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A Determination Of Objective Carcass Grade Standards For Slaughter Hogs

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INTRODUCTION

The problem of classifying and grading livestock has received considerable attention only in recent years. From early colonial times through the first part of the nineteenth century, reference to livestock handled at the markets was generally made on the basis of species rather than by certain classes or grades (1). This was especially true for hogs and sheep. Cattle were sometimes designated or classified by general terms descriptive to the use of which they were to be put, such as "working oxen," and "stock steers."

Lacking specific classes and grades during this time, the sale price was frequently determined by the head in most species of livestock. Very early references to marketing practices show that hogs were sold to packers graded according to weight, with a heavy animal selling for almost double the price per hundred pounds of the lighter weights. Cattle were sold by measurement around the belly in some cases with a given price for a certain number of feet and adding or subtracting an appropriate price differential for every inch over or under this measurement. In general, the market livestock was sold by the head or, in some cases, by the hundredweight with practically no sorting.

With an increase in the volume of slaughter hog marketings around the turn of the nineteenth century, there appeared some voluntary recognition of quality differences by the establishment of price differentials. Premiums for quality were paid by pork packers of the Ohio Valley as early as 1817 (2). Good, corn-fattened hogs commanded a price of $4 per hundred-weight while the oily, soft, mast-fed hogs sold at $3.50 per hundredweight.

There was little progress made in the method of sale of slaughter hogs by classes and grades during the next few decades. Each market developed classifications and adopted descriptive terms peculiar to its own trade area. Interpretations of these market terms varied among individuals on the same market and with the same individual during different seasons

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Figures in parenthesis refer to literature cited, page 51.

of the year. The first issue of *The Country Gentleman* in January, 1853, reported the Brighton market classification of hogs as old hogs, fat distillery-fed hogs, and fat corn-fed hogs and shoats, the latter class being further divided into sows and barrows (1). These classifications were based principally upon differences in age, sex, and method of feeding. In an early report of the Chicago market, *The Prairie Farmer* in 1867 reported prices on choice, medium, and common bacon-type hogs. The price quotations apparently were based largely on weight with heavier hogs selling considerably higher.

During the latter part of the nineteenth century there was a tremendous growth in public markets. This led to the publication of daily and weekly market reports quoting actual transaction in livestock and meat trades. A lack of uniformity and meaning in the classes and descriptive terms used caused considerable confusion and misunderstandings between producers and market interests. These conditions indicated an urgent need for a single set of standards for market classes and grades of hogs and other species of livestock (3).

THE DEVELOPMENT OF GRADE STANDARDS FOR SLAUGHTER HOGS AND FOR HOG CARCASSES IN THE UNITED STATES

There are several kinds or classes of hogs and within each class there is a wide range of quality which usually accounts for a range in market values. Some method of dividing the quality range of a given class or kind into groups of similar and uniform quality was considered necessary for promoting satisfactory marketing. Classifying market hogs is the process of sorting the animals on the basis of age, sex, weight, and use or purpose. The use of conformation, finish, and quality as factors in grading have been, even up to the present time subjective measures and difficult for accurate interpretation.

The Illinois Agricultural Experiment Station made the first approach to word formulation of standard market classes and grades for hogs. This station published Bulletin 97 on "Market Classes and Grades of Swine" by William Dietrich in November, 1904. The work was undertaken with hopes of providing uniform classes and grades for a basis of trading at all markets. This publication emphasized the lack of uniformity in terms used by livestock traders and market reporters. Some of the terms used were not characteristic of what the names represented, and others were too broad in scope.

In 1915, the Bureau of Markets of the United States Department of Agriculture began work on formulating grade standards for both livestock and meats. In initiating the Livestock Market Reporting Service, the department used as a basis for formulating standard classifications and grades of market livestock the work that was done by the Illinois

Agricultural Experiment Station. It was discovered that the classes and grades used at the principal markets lacked uniformity of description and interpretation between markets, and, also, that the meaning of terms varied between seasons of the year and even among individuals at the same market. It was apparent that little progress was made with respect to the adoption of uniform grade standards for market livestock from the time of the first University of Illinois publication on standard market classes of livestock in 1904.

The Department of Agriculture issued several grade standards for slaughter livestock within a few years after initiation of their studies in 1915. The use of tentative and official standards was optional rather than compulsory insofar as the market agencies were concerned. The classifications, however, were and continue to be the basis for reporting prices of livestock by the Market Reporting Service of the United States Department of Agriculture.

Constant efforts were made for adoption and use of the classifications to achieve some degree of uniform terminology among the various markets and market agencies. The first tentative standards for pork carcasses and cuts and miscellaneous meats were issued by the department in 1924 (4). These standards were revised and expanded, and published as standards for pork carcasses and fresh pork cuts in 1933 (5). The standards used to designate and describe the separate classifications of pork carcasses were Fat-type (butcher), Meat-type (bacon), Sow (packing), Shipper, Roasting, and Stag-pork carcasses. The designated grades within each of the classifications were No. 1, No. 2, No. 3, and Cull grade. These were considered sufficient for all commercial purposes.

Tentative standards for classes and grades of slaughter hogs were issued in 1931 (6). These tentative standards were further developed, with the market terms more clearly defined, by the Agricultural Marketing Administration in a revised publication in 1942 (3). Slaughter hogs were classified by age and sex. The terms Fat-type and Meat-type were used to differentiate between two grades of finish, both of which were considered Choice or No. 1. Meat-type hogs were relatively long and narrow with a lower proportion of fat to lean than the Fat-type which were wider in proportion to length and depth with thicker deposits of fat in the same weights.

ACCEPTANCE AND USE OF U. S. GRADE STANDARDS FOR SLAUGHTER HOGS

Tentative grade standards for slaughter hogs and pork carcasses have been published for several years, but no official grade standards have been adopted. A large majority of pork carcasses are disassembled in the packing plant and distributed to the trade in wholesale cuts. Therefore, there was not an urgent need for carcass standards as was true with other species of livestock where carcasses were distributed to the wholesale trade.

Under present conditions, slaughter hogs apparently are graded and sold primarily on a weight basis with little sorting, except for hogs with obvious defects and animals advanced in pregnancy. There is a tendency for hogs within the same class and weight range to sell at about the same price per hundredweight (7). Thus, the price paid tends to be based on average of weights and finish by lots rather than what individual hogs actually yield as pork products. There is an apparent need for more specific standards in market classes and grades of slaughter hogs and pork carcasses.

THE OBJECTIVE OF THE STUDY

The purpose of this investigation was to establish and evaluate objective carcass grade standards for slaughter hogs which would classify hog carcasses into relatively homogeneous groups on the basis of physical composition.

THE APPROACH

In order to provide information to meet the objective of this study, detailed measurements on carcasses were taken and recorded, after which the carcasses were subjected to a detailed cut-out test to obtain weights of various cuts and trimmings. The relationships between various measurements and combinations of high value cuts were determined and methods of predicting some component parts or physical make-up of carcasses at varying degrees of finish and different weights were applied. This correlation approach to the study of carcass merit for development of grade standards was first proposed by Mr. Charles A. Murphey of the United States Department of Agriculture, to be used in an investigation at the University of Minnesota at St. Paul in 1946 (2).

A REVIEW OF CARCASS STANDARDS USED IN OTHER COUNTRIES

Carcass standards have been used for several years as a basis of settlement in Denmark, Great Britain, and Canada. This method of marketing has received little attention in the United States.

In Danish grading the carcasses are placed into three classes according to (1) the thickness of fat along the back, (2) the length, and (3) the firmness of the meat (9).

The bacon hogs in Great Britain are sold by carcass weight and grade. Carcass grades are divided into five letter grades from A to E, according to thickness of shoulder fat and belly pocket (9). Carcasses are further divided into weight classes. Descriptions of carcasses are given with both weight and grade designation.

The standards for Canadian carcass grades are based on specifications of weight, length and thickness of fat over the shoulders and loins. The carcasses meeting the requirements for the bacon grades are usually exported. Other carcasses are termed pork grades and used principally for domestic consumption (12).

An appraisal of the carcass standards used in the three countries mentioned as a basis of settlement for slaughter hogs indicates one common and important feature. Each of the standards is based primarily upon objective and quantitative measures for determining relative carcass merit. Thickness of backfat or fat over the shoulder is a major determinant of excellence in each country. The Danes and Canadians make use of the length measurement, while the British use a belly thickness measurement not considered in other counties. Objective measures of excellence have been simplified for practicability, and provide a means of settlement that reduces dissatisfaction and argument by the parties concerned. Weight classifications are similar in Britain and Canada, while the Danes use a lighter weight range for the premium grades. Danish hog carcasses have world-wide recognition for uniformity and high quality. Grading under these systems is further refined by use of subjective descriptions in addition to the objective measures, particularly in Canada.

A REVIEW OF CARCASS STANDARDS SUGGESTED IN THE UNITED STATES

As indicated previously, there have been attempts to formulate hog carcass standards in the United States. The Department of Agriculture published tentative carcass grade standards in Circular 288, "Market Classes and Grades of Pork Carcasses and Fresh Pork Cuts," dated October, 1933. The general classifications were Fat-type (butcher), Meat-type (bacon), Sow (packing), Shipper-pork, Roasting-pork, Stag-pork, and Boar. These classes, with exception of boar carcasses, were divided into four carcass grades, No. 1 grade, No. 2 grade, No. 3 grade, and Cull grade.

The measures for placing the carcasses within grade classifications were entirely subjective and qualitative. The No. 1, No. 2, and No. 3 grade carcasses were designated by descriptions of desired features using adjectives that were relative in nature. Cull grade carcasses included rejects that could not be merchandised as edible product in wholesale or retail cuts. Margins between grades were located by gradations in degrees of the comparative adjective used.

The Minnesota Agricultural Experiment Station proposed the first tentative objective hog carcass grade standards for this country in 1948 (8). This investigation attemped to establish objective carcass standards with economic significance that would grade hog carcasses according to cut-out value. From statistical analyses using the correlation approach a tentative standard was developed on the basis of carcass weight, backfat thickness, and percentage of lean cuts and trimmings (i.e.: hams, loins, picnics, butts, bellies, and lean trimmings).

SOURCE AND CHARACTER OF DATA

The basic data for the study were obtained at the Wilson & Co. packing plant at Kansas City from February 1, 1949 to March 8, 1949. Data were obtained on 592 hog carcasses. Twelve physical measurements were taken and recorded from the carcasses selected. In addition, the carcasses were put through a detailed cut-out test to provide data for determining the weights and proportions of various wholesale cuts and combinations of these cuts.

SELECTION OF CARCASSES

The sampling techniques followed in selecting carcasses for this study departed from strictly random procedures. The primary concern was not in acquiring a sample of carcasses representative of the population of a certain producing area, a particular season of the year, or even of specific breeds. It was rather in sampling adequately, within limits, the entire range of physical variation in finish within specified weight groups, regardless of the number in which the different categories are marketed.

The weights of carcasses selected varied from 95 to 215 pounds. This range in carcass weight approximates the live weight range of from 160 to 300 pounds. The carcass weight range from 95 to 215 pounds was divided into 12 consecutive weight groups, each having a 10-pound weight range.

Within each weight group carcasses were selected with as wide a range of physical variation in degree of finish as was possible. Special emphasis was placed upon acquiring the extremes of range in finish. The range of finish varied from 20 millimeters to over 60 millimeters of backfat thickness. The finish range was divided into nine consecutive groups, each having a 5-millimeter finish range.

A minimum of twelve weight groups with 9 degrees of finish per weight group gave 108 separate weight and finish cells. Rigid conformance to a sampling model or experimental design was not necessary for the regression type analysis. It was almost impossible to obtain adequate numbers of overfinished carcasses in the lightweight groups and underfinished carcasses in the heavier weight groups. As hogs increase in weight they also tend to increase in degree of finish. Table 1 shows the distribution of carcasses by weight and by degree of finish or backfat thickness.

TABLE 1 -- DISTRIBUTION OF CARCASSES SELECTED FOR CUT-OUT TESTS BY WEIGHT IN POUNDS AND BACKFAT THICKNESS.

Group Number	Carcass Weight	Backfat Thickness (Millimeters)									
		Over 60	56-60	51-55	46-50	41-45	36-40	31-35	26-30	21-25	Total
I	95-105						4	10	7	1	22
II	105-115				1	6	9	14	12	3	45
III	115-125				5	9	11	11	9	1	46
IV	125-135			3	7	9	12	10	8		49
V	135-145		4	3	8	12	17	7	4	2	57
VI	145-155		2	8	10	10	13	7	3		62
VII	155-165	1	7	9	7	9	12	7	2		54
VIII	165-175		3	10	11	12	11	5	1		53
IX	175-185	2	7	10	8	9	7	2			45
X	185-195	4	10	13	10	11	6	2			56
XI	195-205	8	11	12	11	5	7				54
XII	205-215	10	8	10	11	6	3	1			49
Totals		25	52	78	89	107	112	76	46	7	592

CARCASS MEASUREMENTS

The measurements were taken from the chilled carcass hanging on the rail in the cooler. These included body length, backfat thickness at the first rib, last rib, and last lumbar vertebrae, belly pocket thickness, length of hind leg, length of ham, circumference of ham, and width through the shoulders and hams. A detailed description of the measurements recorded is given in Appendix A. Measurements were taken in millimeters to facilitate computations.

CUTTING THE CARCASSES

In the normal operations of the cooperating plant carcasses are cut with power equipment at the rate of several hundred an hour. This results in numerous variations in the particular points of separation of the various cuts, and produces considerable variance in cuts and trim from carcasses of identical composition. Since positive identification of trimmings and cuts from individual carcasses would be difficult, it was decided to use the following cutting procedures:

A selected gang of two master butchers and helpers was provided by the packing plant. This gang cut each carcass individually into wholesale cuts in accordance with a standardized cutting procedure given in Appendix B. The same personnel was used during the course of the study, and supervised for strict adherence to the standardized cutting procedures.

The various cuts and trimmings from each carcass were weighed and recorded on individual record cards as shown in Appendix C. The sum of the weights of the cuts was used as the total weight of the carcass in the analyses.[1] The high value cuts, that is, hams, loins, shoulders and bellies were graded by a federal grader.

[1]The sum of the weights of the cuts and trimmings was not equal to the weight of the carcass determined immediately prior to cutting. This was expected due to minor cutting losses and difficulty of securing a consistent scale "break" each time under cooler temperatures. The deviations ranged from one ounce to 25 ounces and were ignored for the purpose of this study.

ANALYSIS OF DATA

The approach to the development of objective and quantitative carcass standards was guided by the hypothesis that some physical measures of the carcass appear to have a functional relationship with certain combinations of the high value cuts in the carcass. The recorded data for the study included several measurements that could be used as independent variables, and also the percentage components of the carcass of the various cuts and trimmings that could be used as the dependant variables to evaluate carcass value.

DETERMINING ESSENTIAL RELATIONSHIPS

Several combinations of cuts appeared to have some merit as possible criteria of carcass desirability. The high value lean cuts include the hams, loins, butts, and picnics. The belly, although a high value cut, is not considered a lean cut, and probably would have a negative association with the lean components. Four possible combinations of objective criteria of carcass merit were considered. These were as follows:

1. The percentage of four lean cuts—hams, loins, butts, and picnics.
2. The percentage of the four lean cuts plus the belly (commonly referred to as five primal cuts).
3. The percentage of four lean cuts plus the lean trimmings.

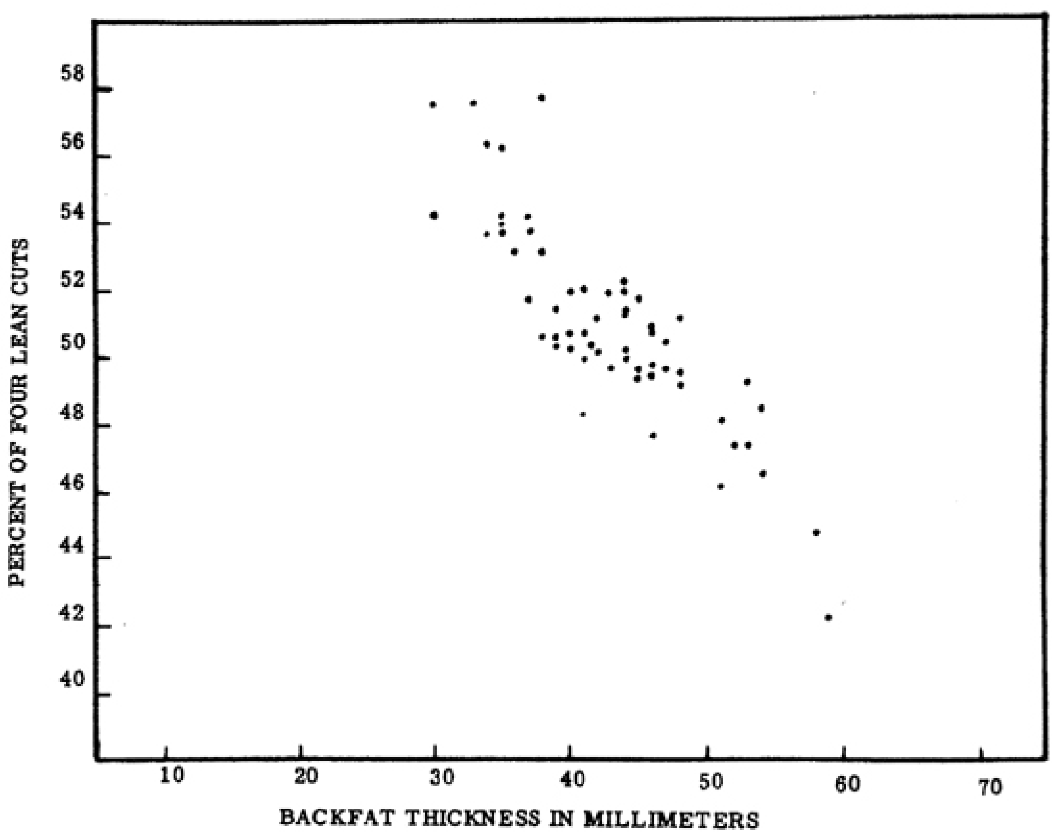

Figure 1.—Relationship of average backfat thickness to per cent of four lean cuts, Weight Group VI, 145 to 155 pounds.

