Industry: Problems and Progress. David G. Topel, editor. Iowa State University Press.

Greeley, M. G., R. J. Meade, L. E. Hanson and J. Nordstrom. 1964. Energy and Protein Intakes by Growing Swine. II. Effects On Rate and Efficiency of Grain and On Carcass Characteristics. J. Animal Sci. 23:816.

Hiner, R. L. and O. G. Hankins. 1939. Significance of Variation in Ham Conformation. J. Agr. Res. 59:293.

Hiner, R. L. and J. Bond. 1971. Growth of Muscle and Fat in Beef Steers From 6 to 36 Months of Age. J. Animal Sci. 32:225.

Kauffman, R. G., R. W. Bray and D. E. Goll. 1959. The Relationship of Lumbar Lean Measurements to Pork Carcass Muscling. J. Animal Sci. 18:1481 (Abstr.).

Kropf, D. H. 1962. Effect of Anatomical Location Upon Pork Longissimus Dorsi Area and Marbling. J. Animal Sci. 21:383 (Abstr.).

Lasley, E. L. and E. A. Kline. 1957. Splitting and Cutting Errors in Swine Carcass Evaluation. J. Animal Sci. 16:485.

McMeekan, C. P. 1940. Growth and Development in the Pig, With Special Reference to Carcass Quality Characters. Part III. Effect of the Plane of Nutrition On the Form and Composition of the Bacon Pigs. J. Agr. Sci. 30:511.

Osinska, A. and Keilanowski, J. Dokladnosc wynikow dyssekcji i najwazniejszych pomiarow tusz bekonowych. Roczniki Nauk Rolniczych 73-B, 1, 1958.

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. J. Animal Sci. 15:86.

Pearson, A. M., R. J. Deans and L. J. Bratzler. 1959. Some Lumbar Lean Measures Related to Swine Carcass Cut-Outs and Loin Eye Area. J. Animal Sci. 18:1087.

Pomeroy, R. W. 1941. The Effect of a Submaintenance Diet On the Composition of the Pig. J. Agr. Sci. 31:50.

Price, J. F., A. M. Pearson and E. J. Benne. 1957. Specific Gravity and Chemical Composition of the Untrimmed Ham As Related to Leanness of Pork Carcasses. J. Animal Sci. 16:85.

Richmond, R. J. and R. T. Berg. 1972. Comparison of Muscle and Fat Distribution in Boars and Gilts. U. of Alberta Feeder's Day. p. 16.

Skjervold, H., N. Standal and R. Bruflot. 1963. Effect of One Form of Exercise On the Body Development in Pigs. J. Animal Sci. 22:458.

Topel, D. G., R. A. Merkel and D. L. Mackintosh. 1965. Relationships Between Certain Whole Muscles and Measures of Pork Carcass Muscling. J. Animal Sci. 24:514.

Waldern, D. E. 1964. Influence of Energy and Protein Level in Rations for Finishing Market Pigs On Performance and Carcass Characteristics. Canadian J. Animal Sci. 44: 168.

Warwick, E. J. 1958. The Effect of Breeding and Production On Beef Carcass Characteristics. Eleventh Annual Reciprocal Meat Conference Proceedings. p. 201. National Livestock and Meat Board, Chicago.

Whiteman, J. V., J. A. Whatley and J. C. Hillier. 1953. A Sufther Investigation of Specific Gravity as a Measure of Pork Carcass Value. J. Animal Sci. 12:859.

CHAPTER III

ASYMMETRY IN PORK CARCASSES

In pork carcass evaluation, the assumption is often made that the carcass is bilaterally symmetrical. It is not clear whether minor differences are attributable to bilateral asymmetry or arise mainly from errors in cutting. Lasley and Kline (1957), studying right and left sides of 222 pork carcasses, reported that errors in splitting the carcass may contribute to differences in wholesale cut weights, but expressed the opinion that such differences were not an expression of bilateral asymmetry. Breidenstein et al. (1964) reported that of nine major pork muscles from the pelvic limb, back and thoracic limb, the supraspinatus, semitendinosus and adductor muscles differed most between sides, but the left and right side averages were not significantly different.

This work was designed to determine whether or not differences existed between right and left sides of pork carcasses for some physically measured carcass traits in pigs that appeared to be bilaterally asymmetrical.

EXPERIMENTAL PROCEDURE

Twelve pigs consisting of five barrows and seven gilts resulting from diallel mating from two sows, one Duroc and one Yorkshire were used. Two Yorkshire, four Duroc and six cross bred pigs were selected. Ten were slaughtered at between 84-95 kg live weight, one at 67 kg and the other one at 77.5 kg.

Immediately after slaughter, the carcasses were carefully split into right and left sides. After chilling to approximately 3^{o} C, each side was weighed to the nearest 0.05 kg and cut following the procedure outlined in the Fifth Annual Reciprocal Meat Conference Proceedings (1952), except the rough shoulder was removed so as to contain one and one-half ribs.

Traits investigated included weights of carcass sides, green belly, loin, picnic, Boston butt, trimmed ham, four lean cuts and five primal cuts to the nearest 0.05 kg. Carcass length, average backfat thickness and loin eye area at the 10th rib were also obtained.

Four major muscles or combinations were excised from each ham, carefully freed of external fat and tendons and weighed to the nearest gram. These muscles were the biceps femoris, quadriceps femoris, semitendinosus and semimembranosus + adductor.

Fiber diameter of biceps femoris, semitendinosus and semimembranosus was measured using the method outlined by Tuma et al. (1962). Fifty fibers from each sample were measured.

Data were analyzed by analysis of variance as described by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Of carcass characteristics shown in Table 1, heavier untrimmed ham, trimmed ham, ham fat and ham muscle weights ($P < .01$); also 4 lean cut, total fat trim and ham bone weights ($P < .05$) were greater for the visually more muscular side, even though total side weight was not different. Linear or area measurements of backfat thickness, carcass length and loin eye area did not differ appreciably.