4. The percentage of the four lean cuts plus the belly and lean trimmings.

These combinations were tested to determine which might be the most desirable to use as the criterion of carcass merit for the dependent variable

The several physical measures that were considered initially as being desirable for use as the independent variable were as follows:

1. Average backfat thickness.
2. Length of body.
3. Length of hind leg.
4. Belly pocket thickness.

An important consideration in the selection of physical measures was the practicability of their application and use in a grade standard.

Calculating separate correlation and regression analyses for each of the possible combinations between the four physical measures and four different criteria of merit would have been a laborious task. In order to reduce these computations, scatter diagrams showing associations were used to eliminate those combinations which indicated little relationship.

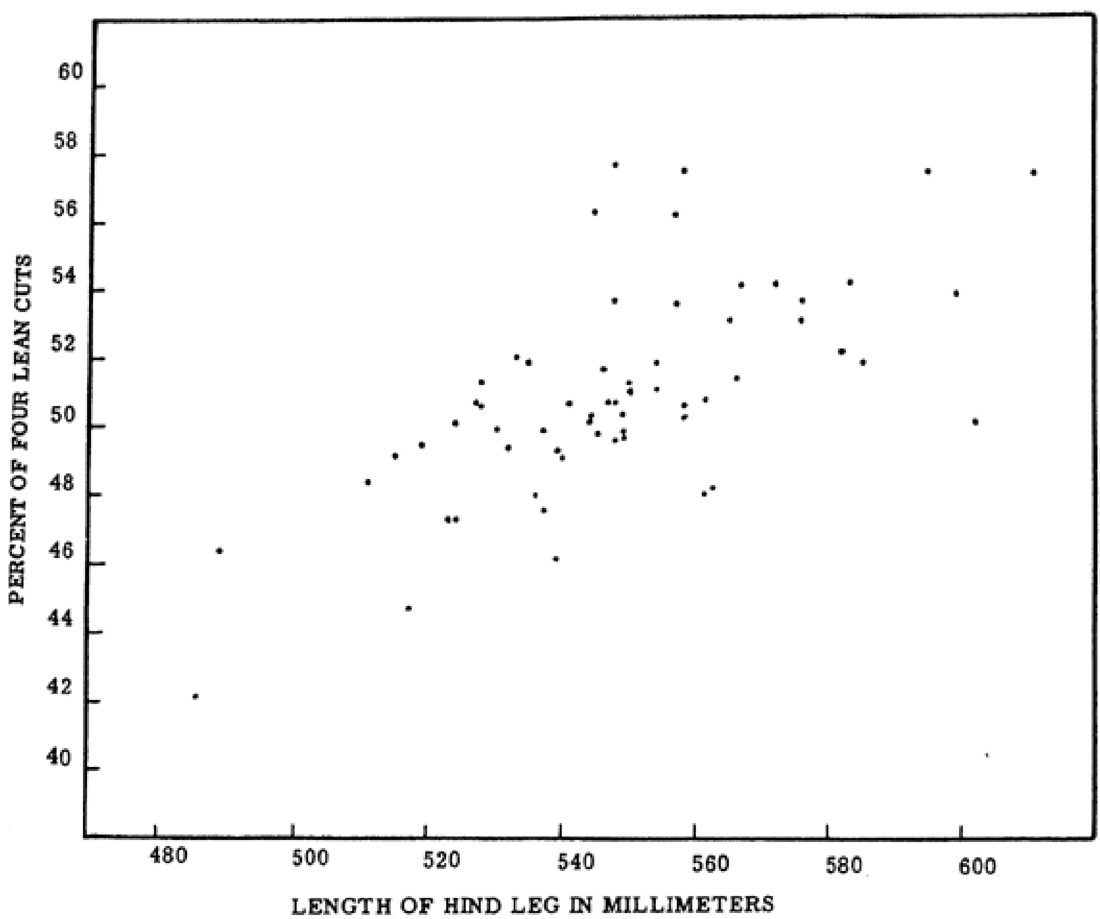

Figure 2.—Relationship of length of hind leg to per cent of four lean cuts, Weight Group VI, 145 to 155 pounds.

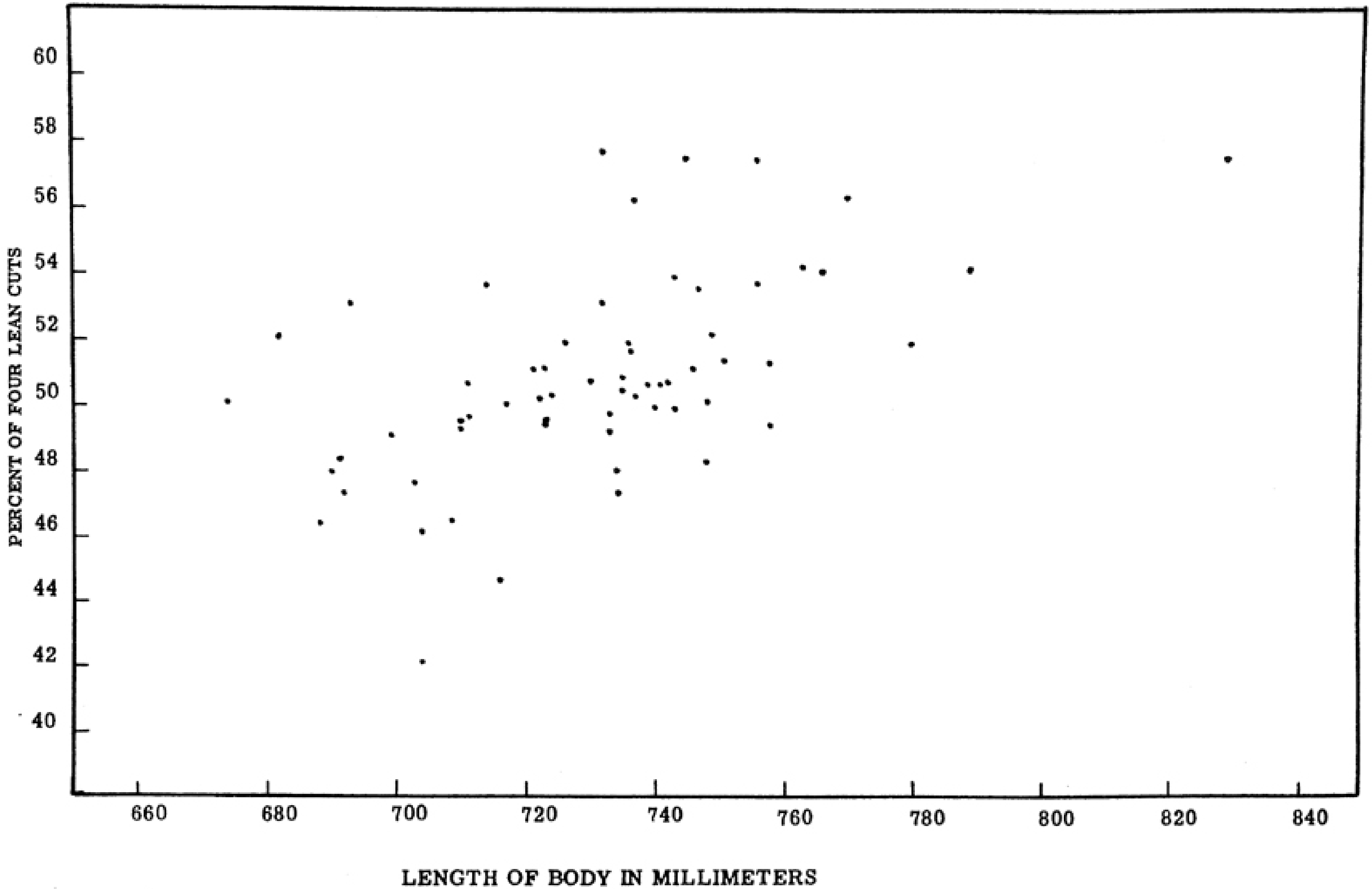

Figure 3.—Relationship of length of body to per cent of four lean cuts, Weight Group VI, 145 to 155 pounds.

Observations of the plotted scatter diagrams showed the following measures had promise of significant relationship with high value cuts, listed in order of their apparent significance:

1. Average backfat thickness.
2. Length of hind leg.
3. Length of body.

Average backfat thickness maintained an outstanding superiority over the other measures. The scatter diagrams of the length of hind leg and the length of body suggested that these measures were worthy of further analyses. The thickness of the belly pocket exhibited little significant relationship to high value cuts and was dropped from further consideration. The scatter diagrams relating average backfat thickness, length of hind leg, and length of body to the percentage of four lean cuts are shown in Figures 1, 2, and 3.

SELECTION OF BASIC CRITERION OF CARCASS MERIT

The first step in the correlation analysis approach was the selection of the particular combination of high value cuts to be used that would be the most desirable criterion of carcass merit. The correlation coefficients expressing the relationships between average backfat thickness and each of the four combinations of high value cuts are shown in Table 2. None of the combinations of high value cuts appeared to be significantly superior

TABLE 2 -- CORRELATION COEFFICIENTS, BY WEIGHT GROUPS, OF AVERAGE BACKFAT THICKNESS RELATED TO EACH OF FOUR CRITERIA OF CARCASS MERIT.

		Correlation Coefficient of Average Backfat to:			
Group Number	Carcass Weight (lbs.)	Per cent of Four Lean Cuts	Per cent of Four Lean Cuts plus Trim	Per cent of Four Lean Cuts plus Trim plus Belly	Per cent of Four Lean Cuts plus Belly
I	95-105	-.7557	-.7520	-.8038	-.7834
II	105-115	-.8460	-.8367	-.8389	-.8503
III	115-125	-.8642	-.8570	-.8026	-.8121
IV	125-135	-.8117	-.8124	-.8473	-.8385
V	135-145	-.8547	-.8324	-.8750	-.8929
VI	145-155	-.8760	-.8667	-.8639	-.8719
VII	155-165	-.8393	-.8417	-.8733	-.8732
VIII	165-175	-.7844	-.7782	-.7837	-.7825
IX	175-185	-.8448	-.8218	-.8846	-.8784
X	185-195	-.8107	-.8090	-.8713	-.8725
XI	195-205	-.8788	-.8718	-.8339	-.8377
XII	205-215	-.8572	-.8616	-.8704	-.8692
	ρ (rho)	-.8426	-.8355	-.8511	-.8538
Z (Zeta estimated)		1.230	1.206	1.262	1.272

Standard deviation of Zeta = 0.0412
Standard deviation of difference of two Zetas = 0.0583

to the others. In all of the combinations, weight Groups I and VIII had the lowest relationships while the remainder of the weight groups had consistently high correlations. The addition of the belly to the percentage of four lean cuts, and the addition of the belly and lean trimmings in another instance seemed to give a slight improvement to the correlations over that obtained when using the combination of four lean cuts alone. On the other hand, including lean trimmings alone with the per cent of four lean cuts appeared to lower the correlations slightly.

The estimated correlation of the entire sample of 592 carcasses is shown in Table 2 in terms of the theoretical weighted average of the several values of r.[2] The estimates of ρ (rho) for the four combinations are very close. The standard deviation of the difference of two Z's was 0.0583 in terms of Z. The difference between the extreme values of Z (Table 2) is 0.066. This difference did not exceed twice the standard error and therefore could be considered as non-significant. In other words, none of these four combinations of high value cuts proved superior to the others as a criterion of carcass merit when associated with backfat thickness.

Since the statistical test of significance indicated no conclusive superiority for any one particular combination of high value cuts, the problem of selecting the basic criterion of carcass merit was reduced to a matter of rationality. Inclusion of all the high value cuts from the carcass, along with associated trimmings, seemed most desirable for the index of carcass merit, as long as fundamental relationships were not lowered. However, standardization of the trimming of the belly and composition of lean trimmings between individuals, as well as between different packing plants, would be difficult. Furthermore, simplicity of the make-up for the basic criterion would be advantageous in the possible practical application of a grade standard. On the basis of this reasoning, the four lean cuts (hams, loins, picnics, and butts) were selected as the combination to be used for the basic criterion of carcass merit.

[2]A weighted arithmetic average of r will not provide the best estimate of the ρ of the population due to an existing skewness. Each r was converted to z_r by use of Mills' table of r as a function of z, and the average of the values of r calculated as follows:

$$Z \text{ (Zeta estimated)} = \frac{\Sigma z_r \text{ (N-3)}}{\Sigma \text{ (N-3)}}$$

Actually there is a small bias which makes the mean value of Z somewhat greater than the true value, ζ, but this correction was considered unimportant for the small number of samples.

$$\rho \text{ (rho)} = Z \text{ as transformed from a table of } z_r.$$

SELECTION OF OBJECTIVE CARCASS MEASURES

The percentage of four lean cuts could be used as an index of carcass merit only after the carcasses had been subjected to a detailed cut-out test. The problem was to provide a method or means of evaluating and predicting the carcass value according to the percentage yield of four lean cuts before the carcass is cut into wholesale cuts. The required information for this evaluation was obtained by measurements and weights of the carcasses while hanging on the rail.

The regression analyses was used to explore the possibility of using independent variables or measures other than average backfat thickness. All of the correlation coefficients for the average backfat were rather high. The average correlation of backfat to the percentage of four lean cuts for the entire sample was .8426 and the coefficient of determination ($\rho 2$) was .7100. Stated in another manner, the variations in backfat thickness explain about 71% of the variations in the percentage of four lean cuts.

Since the length of body is an important measure of carcass standards in other countries, and also because the scatter diagrams indicated some promise for length as being significant, multiple correlations using backfat thickness and body length as independent variables were calculated within each of the 12 weight groups. The resultant correlations and regression coefficients are presented in Table 3. The estimated correlation for the sample (ρ), and the values of Z (Zeta estimated) are given for comparison with standard deviation in standard tests of significance.

The data reveals the small improvement in the multiple R_{123} over the r_{12} for backfat alone. The average improvement ($\rho_{1\,23}$-ρ_{12}) was only .0112. The average correlation of r_{23}, simple relationship of backfat to body length, was .5752 as compared to the average correlation of r_{13}, simple relationship of four lean cuts to body length, of .5717. The high intercorrelation between backfat and body length could possibly explain the small improvement in the multiple R_{123} over the simple r_{12}.

Another interesting fact was the reduction in the regression coefficient of body length when this measure was included in the multiple correlations. In Group VI, for example, the simple regression coefficient, b_{13}, was +.0624. In the multiple correlation the partial regression, $b_{13\,2}$ (backfat is held constant while length is permitted to vary), was reduced to + .0148. This would indicate that a large share of the relationship of body length to percentage of four lean cuts is exerted through its interrelationship with backfat thickness. It is the backfat thickness that is exerting the primary influence upon the dependent variable. When the backfat is held constant the independent effect of body length on the percentage of four lean cuts is greatly reduced.

TABLE 3 -- CORRELATION AND REGRESSION COEFFICIENTS OF AVERAGE BACKFAT THICKNESS AND BODY LENGTH TO PERCENTAGE OF FOUR LEAN CUTS (HAMS, LOINS, PICNICS AND BUTTS).

Group Number	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average Corre- lation	Z (Zeta* estimated)
Carcass Weight, pounds	95-105	105-115	115-125	125-135	136-145	145-155	155-165	165-175	175-185	185-195	195-205	205-up		
Number of Carcasses	22	45	46	49	57	62	54	53	45	56	54	49		
Simple Correlations:														
r_{12}	-.7557	-.8461	-.8642	-.8117	-.8547	-.8760	-.8393	-.7844	-.8448	-.8107	-.8788	-.8572	-.8426	1.230
r_{13}	+.2583	+.4973	+.5754	+.5266	+.5261	+.5548	+.6972	+.2369	+.5421	+.5598	+.7683	+.6635	+.5717	.6500
r_{23}	-.3401	-.5773	-.5675	-.6251	-.6496	-.5240	-.6787	-.3065	-.6410	-.5512	-.6297	-.6058	-.5752	.6565
Multiple Correlations:														
$R_{1.23}$	.7557	.8461	.8704	.8120	.8555	.8832	.8571	.7924	.8448	.8219	.9213	.8762	.8538	1.2739
Partial Correlations:														
$r_{12.3}$	-.7352	-.7891	-.7984	-.7272	-.7932	-.8260	-.6953	-.7595	-.7711	-.7262	-.7944	-.7648	-.7699	1.02
$r_{13.2}$	+.0021	+.0202	+.2052	-.0421	-.0737	+.2332	+.3196	+.1804	+.0015	+.2311	+.5797	+.3520	+.2070	.2135
Simple Regressions:														
b_{12}	-.5120	-.5549	-.4137	-.4051	-.3452	-.3987	-.3523	-.3160	-.3166	-.2973	-.3773	-.2847		
b_{13}	+.0296	+.0692	+.0732	+.0553	+.0589	+.0624	+.0809	+.0201	+.0721	+.0587	+.0863	+.0696		
Partial Regressions:														
$b_{12.3}$	-.5116	-.5499	-.3797	-.3953	-.3584	-.3672	-.2850	-.3015	-.3164	-.2645	-.2810	-.2389		
$b_{13.2}$	+.0002	+.0019	+.0159	+.0033	+.0056	+.0148	+.0274	+.0068	+.0001	+.0170	+.0400	+.0239		

X_1 = Percentage of four lean cuts
X_2 = Average backfat thickness
X_3 = Body length

*Standard Deviation of Z = 0.0412.
Standard Deviation of the difference between any two Z = 0.0583

An examination of the partial values of r further substantiates this conclusion. Noting Group VI again, the simple r for body length was +.5548 while the partial r, $r_{13.2}$ in which backfat is held constant, was reduced to +.2332. Also, the estimate of ρ_{13} for the population was +.5717 while the estimate of the partial $\rho_{13.2}$ was just +.2070. Thus the coefficient of determination of body length was reduced from 32.7% to 4.3% when included in the multiple correlation.