Table 1. Effect of Bilateral Asymmetry on Pork Carcass Characteristics

Item	Muscular	Less Muscular	F-Value	Prob. %
Side Wt., kg	31.49	31.31	0.142	71.6
Fat back Thickness, cm	2.87	2.87	0.057	81.7
Carcass length, cm	74.35	74.24	0.096	76.4
Loin eye area, sq. cm	34.70	34.19	0.824	39.0
Boston Butt, kg	2.36	2.39	0.056	81.8
Picnic Shoulder, kg	3.36	3.30	0.381	55.4
Loin, kg	6.62	6.26	4.68	6.2
Trimmed ham, kg	7.22	6.78	11.479**	1.0
4 lean Cuts, kg	19.98	19.23	8.726*	1.8
Green Belly, kg	3.84	4.34	5.066	5.5
5 Primal Cuts, kg	23.82	23.57	0.485	50.6
Total Fat Trim, kg	3.85	3.59	7.095*	2.9
Untrimmed ham, kg	7.77	7.41	44.398**	0.02
Ham components, kg				
Bone	0.76	0.73	8.260*	2.1
Fat	1.74	1.52	18.985**	0.2
Muscle[a]	4.12	4.02	26.349**	0.09

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

[a] Total of selected muscles

Muscle weights of biceps femoris and semitendinosus (table 2) were greater (P < .01) for the more muscular side, while semimembranosus plus adductor did not differ. Quadriceps tended to be heavier for less muscular sides (P < .051). Muscle fiber diameters of three individual muscles, namely the semitendinosus, semimembranosus and biceps femoris did not show significant differences between sides so apparently heavier muscles were not due to hypertrophy of muscle cells.

Litter x muscularity interactions were calculated for some traits and are shown in table 3.

Table 2. Effect of Bilateral Asymmetry on Mean Muscle Weights and Fiber Diameters

Muscle weight, gms	Muscular	Less Muscular	F-Value	Prob. %
Biceps femoris	1141.75	1068.50	41.427**	0.02
Semitendinosus	378.50	352.75	23.034**	0.14
Semimembranosus + adductor	1087.19	1081.00	0.107	75.2
Quadriceps femoris	961.56	980.00	5.259	5.1
Fiber diameter, microns				
Semitendinosus	83.62	85.65	0.959	35.6
Semimembranosus	84.73	85.88	0.362	56.4
Biceps femoris	84.52	81.53	0.539	48.4

* P < .05, ** P < .01

Table 3. Litter x Muscularity Interaction For Selected Carcass Traits

	Litter 51		Litter 52		Litter 91		Litter 92	
	Muscular	Less Muscular	Muscular	Less Muscular	Muscular	Less Muscular	Muscular	Less Muscular
Untrimmed Ham Wt. (kg)	8.23**	7.50	7.77**	7.30	7.46	7.36	7.62	7.48
Ham Muscle Wt. (gm)	5711.48**	5354.99	5182.48*	5056.49	2403.00	2354.75	3214.50*	3311.00
Biceps femoris (gm)	1227.50**	1099.00	1146.50**	1034.00	1066.75	1053.75	1126.15	1087.25
Semitendinosus (gm)	447.50**	382.50	352.00	339.00	369.50*	347.50	345.00	342.00

* P < .05, ** P < .01

Significant interactions between litter and muscularity were calculated for untrimmed ham, ham muscle, biceps femoris and semitendinosus weights (table 3). Litter 51 and 52 are the apparent purebred and crossbred pigs, respectively, from diallel mating of the Yorkshire sow, while litter 91 and 92 are purebred and crossbred pigs from the Duroc sow.

Untrimmed ham weight differed between the muscular and less muscular sides from two "litters" ($P < .01$). Biceps femoris showed a similar heavier weight for the muscular side of the same two liters.

Combined ham muscle weight tended to be heavier for the muscular side of two litters, but this difference was not significant for only litter 91 and the apparently more muscular side showed less ham muscle in litter 92. Semitendinosus weight was heavier for the muscular side of litter 51 ($P < .01$) and 91 ($P < .05$). This observed case of bilateral asymmetry was more consistent in the offspring of one sow (litter 51 and 52) and larger differences were noted.

A significant difference ($P < .01$) was noted between side and muscularity for untrimmed ham, ham muscle, biceps femoris and semitendinosus in litter 51. The untrimmed ham weight, biceps femoris ($P < .01$) and ham muscle weight ($P < .05$) for litter 52 also showed differences. All carcasses from litter 51 and litter 52 were more muscular on left side and less muscular on right side, but variation was noted in litter 91 and 92.

The observation that the muscular side was usually the left side and tended to yield heavier lean cuts and trimmed ham but lighter belly, is similar to the findings of Lasley and Kline (1957) and also in magnitude of difference.

SUMMARY

An apparent visual bilateral asymmetry in twelve swine is supported by heavier untrimmed ham, trimmed ham, ham muscle, ham fat, ham bone, 4 lean cut and total fat trim weights in sides evaluated to be more muscular.

Mean biceps femoris and semitendinosus weights were significantly heavier in more muscular sides whereas combined semimembranosus plus adductor and quadriceps femoris were not different for the two selected groups.

Semitendinosus, semimembranosus and biceps femoris fiber diameter did not show any difference between the two muscularity groups, even though significant differences in muscle weight were noted.

Litter x muscularity interaction showed muscular side had more consistently heavier ham, total ham muscle, biceps femoris and semitendinosus weights than less muscular side, in litter 51 and 52 (the offspring of one sow).

LITERATURE CITED

Breidenstein, B. C., R. G. Kauffman, T. LaPlant and H. W. Norton. 1964. Bilateral Symmetry of the Pork Carcass. J. Animal Sci. 23:1054.

Lasley, E. L. and E. A. Kline. 1957. Splitting and Cutting Errors in Swine Carcass Evaluation. J. Animal Sci. 16:485.

Report of the Pork Carcass Evaluation Committee. 1952. Cutting Procedure. Fifth Annual Reciprocal Meat Conference Proceedings. p. 120. National Livestock and Meat Board, Chicago.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods (6th ed.), The Iowa State University Press, Ames, Iowa.

Tuma, H. J., J. H. Venable, P. R. Wuthier and R. L. Henrickson. 1962. Relationship of Fiber Diameter to Tenderness and Meatiness As Influences By Bovine Age. J. Animal Sci. 21:33.

CHAPTER IV

THE EFFECT OF CARCASS PROPORTION ON CARCASS YIELDS AND MUSCLE PROPORTION

Pork selection has increased yields of most desired cuts, probably because of decreased carcass fatness. However, limited study casts doubt on whether the proportion of any single muscle to total carcass musculature can be affected by selection.