The other measure that appeared to warrant further analyses was the length of hind leg. Scatter diagrams indicated a possibility of some fundamental relationship. Multiple correlations using backfat thickness, body length, and length of leg as independent variables were calculated for two selected groups. The resultant correlations and regression coefficients are shown in Table 4. The estimated correlation for the population (ρ) and the values of Z (Zeta estimated) were again used for comparison of deviations. The multiple R_{1234} shows very little im-

TABLE 4 -- CORRELATION AND REGRESSION COEFFICIENTS OF AVERAGE BACKFAT THICKNESS, BODY LENGTH, AND LENGTH OF HIND LEG TO PERCENTAGE OF FOUR LEAN CUTS (HAM, LOIN, PICNIC AND BUTT) FOR TWO SELECTED WEIGHT GROUPS.

Group Number	V	IX	Average Correlation	Z (Zeta* estimated)
Carcass Weight, Pounds	135-145	175-185		
Number of carcasses	57	45		
Simple Correlations:				
r_{12}	-.8547	-.8448	-.8426	1.230
r_{13}	+.5261	+.5421	+.5717	.6500
r_{14}	+.6459	+.6765	+.6584	.7919
r_{23}	-.6496	-.6410	-.5752	.6565
r_{24}	-.7254	-.7278	-.7259	.9222
r_{34}	+.5966	+.7319	+.6612	.795
Multiple Correlations:				
$R_{1.23}$	.8555	.8448	.8538	1.2739
$R_{1.234}$	.8569	.8511	.8538	1.2712
Partial Correlations:				
$r_{12.3}$	-.7932	-.7711	-.7699	1.02
$r_{13.2}$	-.0737	+.0015	+.2070	.2135
$r_{12.34}$	-.7200	-.6982	-.7114	.8899
$r_{13.24}$	-.0581	-.0979	-.0765	.0775
$r_{14.23}$	+.0566	+.1938	+.1194	.1183
Simple Regressions:				
b_{12}	-.3452	-.3166		
b_{13}	+.0589	+.0721		
b_{14}	+.0650	+.0766		
Partial Regressions:				
$b_{12.3}$	-.3584	-.3164		
$b_{13.2}$	-.0056	+.0001		
$b_{12.34}$	-.3414	-.2876		
$b_{13.24}$	-.0074	-.0103		
$b_{14.23}$	+.0072	+.0198		

X_1 = Percentage of four lean cuts X_3 = Body length
X_2 = Average backfat thickness X_4 = Length of hind leg

*Standard Deviation of Z = 0.0412
Standard Deviation of the difference between any two Zetas = 0.0583

provement over the simple r_{12}. The simple relationship of length of hind leg to the dependent variable was somewhat higher than the relationship of body length to the dependent variable. In Group V, for example, the r_{14} was +.6459 as compared to the r_{13} of +.5261. There was a high intercorrelation between the two measures, the backfat and length of leg, that may explain the small improvement in the multiple R_{1234} over the simple r_{12}. The average correlation of r_{24}, backfat to length of hind leg, was —.7259 while the average correlation of r_{14}, four lean cuts to length of hind leg, was +.6584.

The regression coefficient of length of leg was reduced when the measure was included in the multiple correlations. Again using Group V, the simple regression coefficient, b_{14}, was +.0650. In the multiple correlation the partial regression, $b_{14\ 23}$ (i.e. backfat and body length was held constant while length of hind leg was permitted to vary) was reduced to +.0072, very much like the reduction when body length was the variable. Another important fact presented by these correlations is the high intercorrelation between body length and length of hind leg as shown by the average correlation of r_{34} which was +.6612.

The partial values of r may be noted for further evidence to support the above conclusion. In Group V the simple r for length of hind leg was +.6459 while the partial r, $r_{14\ 23}$ in which backfat and body length were held constant, was reduced to +.0566. The estimate of ρ_{14} for the population was +.6584 while the estimate of the partial $\rho_{14\ 23}$ was only +.1194. The coefficient of determination of length of hind leg was reduced from 43.4 per cent to 1.4 per cent when included in the multiple correlation.

The foregoing discussion indicates that the addition of the variables, the body length and the length of hind leg, resulted in little improvement in the relation of backfat thickness to the percentage of four lean cuts. There seemed to be a high interrelationship between the measures of backfat, body length, and length of hing leg. Whatever relationship the latter two measures may have had with the basic criterion of carcass merit apparently was due to this interrelationship, but not due to an independent relationship. These were the only measures that appeared to merit analyses by detailed correlations.

Within these weight groups it was apparent that backfat thickness was the predominant measure. The addition of other measures gave only a slight improvement in the ability to predict physical components and differences in carcasses. The addition of these variables would greatly complicate the construction and practical application of a grade standard. The backfat thickness was therefore selected as the objective measure to be used as the primary determinant of carcass merit in the development of a suggested hog carcass grade standard.

SELECTION OF BASIC FORMULAE FOR EXPRESSING RELATIONSHIPS BETWEEN OBJECTIVE MEASURES AND CARCASS COMPOSITION

The computations from the basic regression analyses including means, standard deviations, regression and correlation coefficients, and standard errors of estimate are given in Table 5. The lighter weight carcasses have a higher percentage of lean cuts and considerably less finish than the heavier weight carcasses. The regression coefficient as shown in the table, b_{12}, represents the change in the percentage of four lean cuts associated with a unit change in backfat thickness. In Group XII, for example, an increase of one millimeter in backfat thickness was associated with a decrease of 0.28 in per cent of four lean cuts. Groups I and VIII were low in correlation coefficients[3]. The regression coefficients, generally speaking, exhibited a marked decline going from light-weight carcasses to the heavier carcasses.

The regression lines for the twelve weight groups are shown in Figure 4. It was expected that the regression lines of the heavier weight carcasses would tend to lie to the right of the light-weight carcasses. In other words, with carcasses of unlike weights but with the same degree of finish, the heavier carcasses would be expected to be larger with respect to length, depth, and width, and have more backfat. However, this expected relationship was not shown. The positions were practically reversed from the expected order as the lines tended to intersect. This tendency perhaps is the result of at least two relationships, that is, functional and proportional. There is a functional relationship of a physical measure, backfat thickness, expressed in absolute terms along with a dependent variable, whereas the per cent yield of four lean cuts is expressed in proportional terms. A given change in backfat thickness would be expected to have more influence on the per cent of four lean cuts on a 100 pound carcass than on a 200 pound carcass. However, the dependent variable, four lean cuts, was expressed in terms of per cent rather than actual weight or absolute terms and probably accounted for the transversing of the regression lines due to the narrowed, proportional range. The slope of the regression lines for heavier weight carcasses was generally less steep than the slope of the lines for lighter weight carcasses.

The problem presented by the foregoing discussion was concerned with obtaining the relationships of certain measures to variations in degree of finish. It was presumed that at any given per cent yield of lean cuts the backfat thickness would increase with an increase in carcass weight, but at a decreasing rate. In line with this reasoning, the regres-

[3]The small sample in Group I is probably an inadequate representation of the variation in finish within this weight group. The relatively low correlation of Group VIII can be explained by range of experimental error.

TABLE 5 -- STATISTICAL MEASURES FROM THE BASIC REGRESSION ANALYSIS OF BACKFAT THICKNESS TO THE PERCENTAGE OF FOUR LEAN CUTS (HAM, LOIN, PICNIC AND BUTT).

Weight Group	Carcass Weights (lbs)	Number	Average Weight (lbs)	Per Cent Four Lean Cuts: Average M_1 (%)	Per Cent Four Lean Cuts: Standard Deviation σ_1 (%)	Backfat Thickness: Average M_2 (mm)	Backfat Thickness: Standard Deviation σ_2 (mm)	Correlation r_{12}	Regression b_{12}	Standard Error $S_{1.2}$ (%)
I	95-105	22	100.4682	55.9182	2.7819	32.0455	4.1062	-.7557	-.5120	1.8219
II	105-115	45	109.8622	54.4667	3.6746	33.7555	5.6022	-.8461	-.5549	1.9589
III	115-125	46	120.9652	53.4674	3.0338	36.5652	6.3372	-.8642	-.4137	1.5265
IV	125-135	49	129.6673	53.2449	3.5049	38.7551	7.0234	-.8117	-.4051	2.0471
V	135-145	57	140.9702	52.4702	3.1820	40.9123	7.8791	-.8547	-.3452	1.6519
VI	145-155	62	148.9081	50.9613	3.0130	42.7581	6.6203	-.8760	-.3987	1.4532
VII	155-165	54	159.9222	50.9222	3.5992	44.8704	8.5744	-.8393	-.3523	1.9568
VIII	165-175	53	170.3811	51.5906	2.7916	44.4528	6.9297	-.7844	-.3160	1.7315
IX	175-185	45	179.6044	49.4911	2.9953	48.1555	7.9916	-.8448	-.3166	1.6027
X	185-195	56	189.8553	49.4643	2.9569	49.5000	8.0644	-.8107	-.2973	1.7312
XI	195-205	54	199.9407	48.2444	3.5829	52.1852	8.3446	-.8788	-.3773	1.7097
XII	205-215	49	209.5530	48.2735	2.8330	52.7755	8.5291	-.8572	-.2847	1.4590
All Weights		592	158.4203	51.2701	3.8431	54.7669	9.6333	-.8814	-.3516	1.8153

X_1 = Per cent of four lean cuts (Ham, Lean, Picnic, and Butt)
X_2 = Average backfat thickness

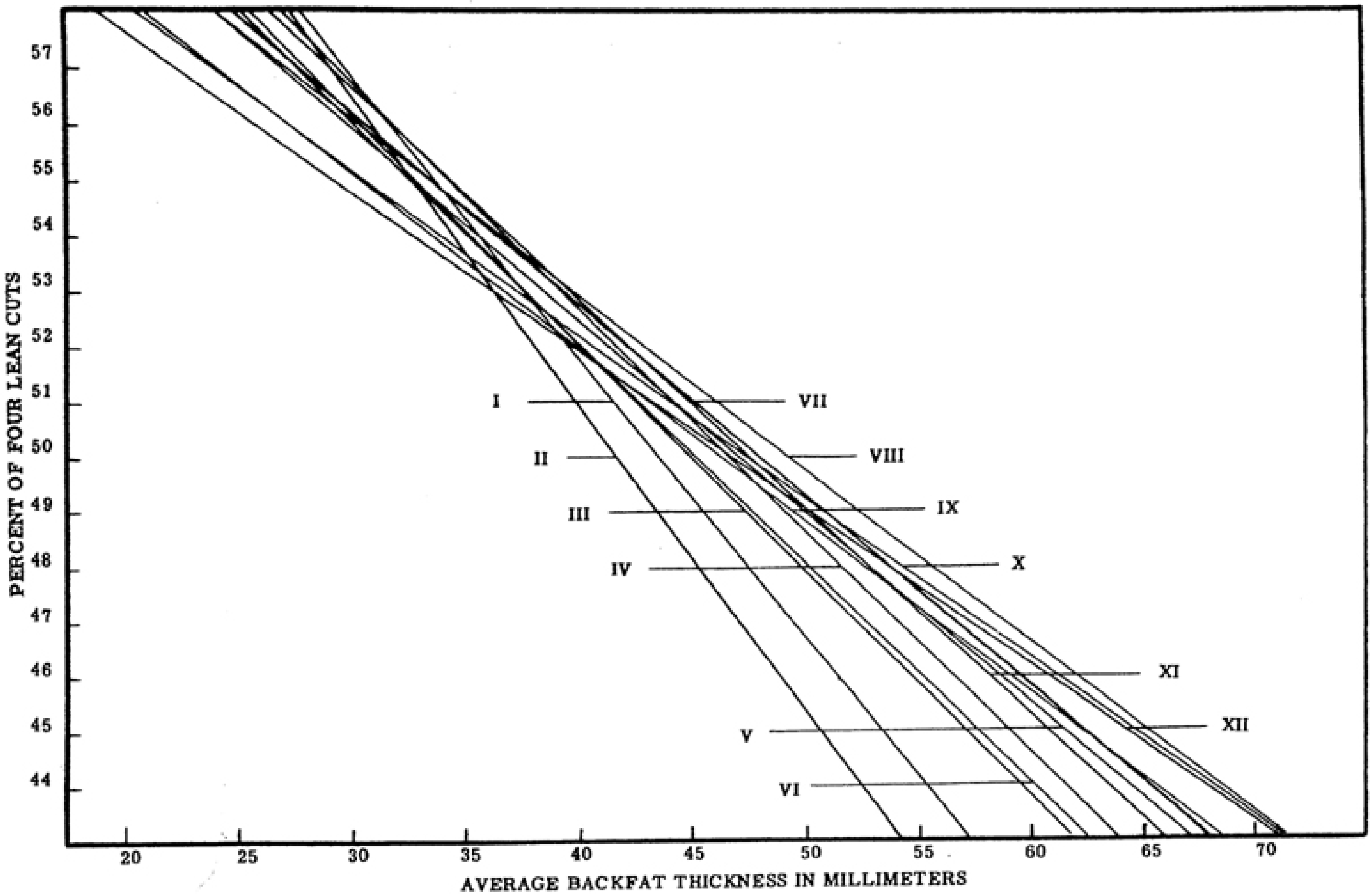

Figure 4.—Relationship between average backfat thickness and per cent of lean cuts for twelve weight groups.

sion coefficients would be expected to decrease with an increase of carcass weight, but at a decreasing rate with additional increments of carcass weight.

In order to describe the relationship of backfat thickness to carcass weight the expected backfat thickness was computed at a given percentage of four lean cuts. This would compare carcasses of like proportional composition of lean cuts at differing carcass weights. The expected backfat thickness within each weight group with the percentage of four lean cuts equal to 51.3 was computed as shown in Table 6.[4] The location of the adjusted backfat thickness in relation to carcass weight is shown in Figure 5. There was an expected slight tendency toward curvilinearity in this relationship of backfat to carcass weight. In other words, increase in backfat would be less when a light-weight carcass is increased a given increment of weight than when a heavier weight carcass is increased by the same increment of weight.

There are several regression equations which might be suggested for describing this curvilinear relationship. For a potential curve the equation would be $Y = a + bX - cX^2$. For exponential curves a semi-logarithmic expression would be $Y = a + b \log X$, while the logarithmic expression would be $\log Y = a + b \log X$. Perhaps one of these equations would be very suitable for the range of carcass weights of the data shown in this study, from 95 to 215 pounds. It would be expected within this range of data that none of the equations would show a radicial departure from the linear expression, $Y = a + bX$. However, it would be desirable to select an equation that would best describe the possible changes taking place beyond the range of carcass weight obtained in the study in addition to explaining the expected changes within the range of the data (2).

The logarithmic equation, $\log Y = a + b \log X$, was chosen as the basic equation to describe the change in backfat thickness associated with changes in carcass weight when the percentage of four lean cuts is held constant.[5] As calculated the expression reads:

$$\log Y = 1.436996415 + 0.0889657477 \log X$$

where Y = expected backfat thickness when percentage of four lean cuts = 51.3

and X = carcass weight.

[4]The standardized value, percentage of four lean cuts = 51.3 was chosen since it was the mean of the entire sample (see Table 5).

[5]This curve expresses the relationship between radius and volume of cylinders of varying sizes, but of the same proportions, where Y = the radius and X = the volume. Thinking in similar terms, the hog carcass with a standardized percentage of lean cuts could be considered to be like the shell of a cylinder of constant proportions. Backfat thickness could be a function of the radius of the cyclinder and carcass weight could be likened to the volume of the cylinder.

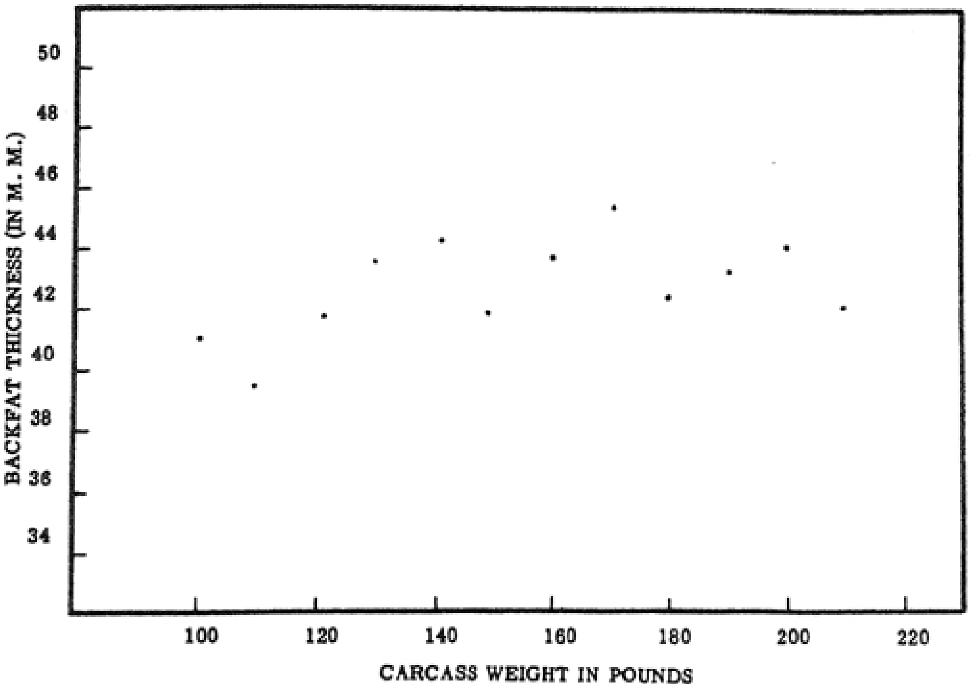

Figure 5.—Relation of backfat thickness at 51.3 per cent of four lean cuts to carcass weight.

TABLE 6 -- CALCULATION OF ADJUSTED AVERAGE BACKFAT THICKNESS AT A STANDARDIZED PERCENTAGE OF FOUR LEAN CUTS FOR DIFFERENT WEIGHT GROUPS.