Richmond and Berg (1972) reported that previous carcass studies in cattle have indicated that bulls have a greater proportion of muscle in the neck and thorax region than steers or heifers but that heifers have a greater proportion of muscle in the proximal hind leg region than steers or bull. Richmond and Berg (1972) reported that in pigs there was no significant difference between barrows and gilts in muscle distribution. However, differences in fat distribution did occur.

McMeekan (1940) showed sex groups to differ markedly in their anatomical composition, castrated males being characterized by less bone and muscle and more fat than gilts and stated that the extent of the difference could be modified by the rate of growth (plane of nutrition) imposed.

Richmond and Berg (1972) concluded that in swine sex had no significant effect on muscle distribution, although slight differences among boars, barrows and gilts were noted when slaughtered at 91 kg live weight.

This investigation was conducted to determine if carcasses selected to be heavy front and heavy hind carcasses differed in wholesale cut yields or proportion of certain individual muscles.

EXPERIMENTAL PROCEDURE

Fourteen pork carcasses were selected for one of two types by visual judgment with seven as heavy front carcasses and seven as heavy hind carcasses. An attempt was made to minimize fat effects on this appraisal. Live weights ranged from 87.5-100 kg.

Carcass measurements taken were carcass length and average backfat thickness.

Four rough cuts: ham, loin, shoulder and belly were separated from the left side of the carcasses. The rough ham was removed half way between the aitchbone and the last lumbar vertebra with the foot and all fat intact and without separating flank muscles. The rough loin was taken with all fat left on. The rough one and one-half rib shoulder was removed with foot on, jowl removed and neck bones not removed. The rough belly had the fat and spare ribs left on.

Specific gravity was calculated from the in-air and in-water weights of the rough cuts. The air weight was taken to the nearest 0.05 kg and water weight to the nearest gram on cuts submerged in water at temperatures ranging from 2-5^{o} C. Specific gravity was determined from the following formula:

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air - Weight in water}}$$

Each cut was trimmed following the procedure outlined in the Fifth Annual Reciprocal Meat Conference Proceedings (1952). The following muscles were dissected, freed of external fat and tendons and weighed to the nearest 0.1 gm: adductor + semimembranosis, biceps femoris, semitendinosus, gracilis, quadriceps femoris, psoas major, gluteus medius, rectus abdominis and other rough ham muscles all from the ham. Loin muscles were the psoas major, gluteus medius, longissimus, spinalis dorsi, trapezius, serratus ventralis and other rough loin muscles, while shoulder muscles were the longissimus, spinalis dorsi, serratus ventralis, rhomboideus, infraspinatus, supraspinatus, teres major, triceps brachii, subscapularis and other rough shoulder muscles.

The muscle weight ratios of ham/shoulder, ham/loin and shoulder/loin; also the specific gravity ratios of ham/shoulder and loin/belly were calculated.

Data were analyzed by analysis of variance as described by Snedecor and Cochran (1967).

Explanation of Plate 1

Plate 1. Inside and outside views of heavy front versus heavy hind carcass.

A. Inside carcass views.
Left - heavy front carcass.
Right - heavy hind carcass.

B. Outside carcass views.
Left - heavy front carcass.
Right - heavy hind carcass.

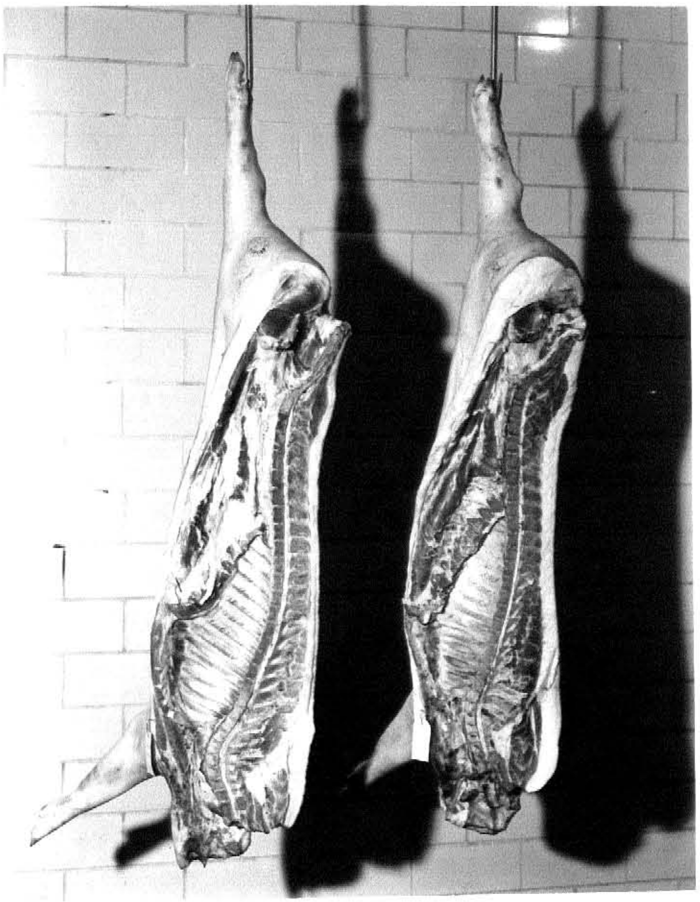
THIS BOOK CONTAINS SEVERAL DOCUMENTS THAT ARE OF POOR QUALITY DUE TO BEING A PHOTOCOPY OF A PHOTO.

THIS IS AS RECEIVED FROM CUSTOMER.

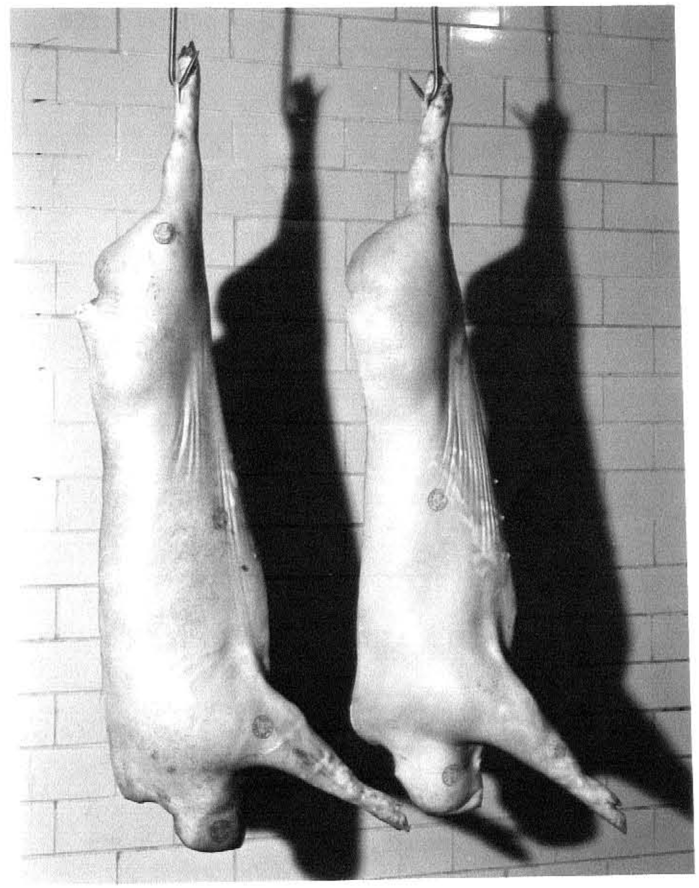
THIS BOOK CONTAINS NUMEROUS PAGES WITH PICTURES THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