Weight Group (lbs.)	Average Weight (lbs.)	Average Per cent of Lean Cuts M_1 (%)	Average Backfat Thickness M_2 (mm.)	Regression Coefficient b_{12}	Backfat Thickness* When X_1 = 51.3 (mm.)
(1)	(2)	(3)	(4)	(5)	(6)
95-105	100.4682	55.9182	32.0455	-.5120	41.0654
105-115	109.8622	54.4667	33.7555	-.5549	39.4623
115-125	120.9652	53.4674	36.5652	-.4137	41.8043
125-135	129.6673	53.2449	38.7551	-.4051	43.5561
135-145	140.9702	52.4702	40.9123	-.3452	44.3022
145-155	148.9081	50.9613	42.7581	-.3987	41.9086
155-165	159.9222	50.9222	44.8704	-.3523	43.7980
165-175	170.3811	51.5906	44.4528	-.3160	45.3724
175-185	179.6044	49.4911	48.1555	-.3166	42.4420
185-195	189.8553	49.4643	49.5000	-.2973	43.3254
195-205	199.9407	48.2444	52.1852	-.3773	44.0866
205-215	209.5530	48.2735	52.7755	-.2847	42.1450

*Backfat Thickness when X_1 is 51.3 = $M_2 - \frac{M_1 - 51.3}{b_{12}}$

X_1 = Percentage of four lean cuts (hams, loins, picnics and butts)
X_2 = Average backfat thickness

TABLE 7 -- COMPUTED RELATION OF BACKFAT THICKNESS AT 51.3% OF FOUR LEAN CUTS TO CARCASS WEIGHT.

Carcass Weight (lbs.)	Backfat Thickness (mm.)	Backfat Thickness (ins.)	Carcass Weight (lbs.)	Backfat Thickness (mm.)	Backfat Thickness (ins.)
(1)	(2)	(3)	(1)	(2)	(3)
90	40.82	1.607	225	44.29	1.744
95	41.02	1.615	230	44.37	1.747
100	41.20	1.622	235	44.46	1.750
105	41.38	1.629	240	44.54	1.754
110	41.55	1.636	245	44.62	1.757
115	41.72	1.643	250	44.70	1.760
120	41.88	1.649	255	44.78	1.763
125	42.03	1.655	260	44.86	1.766
130	42.18	1.661	265	44.93	1.769
135	42.32	1.666	270	45.01	1.772
140	42.46	1.672	275	45.08	1.775
145	42.59	1.677	280	45.16	1.778
150	42.72	1.682	285	45.23	1.781
155	42.84	1.687	290	45.30	1.784
160	42.96	1.691	295	45.37	1.786
165	43.08	1.696	300	45.43	1.789
170	43.20	1.701	305	45.50	1.791
175	43.31	1.705	310	45.57	1.794
180	43.42	1.710	315	45.63	1.797
185	43.52	1.713	320	45.70	1.799
190	43.62	1.717	325	45.76	1.802
195	43.73	1.722	330	45.82	1.804
200	43.82	1.725	335	45.88	1.806
205	43.92	1.729	340	45.94	1.809
210	44.01	1.733	345	46.00	1.811
215	44.11	1.737	350	46.06	1.813
220	44.20	1.740			

$\text{Log } Y = 1.436996415 = .0889657477 \text{ Log } X$

Y = Backfat thickness when per cent four lean cuts = 51.3

X = Carcass weight

The expected values of backfat thickness for carcasses weighing from 90 to 350 pounds are shown in Table 8. The curve for these values is shown in Figure 6.

The next step was to determine the relation of backfat thickness to the per cent of four lean cuts at different carcass weights. This meant the development of an expected rate of change for the regression coefficients with similar changes in carcass weight.

The expected backfat thickness was determined when the percent of four lean cuts was standardized at 51.3 for the theoretical regression lines at 5 pound intervals in carcass weight. The next step was to compute the expected regression coefficients of backfat to percentage of four lean cuts at the same 5 pound weight intervals. It would seem reasonable to expect lighter weight carcasses to have regression values of a higher order than those of heavier weight carcasses. A given change in backfat should have a greater effect on percentage of four lean cuts on 100 pound carcasses than would be expected on 200 pound carcasses. Furthermore, it would seem logical to expect that the regression values would decline to a greater extent from 100 to 110 pounds than they would from 200 to 210 pounds, since a unit change in weight is proportionately greater at the lighter carcass weight. The basis hypothesis is that decreases in regression coefficients were associated with increases in carcass weight but that these deceases would take place at a declining rate.

The values of the regression coefficients for the various weight groups have been given in Table 6. These have been plotted in relation to carcass weight and are shown in Figure 7. A study of this figure indicates that the hypothesis of the preceeding paragraph was borne out by the available data.

The expression of this relationship in estimating backfat at different carcass weights with a uniform degree of finish required the selection of a new basic formula. The formula, log Y = a + b log X, that was used to fix the origin of backfat when the precentage of four lean cuts was standardized at 51.3 did not prove to be the best expression of the relationship desired for the expected rate of change for the regression coefficients. The

TABLE 8 -- RELATION OF THEORETICAL REGRESSION COEFFICIENTS TO COMPUTED BACKFAT THICKNESS AND CARCASS WEIGHT*.

Carcass Weight lbs.	Computed Backfat Thickness** mm.	Theoretical Regression Value mm.	Theoretical Regression Value ins.	Carcass Weight lbs.	Computed Backfat Thickness** mm.	Theoretical Regression Value mm.	Theoretical Regression Value ins.
(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
90	28.83	-.552598	-14.035304	225	57.16	-.278716	-7.079041
95	30.02	-.530693	-13.478944	230	58.10	-.274206	-6.964492
100	31.19	-.510785	-12.973306	235	59.09	-.269795	-6.852358
105	32.35	-.492470	-12.508127	240	59.98	-.265612	-6.746215
110	33.49	-.475706	-12.082343	245	60.91	-.261556	-6.643198
115	34.62	-.460179	-11.687976	250	61.85	-.257623	-6.543305
120	35.74	-.445758	-11.321700	255	62.76	-.253846	-6.447374
125	36.85	-.432331	-10.980671	260	63.68	-.250179	-6.354236
130	37.94	-.419910	-10.665193	265	64.59	-.246654	-6.264706
135	39.03	-.408183	-10.367342	270	65.50	-.243227	-6.177664
140	40.10	-.397292	-10.090724	275	66.40	-.239931	-6.093950
145	41.17	-.386966	- 9.828457	280	67.30	-.236722	-6.012445
150	42.22	-.377342	- 9.584019	285	68.20	-.233598	-5.933100
155	43.27	-.368186	- 9.351468	290	69.09	-.230589	-5.856675
160	44.31	-.359544	- 9.131972	295	69.98	-.227656	-5.782180
165	45.34	-.351376	- 8.924515	300	70.86	-.224829	-5.710378
170	46.36	-.343645	- 8.728157	305	71.74	-.222071	-5.640328
175	47.38	-.336247	- 8.540257	310	72.62	-.219380	-5.571980
180	48.38	-.329297	- 8.363735	315	73.49	-.216783	-5.506019
185	49.38	-.322628	- 8.194351	320	74.36	-.214247	-5.441608
190	50.38	-.316225	- 8.031723	325	75.23	-.211769	-5.378670
195	51.39	-.310010	- 7.873870	330	76.09	-.209376	-5.317891
200	52.34	-.304383	- 7.730951	335	76.95	-.207036	-5.258458
205	53.32	-.298788	- 7.588845	340	77.81	-.204747	-5.200320
210	54.29	-.293450	- 7.453266	345	78.66	-.202535	-5.144138
215	55.25	-.288351	- 7.323758	350	79.51	-.200370	-5.089150
220	56.21	-.283426	- 7.198669				

*$y = \frac{1}{x} \cdot c$

y = Expected regression coefficient

x = Computed backfat thickness

c = Constant

**log Y = b log X

Y = Backfat thickness when per cent of four lean cuts equals 51.3

b = 0.746999497

X = Carcass weight

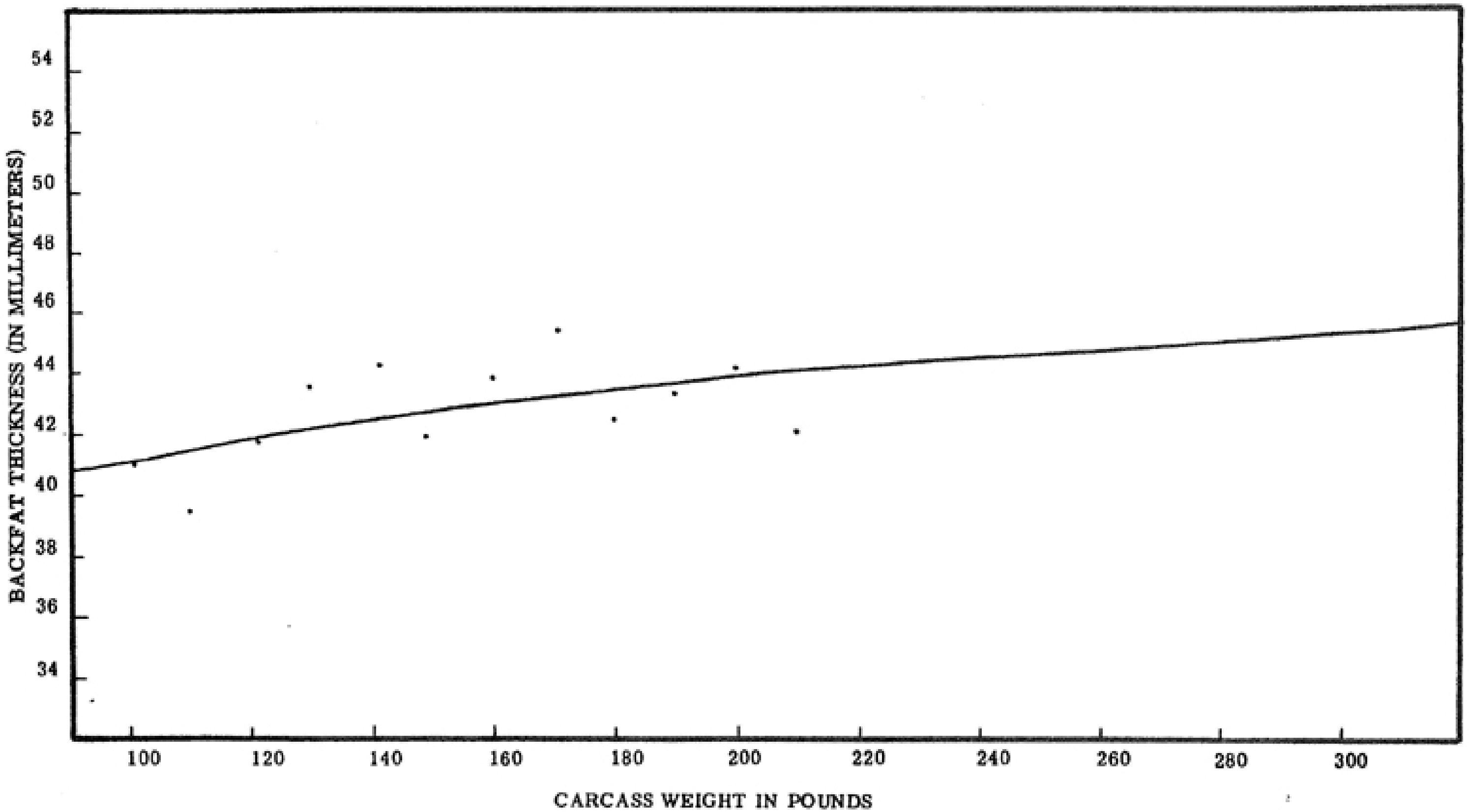

Figure 6.—Theoretical relation of backfat thickness at 51.3 per cent of four lean cuts to carcass weight.

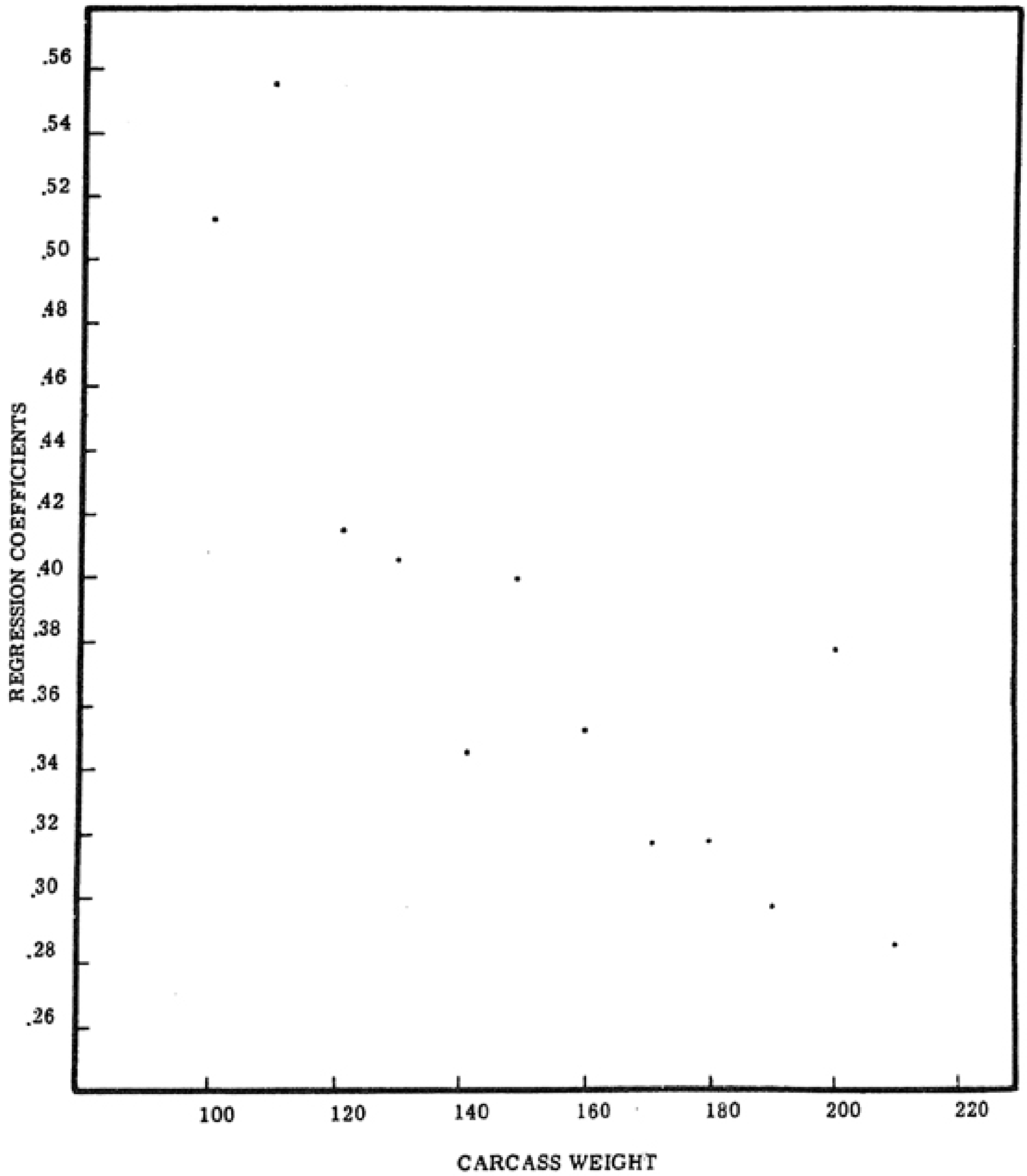

Figure 7.—Relation of regression coefficients to carcass weights.

line, log Y = a + b log X, departed radically from the more logical, rational explanation of the available data. This expression tended to understate the regression coefficients for the lighter weight carcasses, and to over state the regression coefficients for the heavy weight carcasses.[6] A new formula, log Y = b log X, was selected for the expression of the expected rate of change for the regression coefficients. The justification for its selection was based on the fact that the cutting procedures used in col-

[6]The equation, log Y = a + b log X, gave a theoretical regression coefficient value of 0.394 for 100 pound carcass and a value of 0.37 for 210 pound carcass as compared to 0.512 and 0.2845 respectively from actual data.

lection of data for the study were on absolute rather than on proportional specifications (see Appendix B.) For example, the cutting procedure called for leaving one-half inch of fat on the loins regardless of whether the carcasses weighed 90 pounds or 210 pounds. The hams were skinned leaving ¾ inches of fat on the portion of the ham from which the skin was removed. As calculated the expression reads:

$$\log Y = 0.746999497 \log X$$

where Y = expected backfat thickness when per cent of four lean cuts is equal to 51.3

and X = carcass weight.

A combination of the two basic formulae, $\log Y = a + b \log X$ and $\log Y = b \log X$, appeared to provide a suitable expression of the hypothetical relationships.

The primary regression analyses were based on the dimensional concept of backfat thickness (see footnote[5]). Therefore, instead of relating the several regression coefficients directly to carcass weight through the two exponential equations given above, it was considered desirable that they be related to the computed backfat thickness of standardized carcasses. Instead of directly determining the regression values for a 120 pound carcass, this approach would attempt to determine the regression value at the computed millimeters of backfat thickness at that carcass weight. A given *increase* in backfat thickness should be associated with a proportionate *decrease* in the regression coefficient. The curve which expresses this inversely proportional relationship is the rectangular hyperbola. The equation which describes the curve is:

$$y = \frac{1}{x} \cdot c$$

where y = expected regression coefficients,

x = computed backfat thickness,

and c = a constant.

The value of the constant was calculated to be —15.9313935. The values of the regression coefficients are shown in Table 8. Figure 8 presents the curve showing the relation of expected regression values to computed backfat thickness, and Figure 9 shows the relation of these same values to carcass weight as transformed from computed backfat thickness.

The procedure outlined was an attempt to obtain the best possible description of the sample of hog carcasses with respect to the variation of the percentage of four lean cuts using only two measures, the weight of the carcass and the average backfat thickness. The first step involved the determination of the expected changes in backfat thickness associated with changes in carcass weight using standardized carcasses with respect to percentage of lean cuts, and second, the determination of the expected changes in percentage of lean cuts associated with changes in backfat at

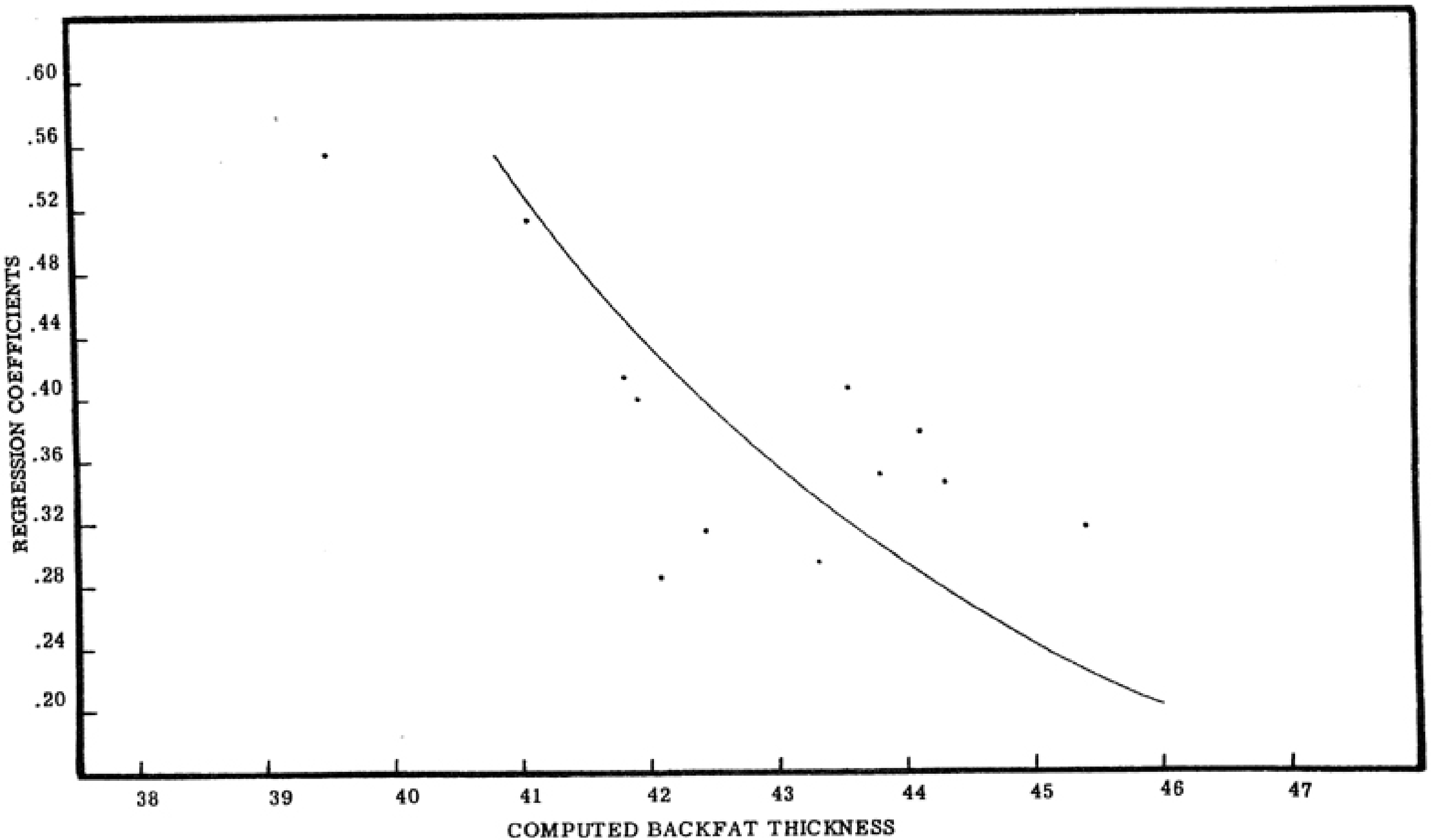

Figure 8.—Theoretical relationship of regression coefficient to computed backfat thickness.

TABLE 9 -- PERCENTAGE OF FOUR LEAN CUTS AT SPECIFIC BACKFAT THICKNESSES, IN MILLIMETERS, AND CARCASS WEIGHTS.

Carcass Weight lbs.	Mid-point	Regression Coefficient	Backfat Thickness in millimeters																										
			22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
95-105	100	-.510785	61.1	60.6	60.1	59.6	59.1	58.6	58.0	57.5	57.0	56.5	56.0	55.5	55.0	54.5	54.0	53.4	52.9	52.4	51.9	51.4	50.9	50.4	49.9	49.4	48.8	48.3	47.8
105-115	110	-.475706	60.6	60.1	59.6	59.2	58.7	58.2	57.7	57.3	56.8	56.3	55.8	55.4	54.9	54.4	53.9	53.5	53.0	52.5	52.0	51.6	51.1	50.6	50.1	49.7	49.2	48.7	48.2
115-125	120	-.445758	60.2	59.7	59.3	58.8	58.4	57.9	57.5	57.0	56.6	56.1	55.7	55.3	54.8	54.4	53.9	53.5	53.0	52.6	52.1	51.7	51.2	50.8	50.4	49.9	49.5	49.0	48.6
125-135	130	-.419910	59.8	59.4	58.9	58.5	58.1	57.7	57.3	56.8	56.4	56.0	55.6	55.2	54.7	54.3	53.9	53.5	53.1	52.6	52.2	51.8	51.4	51.0	50.5	50.1	49.7	49.3	48.9
135-145	140	-.397292	59.4	59.0	58.6	58.2	57.8	57.4	57.0	56.6	56.5	55.9	55.5	55.1	54.7	54.3	53.9	53.5	53.1	52.7	52.3	51.9	51.5	51.1	50.7	50.3	49.9	49.5	49.1
145-155	150	-.377342	59.1	58.7	58.4	58.0	57.6	57.2	56.9	56.5	56.1	55.7	55.3	55.0	54.6	54.2	53.8	53.5	53.1	52.7	52.3	51.9	51.6	51.2	50.8	50.4	50.1	49.7	49.3
155-165	160	-.359544	58.8	58.5	58.1	57.8	57.4	57.0	56.7	56.3	56.0	55.6	55.2	54.9	54.5	54.2	53.8	53.4	53.1	52.7	52.4	52.0	51.6	51.3	50.9	50.6	50.2	49.8	49.5
165-175	170	-.343645	58.6	58.2	57.9	57.6	57.2	56.9	56.5	56.2	55.8	55.5	55.1	54.8	54.5	54.1	53.8	53.4	53.1	52.7	52.4	52.1	51.7	51.4	51.0	50.7	50.3	50.0	49.7
175-185	180	-.329297	58.4	58.0	57.7	57.4	57.0	56.7	56.4	56.0	55.7	55.4	55.1	54.7	54.4	54.1	53.7	53.4	53.1	52.8	52.4	52.1	51.8	51.4	51.1	50.8	50.5	50.1	49.8
185-195	190	-.316225	58.1	57.8	57.5	57.2	56.9	56.6	56.2	55.9	55.6	55.3	55.0	54.7	54.3	54.0	53.7	53.4	53.1	52.8	52.4	52.1	51.8	51.5	51.2	50.9	50.5	50.2	49.9
195-205	200	-.304383	57.9	57.6	57.3	57.0	56.7	56.4	56.1	55.8	55.5	55.2	54.9	54.6	54.3	54.0	53.7	53.4	53.1	52.8	52.5	52.2	51.9	51.5	51.2	50.9	50.6	50.3	50.0
205-215	210	-.293450	57.8	57.5	57.2	56.9	56.6	56.3	56.0	55.7	55.4	55.1	54.8	54.5	54.2	53.9	53.7	53.4	53.1	52.8	52.5	52.2	51.9	51.6	51.3	51.0	50.7	50.4	50.1

TABLE 9 -- (CONTINUED)

Carcass Weight lbs.	Mid-point	Regression Coefficient	Backfat Thickness in millimeters																										
			49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
95-105	100	-.510785	47.3	46.8	46.3	45.8	45.3	44.8	44.3	43.7	43.2	42.7	42.2	41.7	41.2	40.7	40.2	39.7	39.1	38.6	38.1								
105-115	110	-.475706	47.8	47.3	46.8	46.3	45.9	45.4	44.9	44.4	44.0	43.5	43.0	42.5	42.0	41.6	41.1	40.6	40.1	39.7	39.2	38.7							
115-125	120	-.445758	48.1	47.7	47.2	46.8	46.3	45.9	45.5	45.0	44.6	44.1	43.7	43.2	42.8	42.3	41.9	41.4	41.0	40.5	40.1	39.7							
125-135	130	-.419910	48.4	48.0	47.6	47.2	46.8	46.3	45.9	45.5	45.1	44.7	44.2	43.8	43.4	43.0	42.6	42.1	41.7	41.3	40.9	40.5	40.0						
135-145	140	-.397292	48.7	48.3	47.9	47.5	47.1	46.7	46.3	45.9	45.5	45.1	44.7	44.3	43.9	43.5	43.1	42.7	42.3	41.9	41.6	41.2	40.8						
145-155	150	-.377342	48.9	48.6	48.2	47.8	47.4	47.0	46.7	46.3	45.9	45.5	45.2	44.8	44.4	44.0	43.6	43.3	42.9	42.5	42.1	41.8	41.4	41.0					
155-165	160	-.359544	49.1	48.8	48.4	48.0	47.7	47.3	47.0	46.6	46.3	45.9	45.5	45.2	44.8	44.5	44.1	43.7	43.4	43.0	42.7	42.3	41.9	41.6					
165-175	170	-.343645	49.3	49.0	48.6	48.3	47.9	47.6	47.2	46.9	46.6	46.2	45.9	45.5	45.2	44.8	44.5	44.2	43.8	43.5	43.1	42.8	42.4	42.1	41.7				
175-185	180	-.329297	49.5	49.1	48.8	48.5	48.1	47.8	47.5	47.2	46.8	46.5	46.2	45.8	45.5	45.2	44.9	44.5	44.2	43.9	43.5	43.2	42.9	42.5	42.2				
185-195	190	-.316225	49.6	49.3	49.0	48.7	48.3	48.0	47.7	47.4	47.1	46.8	46.4	46.1	45.8	45.5	45.2	44.9	44.5	44.2	43.9	43.6	43.3	43.0	42.6	42.3	42.0	41.7	41.4
195-205	200	-.304383	49.7	49.4	49.1	48.8	48.5	48.2	47.9	47.6	47.3	47.0	46.7	46.4	46.1	45.8	45.5	45.2	44.9	44.5	44.2	43.9	43.6	43.3	43.0	42.7	42.4	42.1	41.8
205-215	210	-.293450	49.8	49.5	49.2	49.0	48.7	48.4	48.1	47.8	47.5	47.2	46.9	46.6	46.3	46.0	45.7	45.4	45.1	44.8	44.6	44.3	44.0	43.7	43.4	43.1	42.8	42.5	42.2

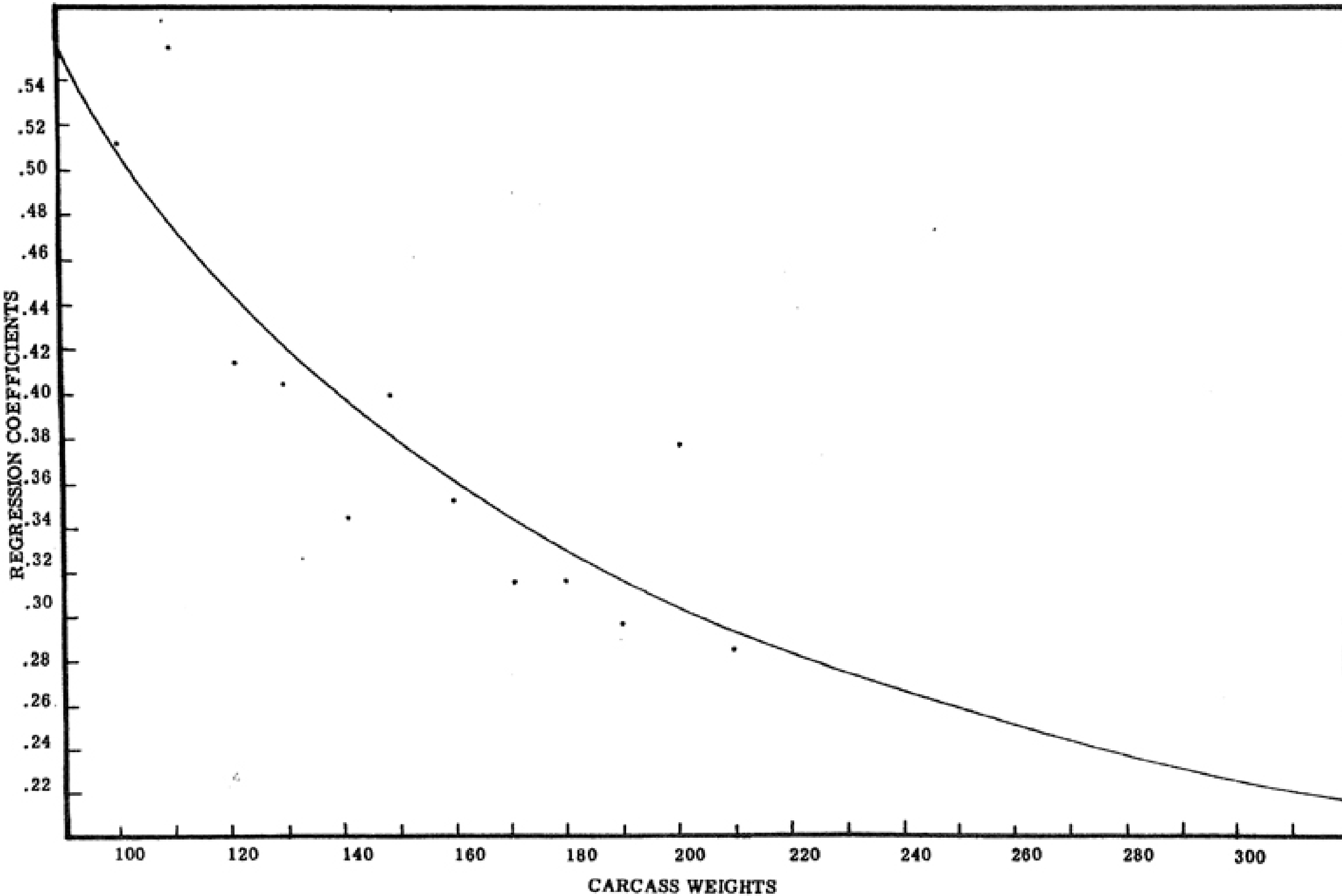

Figure 9.—Theoretical relationship of regression coefficient to carcass weight.

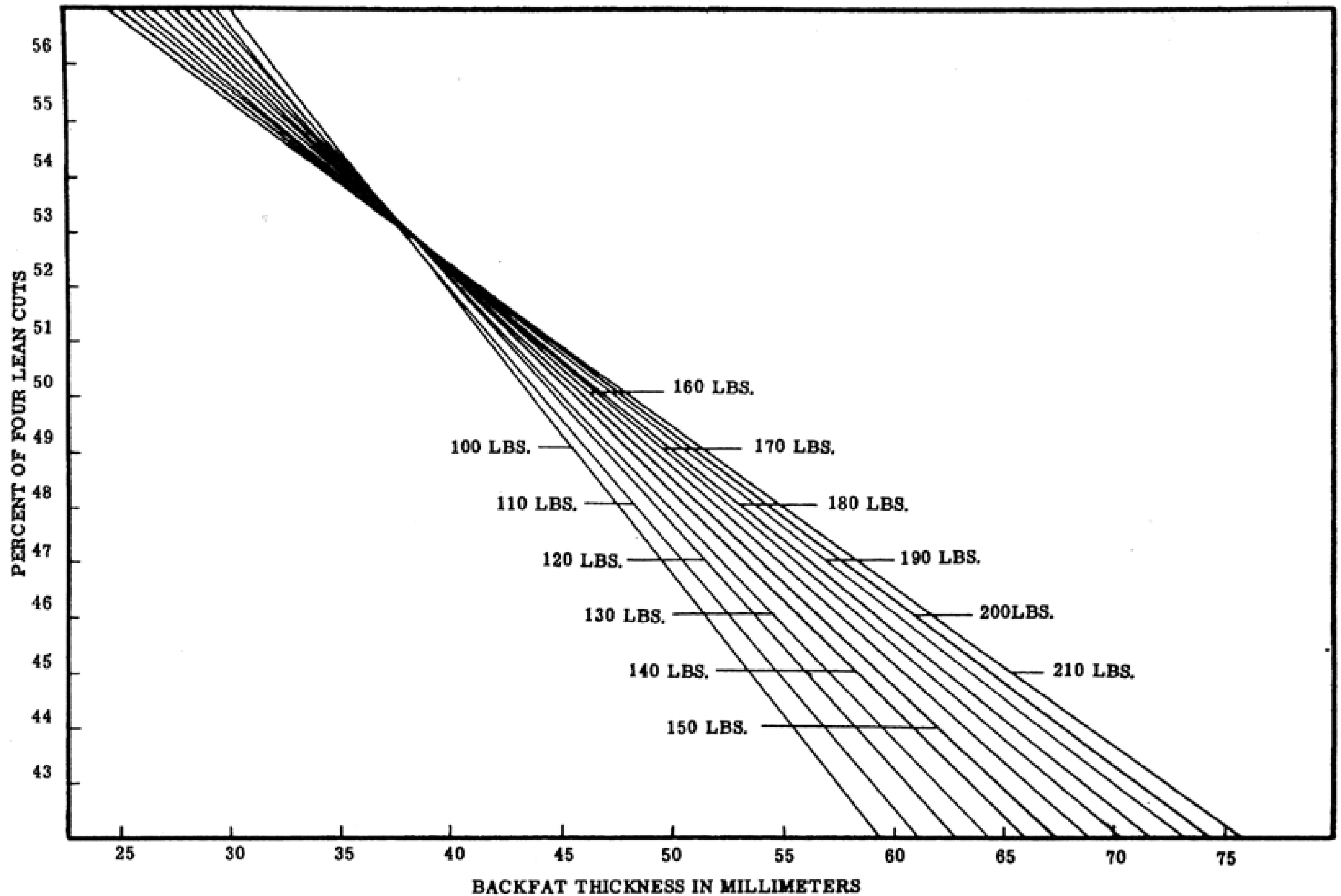

Figure 10.—Expected regression lines showing relationship between average backfat thickness and percentage of four lean cuts for carcass weights from 100 to 210 pounds inclusive at 10 pound intervals.

any given carcass weight. The statistical procedure employed fixed the position of the regression lines (origins located when per cent of four lean cuts = 51.3) and then determined the slope of each successive regression line.