Plate 1



A



B

RESULTS AND DISCUSSION

The untrimmed cut weights and percentages of carcass weight are shown in table 4. Significant differences ($P < .01$) in trimmed ham weight and percent trimmed ham were noted between heavy hind and heavy front groups, with higher values for the heavy hind group. A significant difference ($P < .05$) also existed for trimmed picnic weight, with heaviest weight also noted for the heavy hind group.

Table 4. Effect of Carcass Proportion on Carcass Measurements and on Weights and Percentages[a] of Pork Wholesale Cuts

Item	Heavy Hind	Heavy Front	F-Value	Probability %
Ave. Back Fat Thickness, cm	3.51	3.48	0.010	92.3
Carcass Length, cm	75.59	76.58	1.532	24.0
Live weight, kg	96.88	94.41	0.395	54.1
Cold Carcass weight, kg	36.91	35.40	1.051	32.6
Trimmed Ham, kg	8.28	7.30	13.171**	0.3
Trimmed Loin, kg	7.23	6.95	0.528	48.2
Trimmed Boston Butt, kg	2.89	2.68	1.785	20.6
Trimmed Picnic, kg	4.34	3.87	5.482*	3.7
4 lean cuts, kg	22.73	20.81	4.682	5.1
Green Belly, kg	5.25	5.03	0.457	51.2
5 Primal cuts, kg	27.98	25.85	4.267	6.1
% Trimmed Ham	22.4	20.7	13.938**	0.3
% Trimmed Loin	19.5	19.8	0.058	81.4
% Trimmed Boston Butt	7.8	7.6	0.236	63.6
% Trimmed Picnic	11.8	11.0	3.463	8.9
% 4 Lean cuts	61.5	59.1	1.672	22.0
% Green Belly	14.2	14.2	0.002	96.7
5 Primal Cuts	75.7	73.2	2.226	16.2

[a] % of chilled carcass weight

* P < 5%, ** P < 1%

Specific gravity was not significantly different between heavy hind and heavy front groups in this experiment (table 5), nor were specific gravity ratios affected. Muscle weight ratios between the 3 major cut areas (ham, shoulder, loin) were not significantly affected, although ham/shoulder and ham/loin total muscle ratios tended to be higher for the heavy hind group.

Table 5. Effect of Carcass Production on Wholesale Cut Specific Gravity and Ratios or on Cut Total Muscle Weight Ratios

Item	Heavy Hind	Heavy Front	F-Value	Probability %
Specific Gravity of Shoulder	1.086	1.077	0.079	78.4
Specific Gravity of Loin	1.085	1.110	0.299	59.5
Specific Gravity of Belly	1.080	1.084	0.012	91.5
Specific Gravity of Ham	1.096	1.124	0.743	40.6
Ratio Ham/Shoulder Specific Gravity	1.009	1.004	2.867	11.6
Ratio Loin/Belly Specific Gravity	1.005	1.023	0.935	35.3
Ratio Ham/Shoulder Muscle Weight	1.152	1.108	0.502	49.2
Ratio Ham/Loin Muscle Weight	1.291	1.238	0.351	56.5
Ratio Shoulder/Loin Muscle Weight	1.121	1.117	0.008	93.2

Table 6 shows significantly ($P < .05$) heavier ham muscle weight and shoulder muscle weight for the heavy hind group. The weight of biceps femoris and semitendinosus were also significantly heavier ($P < .01$), while gluteus medius from loin and triceps brachii from shoulder also showed significantly ($P < .05$) greater weights for the heavy hind group. Apparently the selection for heavy hind resulted in heavier muscling, but not necessarily for only more posterior muscles.

Table 6. Effect of Carcass Proportion on Muscle Weights

Item	Heavy Hind	Heavy Front	F-Value	Probability %
Ham Muscle Weight, gm	5964.6	5135.1	8.843*	1.2
Loin Muscle Weight, gm	4666.5	4193.6	2.436	14.5
Shoulder Muscle Weight, gm	5213.4	4640.0	4.969*	4.6
Ham Muscles				
Adductor + Semim., gm	1534.4	1370.4	1.248	28.6
Biceps Femoris, gm	1309.9	1086.2	23.836**	0.04
Semiten., gm	466.6	379.6	10.819**	0.6
Gracilis, gm	255.1	201.0	4.682	5.1
Quadriceps Femoris, gm	973.7	891.6	1.855	19.8
Psoas Major, gm	76.1	90.8	0.489	49.8

Table 6 (continued)

	Heavy Hind	Heavy Front	F-Value	Proba-bility %
Gluteus Medius, gm	156.4	127.0	1.287	27.9
Rectus Abdominis, gm	44.3	49.8	0.224	64.4
Other Rough Ham Muscle, gm	1148.0	938.7	1.514	24.1
Loin Muscles				
Psoas Major, gm	352.9	296.9	3.953	7.0
Gluteus Medius, gm	571.6	474.6	4.943*	4.6
Longissimus Dorsi, gm	1977.3	1833.4	0.566	46.6
Spinalis Dorsi, gm	170.4	130.2	2.513	13.9
Trapezius, gm	124.8	129.5	0.056	81.7
Serratus Ventralis, gm	115.2	200.5	2.177	16.6
Other Rough Loin Muscle, gm	1348.3	1128.5	1.254	28.5
Shoulder Muscles				
Longissimus Dorsi, gm	66.3	56.0	1.244	28.7
Spinalis Dorsi, gm	110.1	85.1	0.429	52.5
Senatus Ventralis, gm	576.9	537.6	0.268	61.4
Rhomboideus, gm	117.0	102.8	0.296	59.6
Infraspinatus, gm	295.0	213.0	2.757	12.3
Supraspinatus, gm	340.1	273.0	0.796	39.0

Table 6 (continued)

	Heavy Hind	Heavy Front	F-Value	Probability %
Teres Major, gm	114.7	86.5	0.709	41.6
Triceps Brachii, gm	763.0	631.4	5.291*	4.0
Subscapularis, gm	249.3	242.6	0.006	94.0
Other Rough Shoulder Muscle, gm	2528.7	2412.2	0.988	34.0

* $P < 5\%$, ** $P < 1\%$

Table 7 compares the two carcass proportion groups but presents muscle weights as a % of total muscle weight from the rough ham, loin and shoulder.