The positions of the expected regression lines are shown in Figure 10. These may be compared with the actual regression lines shown in Figure 4. This procedure in the analysis resulted in the systematic shifting of the lines and provided for an orderly decline in the slope of the lines as carcass weights are increased.

At this point a testing of the procedures was desirable. A tabular description of the twelve regression lines is given in Table 9. At each millimeter of backfat thickness from 22 to 75 millimeters the expected percentage of four lean cuts can be found for each of the twelve carcass weights. The deviation of each carcass from its nearest regression line was computed and is presented in Table 10 for each regression line and for the entire sample as a whole.

It should be noted that when the differential effect of carcass weight was considered, the coefficient of determination was 78.04%. In other words, the selected formulae were capable of explaining more than three-fourths of the variability in the percentage of four lean cuts using only two measures, the average backfat thickness and the carcass weight.

TABLE 10 -- CALCULATION OF STANDARD ERROR OF ESTIMATE AND CORRELATION RATIO FOR 592 CARCASSES FROM EXPECTED REGRESSION LINES.

Nearest Carcass Weight	Number	Squared Deviations (Σd^2)	Standard Error of Percentage of Four Lean Cuts (S_y)
100	22	73.55	1.8284
110	45	194.24	2.0776
120	46	111.11	1.5542
130	49	217.15	2.1051
140	57	183.54	1.7944
150	62	136.48	1.4837
160	54	211.17	1.9775
170	53	196.09	1.9235
180	45	118.49	1.6227
190	56	171.04	1.7476
200	54	191.86	1.8849
210	49	115.17	1.5331
Totals	592	1919.89	

$$S_y = \frac{\sqrt{\Sigma d^2}}{N} = 1.8008$$

$$\sigma = 3.84306$$

$$\eta \text{ (correlation ratio)} = \sqrt{1 - \frac{S_y^2}{\sigma^2}} = .8834$$

$$\eta^2 \text{(coefficient of determination)} = 78.04\%$$

CONSTRUCTION OF DETAILED TABLES OF RELATIONSHIPS BETWEEN CARCASS MEASURES AND CARCASS COMPOSITION (BASIC REGRESSION SURFACE)

The objective in setting up grade standards requires a method of sorting and grouping similar carcasses together in the same classification. In order to determine the limits for grades a provision for specifying the particular average backfat thickness at each carcass weight which will most nearly predict the value of per cent of four lean cuts was necessary. The various backfat thicknesses required to predict the per cent of four lean cuts equal to 51.3 were computed for five pound intervals of carcass weight from 90 to 350 pounds inclusive (Table 7.) At this point it was necessary to compute the backfat thickness at each of these carcass weights for other values of the per cent of four lean cuts, such as 51, 49, etc. By relating the several regression lines together a tabulation can be made which will give a description of the possibilities of combination of the three variables.

The various backfat thicknesses required to predict percentages of four lean cuts from 40.0 to 63.0 inclusive, at intervals of 1.0, for carcass weights from 90 to 350 pounds at five pound intervals are shown in Table 11.[7] Another tabulation of the fundamental relationship between backfat thickness, percentage of four lean cuts, and carcass weight that was useful is shown in Table 12. The computed backfat thickness from Table 7 and the expected rate of change in percentage of four lean cuts from Table 8 form the basis for showing in tabular form the combined effect of backfat thickness and carcass weight on the per cent of four lean cuts. At 0.1 inch intervals of backfat thickness, the predicted percentages of four lean cuts can be read for carcass weights. For example, a 180 pound carcass with a backfat thickness of 2.0 inches would be expected to have 48.87% of four lean cuts. Thus, Tables 11 and 12 present in concise, simplified, tabular form the data developed in this study for use in the derivation of an objective carcass grade standard.

[7]For example, at 160 pounds carcass weight the computed backfat thickness when per cent of four lean cuts equals 51.3 is 1.691 inches (Table 7). The expected regression coefficient is —9.131972 in inches (Table 8). What backfat thickness would predict a percentage of four lean cuts equal to 47.0? The reciprocal of the regression value, —.109505, is multiplied by the change in per cent of four lean cuts, —4.3. The sum of this calculation, +.471, is added to the computed backfat thickness, 1.691, with the result that 2.162 inches of backfat thickness would be required for a 160 pound carcass to yield a percentage of four lean cuts equal to 47.0.

TABLE 11 -- BACKFAT THICKNESS IN INCHES AT SPECIFIE

Carcass Weight lbs.	Regression Coefficient in inches	Reciprocal of Regression	Percentages of Four Lean Cuts									
			40.0	41.0	42.0	43.0	44.0	45.0	46.0	47.0	48.0	49.0
90	-14.035304	.071249	2.412	2.340	2.269	2.198	2.127	2.055	1.984	1.913	1.842	1.770
95	-13.478944	.074190	2.454	2.380	2.306	2.232	2.157	2.083	2.009	1.935	1.861	1.786
100	-12.973306	.077081	2.493	2.416	2.339	2.262	2.185	2.107	2.030	1.953	1.876	1.799
105	-12.508127	.079946	2.532	2.452	2.373	2.293	2.213	2.133	2.053	1.973	1.893	1.813
110	-12.082343	.082765	2.571	2.489	2.406	2.323	2.240	2.158	2.075	1.992	1.909	1.827
115	-11.687976	.085558	2.610	2.525	2.439	2.353	2.268	2.182	2.097	2.011	1.926	1.840
120	-11.321700	.088326	2.647	2.558	2.470	2.382	2.293	2.205	2.117	2.028	1.940	1.852
125	-10.980671	.091069	2.684	2.593	2.502	2.411	2.319	2.228	2.137	2.046	1.955	1.864
130	-10.665193	.093763	2.720	2.627	2.533	2.439	2.345	2.252	2.158	2.064	1.970	1.877
135	-10.367342	.096457	2.756	2.660	2.563	2.467	2.370	2.274	2.177	2.081	1.984	1.888
140	-10.090724	.099101	2.792	2.693	2.594	2.495	2.396	2.297	2.198	2.098	1.999	1.900
145	- 9.828457	.101745	2.827	2.725	2.624	2.522	2.420	2.318	2.217	2.115	2.013	1.911
150	- 9.584019	.104340	2.861	2.756	2.652	2.548	2.443	2.339	2.235	2.130	2.026	1.922
155	- 9.351468	.106935	2.895	2.788	2.681	2.574	2.468	2.361	2.254	2.147	2.040	1.933
160	- 9.131972	.109505	2.929	2.819	2.710	2.600	2.491	2.381	2.272	2.162	2.053	1.943
165	- 8.924515	.112051	2.963	2.851	2.738	2.626	2.514	2.402	2.290	2.178	2.066	1.954
170	- 8.728157	.114572	2.995	2.881	2.766	2.652	2.537	2.422	2.308	2.193	2.079	1.964
175	- 8.540257	.117092	3.028	2.911	2.794	2.677	2.560	2.443	2.325	2.208	2.091	1.974
180	- 8.363735	.119564	3.061	2.942	2.822	2.703	2.583	2.463	2.344	2.224	2.105	1.985
185	- 8.194351	.122035	3.092	2.970	2.848	2.726	2.604	2.482	2.360	2.238	2.116	1.994
190	- 8.031723	.124506	3.124	2.999	2.875	2.750	2.626	2.501	2.377	2.252	2.128	2.003
195	- 7.873870	.127002	3.157	3.030	2.903	2.776	2.649	2.522	2.395	2.268	2.141	2.014
200	- 7.730951	.129350	3.187	3.058	2.928	2.799	2.669	2.540	2.411	2.281	2.152	2.023
205	- 7.588845	.131772	3.218	3.087	2.955	2.823	2.691	2.560	2.428	2.296	2.164	2.033
210	- 7.453266	.134169	3.249	3.115	2.981	2.846	2.712	2.578	2.444	2.310	2.176	2.041
215	- 7.323758	.136542	3.280	3.143	3.007	2.870	2.734	2.597	2.461	2.324	2.188	2.051
220	- 7.198669	.138915	3.310	3.171	3.032	2.893	2.754	2.615	2.477	2.338	2.199	2.060
225	- 7.079041	.141262	3.340	3.199	3.057	2.916	2.775	2.634	2.492	2.351	2.210	2.069
230	- 6.964492	.143585	3.369	3.226	3.082	2.939	2.795	2.652	2.508	2.364	2.221	2.077
235	- 6.852458	.145933	3.399	3.253	3.107	2.961	2.816	2.670	2.524	2.378	2.232	2.086
240	- 6.746215	.148231	3.429	3.280	3.132	2.984	2.836	2.687	2.539	2.391	2.243	2.094
245	- 6.643198	.150530	3.458	3.307	3.157	3.006	2.856	2.705	2.555	2.404	2.254	2.103
250	- 6.543305	.152828	3.487	3.334	3.181	3.029	2.876	2.723	2.570	2.417	2.264	2.112
255	- 6.447374	.155102	3.516	3.361	3.206	3.051	2.896	2.741	2.586	2.430	2.275	2.120
260	- 6.354236	.157375	3.544	3.387	3.229	3.072	2.915	2.757	2.600	2.443	2.285	2.128
265	- 6.264706	.159624	3.573	3.413	3.254	3.094	2.934	2.775	2.615	2.455	2.296	2.136
270	- 6.177664	.161873	3.602	3.440	3.278	3.116	2.954	2.792	2.630	2.468	2.307	2.145
275	- 6.093950	.164097	3.629	3.465	3.301	3.137	2.973	2.809	2.644	2.480	2.316	2.152
280	- 6.012445	.166322	3.658	3.491	3.325	3.159	2.992	2.826	2.660	2.493	2.327	2.161
285	- 5.933100	.168546	3.686	3.517	3.349	3.180	3.012	2.843	2.675	2.506	2.338	2.169
290	- 5.856675	.170745	3.713	3.542	3.372	3.201	3.030	2.859	2.689	2.518	2.347	2.176
295	- 5.782180	.172945	3.740	3.567	3.395	3.222	3.049	2.876	2.703	2.530	2.357	2.184
300	- 5.710378	.175120	3.768	3.593	3.418	3.243	3.068	2.893	2.718	2.542	2.367	2.192
305	- 5.640328	.177295	3.794	3.617	3.440	3.262	3.085	2.908	2.730	2.553	2.376	2.199
310	- 5.571980	.179469	3.822	3.643	3.463	3.284	3.104	2.925	2.745	2.566	2.386	2.207
315	- 5.506019	.181619	3.849	3.667	3.486	3.304	3.122	2.941	2.759	2.577	2.396	2.214
320	- 5.441608	.183769	3.875	3.692	3.508	3.324	3.140	2.957	2.773	2.589	2.405	2.222
325	- 5.378670	.185920	3.903	3.717	3.531	3.345	3.159	2.974	2.788	2.602	2.416	2.230
330	- 5.317891	.188044	3.928	3.740	3.552	3.364	3.176	2.988	2.800	2.612	2.424	2.236
335	- 5.258458	.190170	3.955	3.765	3.575	3.384	3.194	3.004	2.814	2.624	2.434	2.243
340	- 5.200320	.192296	3.982	3.790	3.598	3.405	3.213	3.021	2.828	2.636	2.444	2.252
345	- 5.144138	.194396	4.007	3.813	3.619	3.424	3.230	3.035	2.841	2.647	2.452	2.258
350	- 5.089150	.196496	4.033	3.837	3.640	3.444	3.247	3.051	2.854	2.658	2.461	2.265

D PERCENTAGES OF FOUR LEAN CUTS AND CARCASS WEIGHT.

50.0	51.0	52.0	53.0	54.0	55.0	56.0	57.0	58.0	59.0	60.0	61.0	62.0	63.0
1.699	1.628	1.557	1.486	1.414	1.343	1.272	1.201	1.129	1.058	0.987	0.916	0.844	0.773
1.712	1.638	1.564	1.490	1.415	1.341	1.267	1.193	1.119	1.044	0.970	0.896	0.822	0.749
1.722	1.645	1.568	1.491	1.414	1.337	1.260	1.183	1.105	1.028	0.951	0.874	0.797	0.720
1.733	1.653	1.573	1.493	1.413	1.333	1.253	1.173	1.093	1.013	0.933	0.854	0.774	0.694
1.744	1.661	1.578	1.495	1.413	1.330	1.247	1.164	1.082	0.999	0.916	0.833	0.751	0.668
1.755	1.669	1.583	1.498	1.412	1.327	1.241	1.156	1.070	0.985	0.899	0.813	0.728	0.642
1.763	1.675	1.587	1.498	1.410	1.322	1.233	1.145	1.057	0.968	0.880	0.792	0.703	0.615
1.773	1.682	1.591	1.500	1.409	1.318	1.227	1.136	1.045	0.953	0.862	0.771	0.680	0.589
1.783	1.689	1.595	1.501	1.408	1.314	1.220	1.126	1.033	0.939	0.845	0.751	0.658	0.564
1.791	1.695	1.599	1.502	1.406	1.309	1.213	1.116	1.020	0.923	0.827	0.730	0.634	0.538
1.801	1.702	1.603	1.504	1.405	1.306	1.206	1.107	1.008	0.909	0.810	0.711	0.612	0.513
1.810	1.708	1.606	1.505	1.403	1.301	1.199	1.098	0.996	0.894	0.792	0.691	0.589	0.487
1.817	1.713	1.609	1.504	1.400	1.296	1.191	1.087	0.983	0.878	0.774	0.670	0.565	0.461
1.826	1.719	1.612	1.505	1.398	1.291	1.184	1.077	0.970	0.864	0.757	0.550	0.543	0.436
1.834	1.724	1.614	1.505	1.395	1.286	1.176	1.067	0.957	0.848	0.738	0.629	0.519	0.410
1.842	1.730	1.618	1.506	1.394	1.282	1.170	1.058	0.946	0.834	0.722	0.609	0.497	0.385
1.850	1.735	1.620	1.506	1.391	1.277	1.162	1.048	0.933	0.818	0.704	0.589	0.475	0.360
1.857	1.740	1.623	1.506	1.389	1.272	1.155	1.037	0.920	0.803	0.686	0.569	0.452	0.335
1.866	1.746	1.626	1.507	1.387	1.268	1.148	1.029	0.909	0.789	0.670	0.550	0.431	0.311
1.872	1.750	1.628	1.506	1.384	1.262	1.140	1.018	0.896	0.774	0.652	0.530	0.408	0.286
1.879	1.754	1.629	1.505	1.380	1.256	1.131	1.007	0.882	0.758	0.633	0.509	0.384	0.260
1.887	1.760	1.633	1.506	1.379	1.252	1.125	0.998	0.871	0.744	0.617	0.490	0.363	
1.893	1.764	1.635	1.505	1.376	1.247	1.117	0.988	0.859	0.729	0.600	0.471	0.341	
1.901	1.769	1.637	1.505	1.374	1.242	1.110	0.978	0.847	0.715	0.583	0.451	0.320	
1.907	1.773	1.639	1.505	1.370	1.236	1.102	0.968	0.834	0.700	0.565	0.431	0.297	
1.915	1.778	1.641	1.505	1.368	1.232	1.095	0.959	0.822	0.686	0.549	0.413	0.276	
1.921	1.782	1.643	1.504	1.365	1.226	1.087	0.949	0.810	0.671	0.532	0.393		
1.927	1.786	1.545	1.503	1.362	1.221	1.080	0.938	0.797	0.656	0.515	0.373		
1.934	1.790	1.646	1.503	1.359	1.216	1.072	0.928	0.785	0.641	0.498	0.354		
1.940	1.794	1.648	1.502	1.356	1.210	1.064	0.918	0.772	0.627	0.481	0.335		
1.946	1.798	1.650	1.502	1.353	1.205	1.057	0.909	0.760	0.612	0.464	0.316		
1.953	1.802	1.651	1.501	1.350	1.200	1.049	0.899	0.748	0.598	0.447	0.297		
1.959	1.806	1.653	1.500	1.348	1.195	1.042	0.889	0.736	0.583	0.431	0.278		
1.965	1.810	1.655	1.500	1.345	1.190	1.034	0.879	0.724	0.569	0.414			
1.970	1.813	1.656	1.498	1.341	1.184	1.026	0.869	0.711	0.554	0.397			
1.977	1.817	1.657	1.498	1.338	1.179	1.019	0.859	0.700	0.540	0.380			
1.983	1.821	1.559	1.497	1.335	1.174	1.012	0.850	0.688	0.526	0.364			
1.988	1.824	1.660	1.496	1.332	1.168	1.004	0.839	0.675	0.511	0.347			
1.994	1.828	1.662	1.495	1.329	1.163	0.996	0.830	0.664	0.497	0.331			
2.001	1.832	1.663	1.495	1.326	1.158	0.989	0.821	0.652	0.484	0.315			
2.006	1.835	1.664	1.494	1.323	1.152	0.981	0.811	0.640	0.469	0.298			
2.011	1.838	1.665	1.492	1.319	1.146	0.973	0.800	0.627	0.454	0.281			
2.017	1.842	1.667	1.492	1.317	1.142	0.966	0.791	0.616	0.441	0.266			
2.021	1.844	1.667	1.489	1.312	1.135	0.958	0.780	0.603	0.426				
2.027	1.848	1.669	1.489	1.310	1.130	0.951	0.771	0.592	0.412				
2.033	1.851	1.669	1.488	1.306	1.125	0.943	0.761	0.580	0.398				
2.038	1.854	1.670	1.486	1.303	1.119	0.935	0.751	0.568	0.384				
2.044	1.858	1.672	1.486	1.300	1.114	0.928	0.742	0.557	0.371				
2.048	1.860	1.672	1.484	1.296	1.108	0.920	0.732	0.544	0.356				
2.053	1.863	1.673	1.483	1.292	1.102	0.912	0.722	0.532	0.342				
2.059	1.867	1.675	1.482	1.290	1.098	0.906	0.713	0.521	0.329				
2.063	1.869	1.675	1.480	1.286	1.091	0.897	0.703	0.508	0.314				
2.066	1.872	1.676	1.479	1.283	1.086	0.890	0.693	0.497	0.300				

TABLE 12 -- PERCENTAGES OF FOUR LEAN CUTS AT

Carcass Weight lbs.	Regression in inches	Backfat in inches at 51.3%	Backfat Thickness in inches										
			3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	2.3
90	-14.035304	1.607	27.54	28.94	30.35	31.75	33.15	34.56	35.96	37.36	38.77	40.17	41.57
95	-13.478944	1.615	28.59	29.94	31.28	32.63	33.98	35.33	36.58	38.02	39.37	40.72	42.07
100	-12.973306	1.622	29.53	30.83	32.13	33.42	34.72	36.02	37.31	38.61	39.91	41.21	42.50
105	-12.508127	1.629	30.40	31.65	32.90	34.15	35.40	36.65	37.90	39.15	40.41	41.66	42.91
110	-12.082343	1.536	31.19	32.40	33.61	34.82	36.03	37.24	38.44	39.65	40.86	42.07	43.28
115	-11.687976	1.643	31.93	33.10	34.27	35.44	36.61	37.78	38.95	40.11	41.28	42.45	43.62
120	-11.321700	1.649	32.61	33.74	34.87	36.00	37.14	38.27	39.40	40.53	41.67	42.80	43.93
125	-10.980671	1.655	33.24	34.33	35.43	36.53	37.33	38.73	39.83	40.92	42.02	43.12	44.22
130	-10.665193	1.661	33.82	34.89	35.95	37.02	38.09	39.15	40.22	41.29	42.35	43.42	44.48
135	-10.367342	1.666	34.36	35.40	36.43	37.47	38.51	39.54	40.58	41.62	42.65	43.69	44.73
140	-10.090724	1.672	34.87	35.88	36.89	37.90	38.91	39.92	40.93	41.94	42.94	43.95	44.96
145	- 9.828457	1.677	35.35	36.33	37.31	38.30	39.28	40.26	41.25	42.23	43.21	44.19	45.18
150	- 9.584019	1.682	35.79	36.75	37.71	38.67	39.63	40.59	41.54	42.50	43.46	44.42	45.38
155	- 9.351468	1.687	36.22	37.15	38.09	39.02	39.96	40.89	41.83	42.76	43.70	44.63	45.57
160	- 9.131972	1.691	36.61	37.52	38.43	39.35	40.26	41.17	42.09	43.00	43.91	44.83	45.74
165	- 8.924515	1.696	36.99	37.88	38.77	39.66	40.55	41.45	42.34	43.23	44.12	45.02	45.91
170	- 8.728157	1.701	37.34	38.22	39.09	39.96	40.83	41.71	42.58	43.45	44.33	45.20	46.07
175	- 8.540257	1.705	37.68	38.53	39.39	40.24	41.09	41.95	42.80	43.66	44.51	45.36	46.22
180	- 8.363735	1.710	38.00	38.84	39.67	40.51	41.35	42.18	43.02	43.86	44.69	45.53	46.37
185	- 8.194351	1.713	38.30	39.12	39.93	40.75	41.57	42.39	43.21	44.03	44.85	45.67	46.49
190	- 8.031723	1.717	38.59	39.39	40.19	41.00	41.80	42.60	43.40	44.21	45.01	45.81	46.62
195	- 7.873870	1.722	38.88	39.66	40.45	41.24	42.02	42.81	43.60	44.39	45.17	45.96	46.75
200	- 7.730951	1.725	39.12	39.90	40.67	41.44	42.22	42.99	43.76	44.54	45.31	46.08	46.85
205	- 7.588645	1.729	39.38	40.14	40.90	41.65	42.41	43.17	43.93	44.69	45.45	46.21	46.97
210	- 7.453256	1.733	39.62	40.37	41.11	41.86	42.60	43.35	44.09	44.84	45.58	46.33	47.07
215	- 7.323758	1.737	39.85	40.59	41.32	42.05	42.78	43.51	44.25	44.98	45.71	46.44	47.18
220	- 7.198669	1.740	40.07	40.79	41.51	42.23	42.95	43.67	44.39	45.11	45.83	46.55	47.27
225	- 7.079041	1.744	40.29	40.99	41.70	42.41	43.12	43.82	44.53	45.24	45.95	46.66	47.36
230	- 6.964492	1.747	40.48	41.18	41.88	42.57	43.27	43.97	44.66	45.36	46.06	46.75	47.45
235	- 6.852458	1.750	40.68	41.36	42.05	42.73	43.42	44.10	44.79	45.48	46.16	46.85	47.53
240	- 6.746215	1.754	40.87	41.54	42.22	42.89	43.57	44.24	44.92	45.59	46.27	46.94	47.62
245	- 6.643198	1.757	41.05	41.71	42.38	43.04	43.71	44.37	45.04	45.70	46.36	47.03	47.69
250	- 6.543305	1.760	41.22	41.88	42.53	43.19	43.84	44.49	45.15	45.80	46.46	47.11	47.77
255	- 6.447374	1.763	41.39	42.04	42.68	43.32	43.97	44.61	45.26	45.90	46.55	47.19	47.84
260	- 6.354236	1.766	41.55	42.19	42.82	43.46	44.09	44.73	45.37	46.00	46.64	47.27	47.91
265	- 6.264705	1.769	41.71	42.34	42.96	43.59	44.21	44.84	45.47	46.09	46.72	47.35	47.97
270	- 6.177664	1.772	41.86	42.48	43.10	43.71	44.33	44.95	45.57	46.18	46.80	47.42	48.04
275	- 6.093950	1.775	42.01	42.62	43.23	43.83	44.44	45.05	45.66	46.27	46.88	47.49	48.10
280	- 6.012445	1.778	42.15	42.75	43.35	43.95	44.55	45.16	45.76	46.36	46.96	47.56	48.16
285	- 5.933100	1.781	42.29	42.88	43.47	44.07	44.66	45.25	45.85	46.44	47.03	47.63	48.22
290	- 5.856675	1.784	42.42	43.01	43.59	44.18	44.76	45.35	45.94	46.52	47.11	47.69	48.28
295	- 5.782180	1.786	42.55	43.12	43.70	44.28	44.86	45.44	46.02	46.59	47.17	47.75	48.33
300	- 5.710378	1.789	42.67	43.24	43.81	44.38	44.96	45.53	46.10	46.67	47.24	47.81	48.38
305	- 5.640328	1.791	42.79	43.35	43.92	44.48	45.04	45.61	46.17	46.74	47.30	47.87	48.43
310	- 5.571980	1.794	42.91	43.47	44.02	44.58	45.14	45.69	46.25	46.81	47.37	47.92	48.48
315	- 5.506019	1.797	43.02	43.58	44.13	44.68	45.23	45.78	46.33	46.88	47.43	47.98	48.53
320	- 5.441608	1.799	43.13	43.68	44.22	44.76	45.31	45.85	46.40	46.94	47.49	48.03	48.57
325	- 5.378670	1.802	43.24	43.78	44.32	44.86	45.39	45.93	46.47	47.01	47.55	48.08	48.62
330	- 5.317891	1.804	43.34	43.88	44.41	44.94	45.47	46.00	46.54	47.07	47.60	48.13	48.66
335	- 5.258458	1.806	43.44	43.97	44.50	45.02	45.55	46.07	46.60	47.12	47.65	48.18	48.70
340	- 5.200320	1.809	43.55	44.07	44.59	45.11	45.63	46.15	46.67	47.19	47.71	48.23	48.75
345	- 5.144138	1.811	43.64	44.15	44.67	45.18	45.70	46.21	46.73	47.24	47.76	48.27	48.78
350	- 5.089150	1.813	43.73	44.24	44.75	45.26	45.77	46.28	46.79	47.29	47.80	48.31	48.82

SPECIFIED BACKFAT THICKNESSES BY CARCASS WEIGHTS.

2.2	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	.9	.8	.7	.6
42.98	44.38	45.78	47.19	48.59	49.99	51.40	52.80	54.21	55.61	57.01	58.42	59.82	61.22	62.63	64.03	65.43
43.41	44.76	46.11	47.46	48.81	50.15	51.50	52.85	54.20	55.55	56.89	58.24	59.59	60.94	62.29	63.63	64.98
43.80	45.10	46.40	47.69	48.99	50.29	51.59	52.88	54.18	55.48	56.77	58.07	59.37	60.67	61.96	63.26	64.56
44.16	45.41	46.66	47.91	49.16	50.41	51.66	52.91	54.16	55.42	56.67	57.92	59.17	60.42	61.67	62.92	64.17
44.49	45.69	46.90	48.11	49.32	50.53	51.73	52.94	54.15	55.36	56.57	57.78	58.98	60.19	61.40	62.61	63.82
44.79	45.96	47.13	48.30	49.46	50.63	51.80	52.97	54.14	55.31	56.48	57.65	58.82	59.98	61.15	62.32	63.49
45.06	46.19	47.33	48.46	49.59	50.72	51.85	52.99	54.12	55.25	56.38	57.52	58.65	59.78	60.91	62.04	63.18
45.32	46.41	47.51	48.61	49.71	50.81	51.90	53.00	54.10	55.20	56.30	57.39	58.49	59.59	60.69	61.79	62.88
45.55	46.62	47.68	48.75	49.82	50.88	51.95	53.02	54.08	55.15	56.22	57.28	58.35	59.42	60.48	61.55	62.62
45.76	46.80	47.84	48.87	49.91	50.95	51.98	53.02	54.06	55.09	56.13	57.17	58.20	59.24	60.28	61.31	62.35
45.97	46.98	47.99	49.00	50.01	51.02	52.03	53.04	54.04	55.05	56.06	57.07	58.08	59.09	60.10	61.11	62.12
46.16	47.14	48.13	49.11	50.09	51.07	52.06	53.04	54.02	55.01	55.99	56.97	57.95	58.94	59.92	60.90	61.89
46.34	47.29	48.25	49.21	50.17	51.13	52.09	53.04	54.00	54.96	55.92	56.88	57.84	58.79	59.75	60.71	61.67
46.50	47.44	48.37	49.31	50.24	51.18	52.11	53.05	53.98	54.92	55.85	56.79	57.72	58.66	59.59	60.53	61.47
46.65	47.57	48.48	49.39	50.30	51.22	52.13	53.04	53.96	54.87	55.78	56.70	57.61	58.52	59.44	60.35	61.26
46.80	47.69	48.59	49.48	50.37	51.26	52.16	53.05	53.94	54.83	55.73	56.62	57.51	58.40	59.30	60.19	61.08
46.94	47.82	48.69	49.56	50.44	51.31	52.18	53.05	53.93	54.80	55.67	56.55	57.42	58.29	59.16	60.04	60.91
47.07	47.93	48.78	49.63	50.49	51.34	52.20	53.05	53.90	54.76	55.61	56.47	57.32	58.17	59.03	59.88	60.74
47.20	48.04	48.87	49.71	50.55	51.38	52.22	53.06	53.89	54.73	55.57	56.40	57.24	58.07	58.91	59.75	60.58
47.31	48.13	48.95	49.77	50.59	51.41	52.23	53.05	53.86	54.68	55.50	56.32	57.14	57.96	58.78	59.60	60.42
47.42	48.22	49.03	49.83	50.63	51.44	52.24	53.04	53.85	54.65	55.45	56.26	57.06	57.86	58.67	59.47	60.27
47.54	48.32	49.11	49.90	50.69	51.47	52.26	53.05	53.84	54.62	55.41	56.20	56.98	57.77	58.56	59.35	60.13
47.63	48.40	49.17	49.95	50.72	51.49	52.27	53.04	53.81	54.59	55.36	56.13	56.90	57.68	58.45	59.22	60.00
47.73	48.48	49.24	50.00	50.76	51.52	52.28	53.04	53.80	54.56	55.31	56.07	56.83	57.59	58.35	59.11	59.87
47.82	48.56	49.31	50.06	50.80	51.55	52.29	53.04	53.78	54.53	55.27	56.02	56.76	57.51	58.25	59.00	59.74
47.91	48.64	49.37	50.11	50.84	51.57	52.30	53.04	53.77	54.50	55.23	55.97	56.70	57.43	58.16	58.89	59.63
47.99	48.71	49.43	50.15	50.87	51.59	52.31	53.03	53.75	54.47	55.19	55.91	56.63	57.35	58.07	58.79	59.51
48.07	48.78	49.49	50.20	50.90	51.61	52.32	53.03	53.74	54.44	55.15	55.86	56.57	57.27	57.98	58.69	59.40
48.15	48.84	49.54	50.23	50.93	51.63	52.32	53.02	53.72	54.41	55.11	55.81	56.50	57.20	57.90	58.59	59.29
48.22	48.90	49.59	50.27	50.96	51.64	52.33	53.01	53.70	54.38	55.07	55.[illegible]	56.44	57.12	57.81	58.50	59.18
48.29	48.97	49.64	50.32	50.99	51.66	52.34	53.01	53.69	54.36	55.04	55.71	56.39	57.06	57.74	58.41	59.09
48.36	49.02	49.69	50.35	51.01	51.68	52.34	53.01	53.67	54.34	55.00	55.66	56.33	56.99	57.66	58.32	58.99
48.42	49.08	49.73	50.38	51.04	51.69	52.35	53.00	53.66	54.31	54.96	55.62	56.27	56.93	57.58	58.24	58.89
48.48	49.13	49.77	50.42	51.06	51.71	52.35	53.00	53.64	54.29	54.93	55.57	56.22	56.86	57.51	58.15	58.80
48.54	49.18	49.81	50.45	51.08	51.72	52.35	52.99	53.63	54.26	54.90	55.53	56.17	56.80	57.44	58.07	58.71
48.60	49.23	49.85	50.48	51.11	51.73	52.36	52.99	53.61	54.24	54.86	55.49	56.12	56.74	57.37	58.00	58.62
48.66	49.27	49.89	50.51	51.13	51.74	52.36	52.98	53.60	54.22	54.83	55.45	56.07	56.69	57.30	57.92	58.54
48.71	49.32	49.93	50.54	51.15	51.76	52.37	52.98	53.59	54.19	54.80	55.41	56.02	56.63	57.24	57.85	58.46
48.76	49.36	49.97	50.57	51.17	51.77	52.37	52.97	53.57	54.17	54.78	55.38	55.98	56.58	57.18	57.78	58.38
48.81	49.41	50.00	50.59	51.19	51.78	52.37	52.97	53.56	54.15	54.75	55.34	55.93	56.53	57.12	57.71	58.31
48.86	49.45	50.03	50.62	51.21	51.79	52.38	52.96	53.55	54.13	54.72	55.31	55.89	56.48	57.06	57.65	58.23
48.91	49.48	50.06	50.64	51.22	51.80	52.38	52.95	53.53	54.11	54.69	55.27	55.84	56.42	57.00	57.58	58.16
48.95	49.52	50.10	50.67	51.24	51.81	52.38	52.95	53.52	54.09	54.66	55.23	55.81	56.38	56.95	57.52	58.09
48.99	49.56	50.12	50.69	51.25	51.81	52.38	52.94	53.51	54.07	54.63	55.20	55.76	56.33	56.89	57.45	58.02
49.04	49.59	50.15	50.71	51.27	51.82	52.38	52.94	53.50	54.05	54.61	55.17	55.72	56.28	56.84	57.40	57.95
49.08	49.63	50.18	50.73	51.28	51.83	52.38	52.94	53.49	54.04	54.59	55.14	55.69	56.24	56.79	57.34	57.89
49.12	49.66	50.21	50.75	51.29	51.84	52.38	52.93	53.47	54.02	54.56	55.10	55.65	56.19	56.74	57.28	57.82
49.16	49.70	50.24	50.77	51.31	51.85	52.39	52.92	53.46	54.00	54.54	55.08	55.61	56.15	56.69	57.23	57.77
49.19	49.73	50.26	50.79	51.32	51.85	52.38	52.92	53.45	53.98	54.51	55.04	55.58	56.11	56.64	57.17	57.70
49.23	49.75	50.28	50.81	51.33	51.86	52.38	52.91	53.43	53.96	54.49	55.01	55.54	56.06	56.59	57.12	57.64
49.27	49.79	50.31	50.83	51.35	51.87	52.39	52.91	53.43	53.95	54.47	54.99	55.51	56.03	56.55	57.07	57.59
49.30	49.81	50.33	50.84	51.36	51.87	52.39	52.90	53.41	53.93	54.44	54.96	55.47	55.99	56.50	57.02	57.53
49.33	49.84	50.35	50.86	51.37	51.88	52.38	52.89	53.40	53.91	54.42	54.93	55.44	55.95	56.46	56.96	57.47

DEVELOPMENT OF OBJECTIVE CARCASS STANDARDS

The data presented in Table 12 (page 37) may be thought of as a Theoretical Grade Standard for classifying or grading hog carcasses. Obviously this form could not be used in grading operations due to the lack of feasibility in applying the minute gradations of the variables. Consequently, the next procedure was to combine the objective measures in such a manner as to present a simpler grade standard that might be practical and, at the same time, sort the carcasses according to their merit or value.

DETERMINING THE OPTIMUM DEGREE OF FINISH AND PER CENT OF LEAN CUTS

The first concern in developing an objective hog carcass grade standard is the selection of a point of departure on the scale of degree of finish to be used as a base for construction. It was decided that the most feasible starting point would be what was considered the optimum degree of finish and per cent of lean cuts.

Under present-day marketing and economic conditions, carcasses that have an excessively high degree of finish are worth less per pound than carcasses with a moderate degree of finish. This is due to the fact that the highly finished carcasses yield a smaller proportion of the high value lean cuts and a larger proportion of lower value lard. On the other hand, the excessively underfinished carcasses yield a larger proportion of lean cuts along with a smaller proportion of lard, but these must be discounted in value due to the lack of quality. Thus, the movement along the scale of finish from a high degree to a low degree gives an increasing percentage of lean cuts, but stated in terms of value the increase reaches a maximum at some moderate degree of finish when thereafter the discounts on lean cuts more than offset the value effect of a lower proportion of lard. The problem at this stage was to locate this point of optimum degree of finish.