Neither % ham, loin and shoulder nor % of any individual muscle was found to differ between heavy hind and heavy front carcasses. Although some weight differences were found, they were minimized when divided by total muscle. Therefore muscle proportion was not different for the two selected groups. Similar results were reported by Warwick (1958) and Richmond and Berg (1972).

Table 7. Effect of Carcass Proportion on Individual Muscle Percentages of Combined Muscle Mass[a]

Item	Heavy Hind	Heavy Front	F-Value	Probability %
Ham Muscle Weight, %	37.73	36.77	0.545	47.45
Loin Muscle Weight, %	29.38	29.98	0.312	58.66
Shoulder Muscle Weight, %	32.89	33.25	0.199	66.34
Ham Muscles				
Adductor + Semim., %	9.68	9.84	0.027	87.2
Biceps Femoris, %	8.31	7.80	2.099	17.3
Semiten., %	2.96	2.71	2.608	13.2
Gracilis, %	1.63	1.44	1.085	31.8
Quadriceps Femoris, %	6.16	6.39	0.406	53.6
Psoas Major, %	0.48	0.65	1.445	25.3
Gluteus Medius, %	0.97	0.92	0.166	69.1
Rectus Abdominus, %	0.28	0.36	1.208	29.3
Other Rough Ham Muscle, %	7.26	6.68	0.291	60.0
Loin Muscles				
Psoas Major, %	2.23	2.12	0.531	48.0
Gluteus Medius, %	3.61	3.41	0.490	49.7
Longissimus Dorsi, %	12.41	13.09	0.449	51.6
Spinalis Dorsi, %	1.07	0.93	0.780	39.5
Trapezius, %	0.79	0.94	0.950	34.9
Serratus Ventralis, %	0.74	1.44	3.135	10.2

Table 7 (continued)

	Heavy Hind	Heavy Front	F-Value	Probability %
Other Rough Loin Muscle, %	8.48	8.04	0.143	71.2
Shoulder Muscles				
Longissimus Dorsi, %	0.41	0.40	0.043	83.9
Spinalis Dorsi, %	0.68	0.60	0.113	74.2
Serratus Ventralis, %	3.61	3.84	0.304	59.2
Rhomboideus, %	0.74	0.74	0.002	97.0
Infraspinatus, %	1.85	1.53	1.039	32.8
Supraspinatus, %	2.14	1.96	0.125	73.0
Teres Major, %	0.72	0.62	0.209	65.6
Triceps Brachii, %	4.80	4.52	1.223	29.0
Subscapularis, %	1.56	1.74	0.104	75.3
Other Rough Shoulder Muscle, %	16.04	17.30	2.602	13.3

[a] Total muscles from rough ham, loin and shoulder.

The subjective evaluation of heavy hind and heavy front carcasses may have stressed the biceps femoris and semitendinosus, two superficial muscles on the outside part of ham as they were slightly larger for heavy hind carcasses (table 6). Some other selection emphasis may have obtained groups with differences in muscle proportion, but this is doubtful.

SUMMARY

Two groups of seven pork carcasses each were visually selected to represent heavy hind and heavy front carcass proportion in such a way as to minimize fat effect and maximize muscle differences.

The heavy hind group tended to have heavier trimmed ham weight and a larger percent trimmed ham ($P < .01$), and heavier trimmed picnic weight ($P < .05$). The heavy hind group had heavier gluteus medius (loin portion), ham and shoulder weight ($P < .05$); also heavier biceps femoris and semitendinosus ($P < .01$). No differences were found in specific gravity of various rough cuts, or of % of individual muscles of the total muscle of ham, loin and shoulder (muscle proportion).

Therefore, this selection did not sort out carcass which differed in muscle proportion.

LITERATURE CITED

McMeekan, C. P. 1940. Growth and Development in the Pig, With Special Reference to Carcass Quality Characters. Part I. J. Agr. Sci. 30:276.

Report of the Pork Carcass Evaluation Committee. 1951. Cutting Procedure. Fifth Annual Reciprocal Meat Conference Proceedings. p. 120. National Livestock and Meat Board, Chicago.

Richmond, R. J. and R. T. Berg. 1972. Comparison of Muscle and Fat Distribution in Boars, Barrows, and Gilts. U. of Alberta Feeder's Day. p. 16.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods (6th ed.), The Iowa State University Press, Ames, Iowa.

Warwick, E. J. 1958. The Effect of Breeding and Production on Beef Carcass Characteristics. Eleventh Annual Reciprocal Meat Conference Proceedings. p. 201. National Livestock and Meat Board, Chicago.

CHAPTER V

THE RELATIONSHIP OF CHINE DEPTH TO PORK CARCASS TRAITS AND INDIVIDUAL MUSCLE WEIGHTS

Some grading and evaluation systems require appraisal of intact pork carcass sides. Visual evaluation of pork carcasses is difficult and often fails to conform with carcass cut-out value. Thus, other visual carcass characteristics besides carcass length, backfat thickness and overall conformation may aid in appraisal of the intact carcass. Pearson, et al. (1959) reported that under the Canadian system of carcass rail grading, some experienced graders have indicated that the appearance of the exposed lumbar muscles in combination with other visual measurements can be used in accurately arriving at carcass grade. This study was undertaken to investigate chine depth relationships to various pork carcass traits and individual muscle weights.

EXPERIMENTAL PRODECURE

Fourteen pork carcasses were selected for one of two types by visual judgment; seven as heavy front carcasses and seven as heavy hind carcasses. An attempt was made to minimize fat effects on this appraisal. Data for both groups were combined because practically no significant differences were noted. Live weights ranged from 87.5 to 100 kg.

Carcass measurements included carcass length and average backfat thickness. Chine depth was measured from the dorsal edge of spinal canal to the dorsal edge of dorsal vertebral process at 10 T (10th thoracic vertebra), 1 L (1st lumbar vertebra) and to the dorsal edge of muscle at 5 L (5th lumbar vertebra).

Four rough cuts: ham, loin, shoulder and belly were cut from the left side of the carcasses. The rough ham was removed half way between the aitchbone and the last lumbar vertebra with the foot and all fat intact and without separating flank muscles. The rough loin was taken with all fat left on. The rough one and one-half rib shoulder was removed with foot on, the jowl was removed and neck bones were not removed. The rough belly had spare ribs left on.

Specific gravity was calculated from the in-air and in-water weights of the rough cuts. The air weight was taken to the nearest 0.05 kg and water weight to the nearest gm on cuts submerged in water at temperatures ranging from 2-5° C. Specific gravity was determined from the following formula:

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{Weight in water}}$$

Each cut was trimmed following the procedure outlined in the Fifth Annual Reciprocal Meat Conference Proceedings (1952). The following muscles were dissected, freed of external fat and tendons and weighed to the nearest 0.1 gm: adductor +

semimembranosis, biceps femoris, semitendinosus, gracilis, quadriceps femoris, psoas major, gluteus medius, rectus abdominis and other ham muscles all from the rough ham. Loin muscles were the psoas major, gluteus medius, longissimus, spinalis dorsi, trapezius, serratus ventralis and other rough loin muscles; while rough shoulder muscles were the longissimus, spinalis dorsi, serratus ventralis, rhombeideus, infraspinatus, supraspinatus, teres major, triceps brachii, subscapularis and other shoulder muscles.

The muscle weight ratios of ham/shoulder, ham/loin and shoulder/loin were calculated.

Data were analyzed by calculating simple correlation coefficients as described by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

The results (tables 8 - 11) showed that chine depth at 10 T, 1 L, 5 L or average chine depth were essentially the same in strength of relationship to carcass traits or muscle weights and percentages.

Table 8 showed no significant correlation of the chine depth to weight of any wholesale cut, 4 lean cuts or 5 primal cuts, although correlations were slightly higher for shoulder than other cuts. Significant and negative correlations of -0.59*, -0.66* and -0.71** were noted with the specific gravity of loin, belly and ham, respectively. A correlation coefficient of 0.32** between average chine bone depth and whole carcass specific gravity had been reported by Kropf (1962). No strong relationship of chine depth to total ham, loin or shoulder muscle was found.

Table 8. Pork Chine Depth Relationships to Wholesale Cut Weights, Specific Gravity and Muscle Weight

	Chine Depth[a]			
Item	10 T	1 L	5 L	Average
Trimmed ham, Kg	-0.05	0.05	0.02	0.01
Trimmed loin, Kg	0.29	0.29	0.28	0.29
Trimmed butt, Kg	0.23	0.25	0.23	0.24
Trimmed picnic, Kg	0.44	0.52	0.50	0.49
4 lean cuts, Kg	0.23	0.28	0.26	0.26
Green belly, Kg	-0.35	-0.30	-0.33	-.033
5 primal cuts, Kg	0.10	0.16	0.14	0.14
Specific gravity of shoulder	-0.46	-0.46	-0.47	-0.46
Specific gravity of loin	-0.59*	-0.58*	-0.59*	-0.59*
Specific gravity of belly	-0.68**	-0.64*	-0.66*	-0.66*
Specific gravity of ham	-0.71**	-0.70**	-0.71**	-0.71**
Ham muscle, gm	-0.02	0.08	0.05	0.04
Loin muscle, gm	0.34	0.36	0.35	0.35
Shoulder muscle, gm	0.29	0.36	0.33	0.33

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

[a] 10 T = 10th thoracic, 1 L = 1st lumbar, 5 L = 5th lumbar

The correlations of percent trimmed picnic and percent 5 primal cuts with average chine depth were 0.85** and 0.62* (table 9). Correlations between average chine depth and percent 4 lean cuts was 0.64*, compared to values of 0.544 (Kauffman, 1959), 0.57 (Pearson, 1959) and 0.40** (Kropf, 1962). No significant correlations were calculated of chine depth to the ratio of ham, loin or shoulder muscles to total muscle weight from these three cuts. However, proportion of ham muscle tended to be negatively correlated to chine depth.

Table 9. Correlation Coefficients of Pork Chine Depth Measurements to Wholesale Cut Percentages[a] and Muscle Percentages

	Chine Depth[c]			
Item	10 T	1 L	5 L	Average
Trimmed ham, %	0.27	0.32	0.31	0.31
Trimmed loin, %	0.54	0.47	0.48	0.50
Trimmed butt, %	0.51	0.47	0.47	0.48
Trimmed picnic, %	0.83**	0.86**	0.86**	0.85**
4 lean cuts, %	0.64*	0.63*	0.63*	0.64*
Green belly, %	-0.30	-0.29	-0.31	-0.30
5 primal cuts, %	0.63*	0.61*	0.61*	0.62*
Ham muscles/total muscle[b], %	-0.42	-0.37	-0.37	-0.38
Loin muscles/total muscle[b], %	0.36	0.30	0.30	0.32
Shoulder muscles/total muscle[b], %	0.21	0.20	0.20	0.20

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

[a] % of chilled carcass weight

[b] total muscle from rough ham, loin and shoulder

[c] 10 T - 10th thoracic, 1 L = 1st lumbar, 5 L = 5th lumbar

Table 10 shows correlations between chine depth and individual muscle weights. Muscles that were heavier when chine was deeper included loin spinalis dorsi (r = 0.70**), shoulder serratus ventralis (r = 0.54*), infraspinatus (r = 0.86**) and supraspinatus (r = 0.97**).

Table 10. Correlation Coefficients of Pork Chine Depth Measurements to Individual Muscle Weights

Item	Chine Depth[a]			
	10 T	1 L	5 L	Average
Loin Muscles				
Psoas major, gm	0.07	0.16	0.15	0.14
Gluteus medius, gm	-0.24	-0.20	-0.19	-0.20
Longissimus dorsi, gm	0.29	0.28	0.28	0.29
Spinalis dorsi, gm	0.71**	0.68**	0.69**	0.70**
Trapezius, gm	-0.39	-0.39	-0.39	-0.39
Serratus Ventralis, gm	-0.78**	-0.80**	-0.80**	-0.80**
Other rough loin muscles, gm	0.50	0.53	0.50	0.50
Shoulder Muscles				
Longissimus dorsi, gm	-0.01	0.14	0.07	0.06
Spinalis doris, gm	0.35	0.44	0.37	0.38
Serratus ventralis, gm	0.50	0.60*	0.53	0.54*
Rhomboideus, gm	-0.46	-0.52	-0.47	-0.47

Table 10 (continued)

	Chine Depth[a] 10 T	1 L	5 L	Average
Infraspinatus, gm	0.85**	0.85**	0.85**	0.86**
Supraspinatus, gm	0.95**	0.97**	0.97**	0.97**
Teres major, gm	-0.19	-0.12	-0.19	-0.18
Triceps brachii, gm	0.39	0.48	0.45	0.49
Supscapularis, gm	-0.82**	-0.81**	-.81**	-0.81**

* P < .05, ** P < .01

[a] 10 T = 10th thoracic, 1 L = 1st lumbar, 5 L = 5th lumbar

Muscles that were higher in % with a deeper chine included ham gluteus medius (r = 0.57*), loin spinalis dorsi (4 = 0.70**), infraspinatus (r = 0.88**) and supraspinatus (= 0.96**). Of these, only loin spinalis dorsi lies in close proximity to one of the chine measurement locations, although gluteus medius depth near the ham-loin junction is a major component of the 5 L chine depth measurement.

Table 11. Correlation Coefficients of Pork Chine Depth to Percentages of Individual Muscles[a]

Item	Chine Depth[b] 10 T	1 L	5 L	Average
Ham Muscles				
Adductor + Semimembranosus, %	-0.78**	-0.73**	-0.76**	-0.76**

Table 11 (continued)

	Chine Depth[b]			
	10 T	1 L	5 L	Average
Biceps femoris, %	-0.21	-0.18	-0.14	-0.17
Semitendinosus, %	-0.03	0.06	0.03	0.02
Gracilis, %	-0.50	-0.50	-0.49	-0.50
Quadriceps femoris, %	-0.41	-0.48	-0.44	-0.44
Psoas major, %	-0.34	-0.32	-0.33	-0.33
Gluteus medius, %	-0.57	0.53	0.57*	0.57*
Rectus abdominis, %	-0.22	-0.21	-0.19	-0.20
Other rough ham muscles, %	0.45	0.48	0.47	0.46
Loin Muscles				
Psoas major, %	-0.13	-0.06	-0.05	-0.07
Gluteus medius, %	-0.47	-0.48	-0.45	-0.46
Longissimus dorsi, %	0.22	0.16	0.17	0.19
Spinalis dorsi, %	0.73**	0.67*	0.69**	0.70**
Trapezius, %	-0.42	-0.44	-0.44	-0.43
Serratus ventralis, %	-0.79**	-0.80**	-0.80**	-0.80**
Other rough loin muscles, %	0.52	0.52	0.50	0.51
Shoulder Muscles				
Longissimus dorsi, %	-0.17	-0.03	-0.10	-0.10
Spinalis dorsi, %	0.36	0.43	0.37	0.38

Table 11 (continued)

	Chine depth[b]			
	10 T	1 L	5 L	Average
Serratus Ventralis, %	0.46	0.54	0.48	0.49
Rhomboideus, %	-0.56*	-0.62*	-0.57*	-0.58*
Infraspinatus, %	0.90**	0.87**	0.88**	0.88**
Supraspinatus, %	0.95**	0.95**	0.95**	0.96**
Teres major, %	-0.24	-0.17	-0.24	-0.23
Triceps brachii, %	0.45	0.52	0.49	0.49
Subscapularis, %	-0.88**	-0.87**	-0.88**	-0.88**
Other rough shoulder muscles, %	0.28	0.37	0.31	0.31
Total muscles, gm	0.22	0.29	0.26	0.26

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

[a] % of total muscle from rough ham, loin shoulder

[b] 10 T = 10th thoracic, 1 L = 1st lumbar and 5 L = 5th lumbar locations

Muscles that were heavier with a lesser chine measurement were loin part of serratus ventralis (r = -0.88**) and subscapularis (r = -0.81**). Those higher in % with a smaller chine depth were adductor plus semimembranosus (r = -0.76**), loin serratus ventralis (r = -0.80**), rhomboideus (r = -0.58*) and subscapularis (r = -0.88**). Most of these are not closely located to chine measurement locations, so such relationships to percentage of individual muscles might be expected.

Unexpected low, non-significant relationships were calculated between chine depth and either weight or % of longissimus. Pearson et al. (1959) and Kauffman et al. (1959) reported that the chine depth can be used to predict the loin eye area, with correlation coefficients of 0.53 and 0.361, respectively. However, cross-sectional area is only one dimension of longissimus size.

From these results, pork chine depth seems to be a reliable predictor of % but not weight of lean cuts and 5 primal cuts largely because of the high correlation of % trimmed shoulder (r = 0.85**).

SUMMARY

Pork carcass chine depth measurements at 10th thoracic, 1st lumbar and 5th lunbar vertebral locations or an average were obtained as well as wholesale cut weights and percentages. Certain individual muscle weights were also obtained from 15 pork carcasses.

Significant and negative correlations of -0.59*, -0.66*, and -0.77** were found between chine depth and specific gravity of loin, belly and ham, respectively. However, no significant correlations were found with weights of any wholesale cut or 4 lean cuts.

Correlations between chine depth with % trimmed ham, % 4 lean cuts and % 5 primal cuts were 0.85**, 0.64* and 0.62*, respectively.

LITERATURE CITED

Kauffman, R. G., R. W. Bray and D. E. Goll. 1959. The Relationship of Lumbar Lean Measurements to Pork Carcass Muscling. J. Animal Sci. 18:1481 (Abstr.).

Kropf, D. H. 1962. Effect of Anatomical Location Upon Pork Longissimus Dorsi Area and Marbling. J. Animal Sci. 21:383 (Abstr.).

Pearson, A. M., R. J. Deans and L. J. Bratzler. 1959. Some Lumbar Lean Measures Related to Swine Carcass Cut-Out and Loin Eye Area. J. Animal Sci. 18:1087.

Report of the Pork Carcass Evaluation Committee. 1952. Cutting Procedure. Fifth Annual Reciprocal Meat Conference Proceedings. p. 120. National Livestock and Meat Board, Chicago.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods. (6th ed.), The Iowa State University Press, Ames, Iowa.

CHAPTER VI

GENERAL SUMMARY

Twelve pork carcasses from pigs resulting from diallel matings were used to determine whether differences existed between right and left sides of pork carcasses for some physically measured carcass traits in pigs that appeared to be bilaterally asymmetrical.

The average backfat thickness, carcass length and loin eye area were measured; and weights of individual lean cuts were taken. The biceps femoris, quadriceps femoris, semitendinosus and semimembranosus + adductor were excised from each ham. Muscle fiber diameter of biceps femoris, semitendinosus and semimembranosus was also measured.

An apparent visual bilateral asymmetry in twelve swine is supported by heavier untrimmed ham, trimmed ham, ham muscle, ham fat, ham bone, 4 lean cut and total fat trim weights in sides evaluated to be more muscular.

Mean biceps femoris and semitendinosus weights were significantly heavier in more muscular sides whereas combined semimembranosus plus adductor and quadriceps femoris were not different for the two selected groups.

Semitendinosus, semimembranosus and biceps femoris fiber diameter did not show any difference between the two muscularity groups, even though significant differences in muscle weight were noted.

Litter x muscularity interaction showed muscular side had more consistently heavier ham, total ham muscle, biceps femoris and semitendinosus weights than less muscular side, in litter 51 and 52 (the offspring of one sow). The muscular side was usually the left side.

Fourteen carcasses were selected by visual judgment; seven as heavy hind ended carcasses and seven as heavy front ended carcasses in such a way as to minimize fat effect on selection. Average backfat thickness, carcass length and chine depth were measured. The weights of four rough cuts and trimmed cuts were taken and specific gravity was calculated from the rough cuts. The individual muscles from ham, loin and shoulder were dissected.

The heavy hind group tended to have heavier trimmed ham weight and a larger percent trimmed ham ($P < .01$) and heavier trimmed picnic weight ($P < .05$). The heavy hind group had heavier gluteus medius (loin portion), ham and shoulder muscle weight ($P < .05$); also heavier biceps femoris and semitendinosus ($P < .01$). No differences were found in specific gravity of various rough cuts, or of % of individual muscles of the total muscle of ham, loin and shoulder (muscle proportion).

Chine depth was measured from the dorsal edge of spinal canal to the dorsal edge of dorsal vertebral process at 10 T (10th thoracic vertebra), 1 L (1st lumbar vertebra) and to dorsal edge of muscle at 5 L (5th lumbar vertebra).

Significant and negative correlations of -0.59*, -0.66* and -0.77* were found between chine depth and specific gravity of loin, belly and ham, respectively. However, no significant correlations were found with weights of any wholesale cut or 4 lean cuts.

Correlation between chine depth with % trimmed ham, % 4 lean cuts and % 5 primal cuts were 0.85**, 0.64* and 0.62*, respectively.

The average chine depth was positively correlated with the weights of spinalis dorsi (0.70**) from loin, serratus ventralis (0.54*), infraspinatus (0.86**) and supraspinatus (0.97**) from shoulder; with % of gluteus medius (0.57*) from ham, spinalis dorsi (0.70**) from loin, infraspinatus (0.88**) and supraspinatus (0.96**) from shoulder.

Significant and negative correlations were found between chine depth and weight of serratus ventralis (-0.80**) from loin and subscapularis (-0.81**) from loin, rhomboideus (-0.58*) and subscapularis (-0.88**) from shoulder.

Chine depth at 10 T, 1 L, 5 L or average of three locations were essentially same in strength of relationship to carcass traits or individual muscle weights and %.

ASYMMETRY AND MUSCLE PROPORTION IN PORK CARCASSES

by

YIE-SHIUNG CHEN

B. S., Chung Hsing University, 1962

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

Twelve pork carcasses from pigs resulting from diallel matings that appeared to be bilaterally asymmetrical were used to determine whether or not differences existed between two sides.

The average backfat thickness, carcass length and loin eye area were measured; and weights of individual lean cuts were taken. The biceps femoris, quadriceps femoris, semitendinosus and semimembranosus + adductor were excised from each ham. Muscle fiber diameter of biceps femoris, semitendinosus and semimembranosus was also measured.

The muscular side had heavier untrimmed ham, trimmed ham, ham muscle, ham fat, ham bone, 4 lean cut and total fat trim weights. Mean biceps femoris and semitendinosus weights were significantly heavier in more muscular sides whereas combined semimembranosus plus adductor and quadriceps femoris were not different for the two selected groups.

Fourteen carcasses were selected by visual judgment; seven as heavy hind ended carcasses and seven as heavy front ended carcasses. Average backfat thickness, carcass length and chine depth were measured. The weights of four rough cuts and trimmed cuts were taken and specific gravity was calculated from the rough cuts. The individual muscles from ham, loin and shoulder were dissected.

The heavy hind group tended to have heavier trimmed ham weight and a larger % trimmed ham ($P < .01$) and heavier trimmed picnic weight ($P < .05$). The heavy hind group had heavier gluteus medius (loin portion), ham and shoulder weight ($P < .05$); also heavier biceps femoris and semitendinosus ($P < .01$). No differences were found in specific gravity of various rough cuts, or of % of individual muscles of the total muscle of ham, loin and shoulder (muscle proportion).

Chine depth was measured from the dorsal edge of spinal canal to the dorsal edge of dorsal vertebral process at 10 T (10th thoracic vertebra), 1 L (1st lumbar vertebra) and to dorsal edge of muscle at 5 L (5th lumbar vertebra).

Correlation between chine depth with % trimmed ham, % 4 lean cuts and % 5 primal cuts were 0.85**, 0.64* and 0.62*, respectively.

The chine depth was highly correlated with the weights of spinalis dorsi (0.70**) from loin, serratus ventralis (0.54*), infraspinatus (0.86**) and supraspinatus (0.97**) from shoulder; with % of gluteus medius (0.57*) from ham, spinalis dorsi (0.70**) from loin, infraspinatus (0.88**) and supraspinatus (0.96**) from shoulder.

Significant and negative correlations were found between chine depth and weight of serratus ventralis (-0.80**) from loin and subscapularis (-0.81**) from shoulder; with % of serratus ventralis (-0.80**) from loin, rhomboideus (-0.58*) and subscapularis (-0.88**) from shoulder.