The carcasses used in this study were not selected on the basis of any grading standard. Hence, the study had no basis for comparison with respect to a clue for the optimum grade.

Four of the major cuts including hams, picnics, lions, and bellies were graded on the basis of the present government grading standards for pork cuts. The accuracy of this grading may have been reduced due to changes in personnel representing the Standardization and Grading Section that were made during the course of the study. Also, the grading standard for pork cuts has not been rigidly defined which results in a certain amount of variation due to individual interpretations.

The distribution of grades of hams, loins, picnics, and bellies by percentage of lean cuts is shown in Appendix D. A study of these distributions reveal that the higher the per cent of lean cuts in the carcasses, the greater the probability for discounted cuts. There was a general indication that a higher percentage of the top quality cuts will be found in carcasses having from 49 to 52% of the weight in four lean cuts.

There has been much discussion and many ideas proposed in recent years by leading authorities as to specific requirements for this top grade carcass. H. E. Reed, United States Department of Agriculture, stated that on the basis of research in the department the optimum grade or degree of finish carcass will produce between 48 and 51 per cent of the four lean cuts (10). O. G. Hankins, In charge, meat section, Bureau of Animal Industry, United States Department of Agriculture, stated that the Bureau of Animal Industry data indicates that carcasses weighing 155 pounds have adequate firmness at 1.5 inches of backfat (11). This backfat thickness would be offered as the point to separate the optimum grade from the first underfinished grade. Hankins further states that 1.4 inches backfat would probably be the minimum amount of thickness required in the optimum grade for the 155 pound carcass. Gerald Engleman, University of Minnesota, reported that Minnesota had tentatively suggested 1.5 inches backfat as the critical margin at 160 pounds carcass weight between the desired degree of carcass finish and the first underfinished carcass grade (11).

The optimum degree of finish and per cent of lean cuts that was selected tentatively centered the optimum carcass grade at 51.5 % of four lean cuts, which was the mean of the entire sample used in the study, and set the lower margin of this optimum grade at approximately 1.5 inches backfat thickness.

DETERMINING THE NUMBER OF GRADES AND WEIGHT CLASSES AND LOCATING THE MARGINS

Two additional factors concerning the development of an objective carcass grade standard needed to be considered. First, there was the problem of the number of grades required. Keeping in mind the practicability, simplicity of application, and economic significance of the standard, five grades or finish classifications were tentatively selected and considered as being adequate for the purposes of this study. The range in finish could be divided readily into more or less than five designations.

The development of grade designations for hog carcasses presents a unique situation in comparison with other species of slaughter livestock. The increase or decrease in values of hog carcasses is not continuous or consistent in association with the changes in physical variation. The change in value from a highly finished, compact carcass to the longer, lean or underfinished carcass cannot be accurately described by a continuous numerical grading. For example, the descriptive grade terms that have proven desirable in beef grading would not correctly designate the value of hog carcasses. In beef carcasses the Prime grade consists of a higher degree of finish, quality, and compactness than the next lower grade, Choice, and is the highest value carcass. In the same manner, the grade Choice is more desirable and of higher value than the next lower grade, Good. This does not hold true with hog carcasses as the most highly finished, compact carcasses and the longer, lean and underfinished carcasses are less valuable than the moderately finished, in-between carcasses. The highly finished carcasses are less valuable than the moderately finished carcasses due to the lower percentage of high value lean cuts and the higher percentage of lower-value lard. The lean, extremely underfinished carcasses contain a higher percentage of lean cuts but these are usually discounted for lack of quality.

A possible solution of grade designations was a combination of numerical and letter designations. The moderately finished carcass that was selected as the optimum grade for degree of finish would be designated as Grade 1A with the overfinished and extremely overfinished carcasses designated as 1B and 1C respectively. The wholesale cuts from carcasses grading 1A, 1B, 1C, would be of acceptable quality. However, on the overfinished grades the cuts would require a greater amount of trimming

TABLE 13 -- TENTATIVE HOG CARCASS GRADE STANDARD X BASED ON BACKFAT THICKNESS AND CARCASS WEIGHT WITH THREE-POINT RANGE IN PERCENTAGE OF FOUR LEAN CUTS, AND WITH GRADE 1A CENTERED AT 51.5% OF FOUR LEAN CUTS.

Grade	1C	1B	1A	2	3	
Per cent of Four Lean Cuts	45.5	48.5	51.5	54.5	57.5	
Carcass Weight (lbs.)	Backfat Thickness (ins.)					
90-100	2.157	1.935	1.712	1.490	1.267	1.044
100-110	2.213	1.973	1.733	1.493	1.253	1.013
110-120	2.268	2.011	1.755	1.498	1.241	.985
120-130	2.319	2.046	1.773	1.500	1.227	.953
130-140	2.370	2.081	1.791	1.502	1.213	.923
140-150	2.420	2.115	1.810	1.505	1.199	.894
150-160	2.468	2.147	1.826	1.505	1.184	.864
160-170	2.514	2.178	1.842	1.506	1.170	.834
170-180	2.560	2.208	1.857	1.506	1.155	.803
180-190	2.604	2.238	1.872	1.506	1.140	.774
190-200	2.649	2.268	1.887	1.506	1.125	.744
200-210	2.691	2.296	1.901	1.505	1.110	.715
210-220	2.734	2.324	1.915	1.505	1.095	.686
220-230	2.775	2.351	1.927	1.503	1.080	.656
230-240	2.816	2.378	1.940	1.502	1.064	.627
240-250	2.856	2.404	1.953	1.501	1.049	.598
250-260	2.896	2.430	1.965	1.500	1.034	.569

of the excess fat. The carcasses that lack finish and quality would be designated as Grades 2 and 3. The suggested grade designations would be:

Extremely Overfinished	Over-finished	Optimum Finish	Under-finished	Extremely Underfinished
1C	1B	1A	2	3

In developing an objective grade standard it was necessary to consider the range of physical variation or degree of finish to be included with the grade classifications. Approximately 97% of the carcasses selected for this study were included within the range of 44 to 59% of the lean cuts, or a physical variation of 15% (Appendix D). With five grade classifications suggested, this would be a range of 3% for each grade. The range of 3.0% in yield of lean cuts was considered adequate.

The first step to provide a basis for further refinement of grade margins and weight classes is shown in Tentative Hog Carcass Grade Standard X, Table 13. The reference point was the optimum grade 1A centered at 51.5% of four lean cuts. The other grade classifications were centered to the right and left at 3.0% intervals. The purpose of this grouping was to obtain some clue as to the backfat thickness margins associated with the range of 3.0% in the yield of four lean cuts for each grade classification and then to develop the related carcass weight groupings.[8]

TABLE 14 -- TENTATIVE HOG CARCASS GRADE STANDARD Y BASED ON BACKFAT THICKNESS AND CARCASS WEIGHT WITH THREE-POINT RANGE IN PERCENTAGE OF FOUR LEAN CUTS, AND WITH GRADE 1B CENTERED AT 48.5% OF FOUR LEAN CUTS.

Grade	1C	1B	1A	2	3	
Per cent of Four Lean cuts	45.5	48.5	51.5	54.5	57.5	
Carcass Weight (lbs.)	Backfat Thickness (ins.)					
90-120 (105 av.)	2.213	1.973	1.733	1.494	1.254	1.014
120-160 (140 av.)	2.394	2.097	1.800	1.503	1.206	.908
160-210 (185 av.)	2.604	2.238	1.872	1.506	1.140	.774
210-260 (235 av.)	2.815	2.377	1.940	1.502	1.064	.627

[8]The backfat thickness associated with any given percentage of four lean cuts at different carcass weights are shown in Table 11. The midpoint of each weight group was used to obtain the margins of backfat thickness for the five grade classifications. For 120 pound carcass there was .26 inch change in backfat thickness for each 3 per cent change in four lean cuts. At 220 pound carcass weight a .42 inch change in backfat was associated with 3 per cent change in four lean cuts.

Grade 1C carcasses were very fat as indicated by the thick backfat and the relatively low percentage of four lean cuts. Each successive grade to the right in the table exhibited a lower degree of finish with an increasing percentage of four lean cuts.

Reduction of the number of weight groups would contribute toward the feasibility of a standard in commercial practice. Tentative Hog Carcass Standard Y was developed for this purpose from the data in Table 13, combining 17 weight groups into four major groups. The margins for backfat thickness in Grade 1B seemed to exhibit an acceptable range in backfat thickness for the grade and also a logical sequence of "breaks" going from light-weight to heavier weight carcasses that could be used as a basis for establishing the several weight classes. The carcass weights which most nearly approach the backfat thickness margins and "breaks" from Grade 1B, Table 13, are shown below:

Approximate Range of Backfat Thickness for Grade 1B	Midpoint Backfat Thickness (inches)	Backfat-Thickness at 48.5 per cent Four Lean Cuts (inches)	Carcass Weight Midpoint of Weight Group (pounds)	Range of Weights per Weight Group (pounds)
1.7 - 2.0	1.85	1.853	105	90-120
1.8 - 2.1	1.95	1.949	140	120-160
1.9 - 2.2	2.05	2.055	185	160-210
1.9 - 2.4	2.15	2.153	235	210-260

It should be noted that the carcass weights in the fourth column that predicted the midpoint backfat thickness in the second column increased at an increasing rate as constant increments of backfat were added. This was expected as the backfat thickness of a standardized carcass increased at a decreasing rate as constant increments of carcass weight were added.

The approximate limits in backfat thickness for Grade 1B are shown at the left above in the first column. The approximate margins for the other grades were established by moving out at successive intervals of 3.0% range in per cent of lean cuts from the midpoint of Grade 1B at 48.5%, along the regression lines of midpoints of the selected carcass weight groups from Table 11. The tabulation of the data according to the specified weight classifications was called Grade Standard Y as shown in Table 14.

Grade 1C is the most highly finished carcass and declines in per cent of lean cuts to 44.0. It is entirely possible that some carcasses of the heavier weights will go below this limit in per cent of four lean cuts. A Grade 1D could be added if the number was sufficient to have economic significance. Grade 3 increases in the per cent of lean to 59.0. It is very unlikely that a sufficient number of the lighter weight carcasses would exceed this limit to call for addition of another grade.

DERIVING OBJECTIVE GRADE STANDARDS

The Tentative Grade Standard Y would not be entirely feasible for actual grading operations. The margins for backfat thickness between grades is given to the nearest one-thousandth of an inch. This degree of refinement would be impractical. It was believed that backfat thickness to the nearest one-tenth of an inch would be practical and sufficiently accurate.

The data for further refinement of the tentative standard were secured from Table 12. These fundamental relationships were used in constructing the simplified grade standard.

Objective Hog Carcass Grade Standard A is shown in Table 15. This standard was formulated on the basis of previous tentative standards. The backfat margins for each grade classification were obtained by taking the midpoint or the average for the indicated weight classes. The indicated percentages of four lean cuts are shown at the margins and at the midpoints of the various grades.

Grade Standard A approximates the 3.0 point range in per cent of four lean cuts. It should be noted that the range in backfat thickness is not a constant figure. This was explained by the fact that the basic relationships between backfat thickness and per cent of four lean cuts are changed with increasing carcass weights. A uniform degree of finish should be maintained within grades among different carcass weights.

Another characteristic of this standard pertaining to the grades at the extremes is of paramount importance. The overfinished grades, Grades 1B and 1C, maintained a fairly constant unit increase of backfat thickness at the margins. At a given unit thickness of backfat the per cent of four lean cuts increased continuously with increased carcass weights. However, it will be noted that at the other extreme of the standard another tendency was apparent. The lower limits of backfat thickness for the optimum grade, Grade 1A, was a constant 1.5 inches for all the weight groups. For Grades 2 and 3, the underfinished grades, there was a slight decrease in the backfat thickness margins associated with increased carcass weights. In other words, at a specified backfat thickness on the lean side of the standard the per cent of four lean cuts *decreased* slightly with additional carcass weight. This would appear to indicate that hogs get fatter proportionately as weight increases while backfat thickness is held constant. Actually, however, this phenomenon may be explained by the fact that the trimming was *proportionately* closer on heavier carcasses than on the lighter carcasses. The standardized cutting procedures called for *absolute* specifications, rather than *proportional* specifications. Perhaps this accounted for the fact that the heavier carcasses on the lean side of the standard yielded a lower percentage of lean cuts than might be expected.

TABLE 15 -- OBJECTIVE HOG CARCASS GRADE STANDARD A, BASED ON CARCASS WEIGHT AND BACKFAT THICKNESS, GRADE 1A CENTERED AT APPROXIMATELY 51.5% OF FOUR LEAN CUTS.

Carcass Weight (lbs)		GRADES										
			1C		1B		1A		2		3	
		Margins	Mid-points	Margins	Mid-point	Margins	Mid-point	Margins	Mid-point	Margins	Mid-point	Margins
90-120 (105 av.)	Backfat Thickness	2.2		2.0		1.7		1.5		1.2		1.0
	Per cent four lean cuts	44.2	45.5	46.7	48.5	50.4	51.6	52.9	54.8	56.7	57.9	59.2
120-160 (140 av.)	Backfat Thickness	2.4		2.1		1.8		1.5		1.2		.9
	Per cent four lean cuts	44.0	45.5	47.0	48.5	50.0	51.5	53.0	54.6	56.1	57.6	59.1
160-210 (185 av.)	Backfat Thickness	2.6		2.2		1.9		1.5		1.1		.8
	Per cent four lean cuts	44.0	45.6	47.3	48.5	49.8	51.4	53.0	54.6	56.3	57.6	58.8
210-260 (235 av.)	Backfat Thickness	2.8		2.4		2.0		1.5		1.1		.7
	Per cent four lean cuts	44.1	45.5	46.9	48.3	49.6	51.3	53.0	54.4	55.8	57.2	58.5

TABLE 16 -- OBJECTIVE HOG CARCASS GRADE STANDARD B, MODIFIED, BASED ON CARCASS WEIGHT AND BACKFAT THICKNESS.

Carcass Weight (lbs)		GRADES										
			1C		1B		1A		2		3	
		Margins	Mid-point	Margins	Mid-point	Margins	Mid-point	Margins	Mid-point	Margins	Mid-point	Margins
90-120 (105 av.)	Backfat Thickness	2.2		2.0		1.7		1.4		1.1		.9
	Per cent four lean cuts	44.2	45.5	46.7	48.5	50.4	52.3	54.2	56.0	57.9	59.1	60.4
120-160 (140 av.)	Backfat Thickness	2.4		2.1		1.8		1.5		1.2		.9
	Per cent four lean cuts	44.0	45.5	47.0	48.5	50.0	51.5	53.0	54.6	56.1	57.6	59.1
160-210 (185 av.)	Backfat Thickness	2.6		2.2		1.8		1.5		1.2		.8
	Per cent four lean cuts	44.0	45.6	47.3	48.9	50.6	51.8	53.0	54.2	55.5	57.1	58.8
210-260 (235 av.)	Backfat Thickness	2.8		2.4		1.9		1.5		1.2		.8
	Per cent four lean cuts	44.1	45.5	46.9	48.6	50.3	51.6	53.0	54.0	55.1	56.4	57.8

THE SUGGESTED GRADE STANDARD

Grade Standard A met the requirements for simplicity and practicability, but it was believed that with some modifications the relative accuracy could be improved. Some alterations were considered necessary to offset concessions for simplicity, and, also, attempt to maintain a uniform degree of finish or homogeneity within grades at all carcass weights. This was especially true on the lean side of the standard as the slope of the basic regression line expressing relationships in this area was very small.

A suggested grade standard, Objective Hog Carcass Grade Standard B, is given in Table 16. This standard was developed by modification and interpolation. The lower backfat margin for Grade 1A in the 90 to 120 pound weight group was changed from 1.5 to 1.4 inches, with the lower margins of Grades 2 and 3 lowered to 1.1 and .9 inches respectively. This gave a backfat range of 0.2 inch for the extreme grades and 0.3 range for the in-between grades. The 120 to 160 pound weight group was unchanged. The upper limit of backfat for Grade 1A in 160 to 210 pound weight group was changed from 1.9 to 1.8 inches, and the lower limit for Grade 2 was moved up to 1.2 inches. This provided a 0.3 inch range for the middle grades and a 0.4 inch range for the extremes. For the heaviest weight grouping the optimum grade, 1A, was given a 0.4 range and the extremes for the lean side were increased 0.1 inch in the backfat. With this adjustment Grade 1B, the over-finished class, was given a backfat range of 0.5 inch from 1.9 to 2.4 inches.

Grade Standard A was somewhat more consistent in predicting the percentage of four lean cuts within grade classifications than Grade Standard B. However, the latter standard was preferred for two important reasons. First, it was believed that 1.5 inches of backfat was too much to require for adequate finish on the optimum grade for carcasses under 120 pounds. Secondly, Grade 1A was somewhat more discriminating for degree of finish on the fat side of the grade classification.

TESTING THE PERFORMANCE OF THE GRADE STANDARDS IN CLASSIFYING CARCASSES

Any proposed or suggested grade standard must be appraised for ability to sort or classify carcasses according to physical differences and indicated values. Two methods of testing accuracy of classification were selected. One was to determine the number of carcasses the standard would classify accurately. Another was to determine or measure the amount of dispersions of the final criteria of merit, percentage of four lean cuts, within grades that the standard could account for in comparison with the total dispersions.

Analysis of Grading Accuracy. The distribution of these carcasses according to the sorting of each standard is shown in Table 17. The distribution of carcasses by these standards did not vary to a great degree. Grade Standards X and A placed a few more carcasses in the presumed optimum grade 1A, and sorted a larger number in the extremely underfinished grade 3. In contrast, Grade Standard B indicated a slightly lower number of carcasses for the optimum grade 1A, and placed several additional carcasses in the moderately over-finished grade 1B. Standard B was slightly more discriminating on the fat side of grade classification 1A.

To determine the effectiveness or accuracy with which any standard classifies the carcasses, an analysis must be made to determine the relative frequency that carcasses were placed in grade according to the final criteria of merit, per cent of four lean cuts. For example, Grade 1A in Grade Standard X contained 182 carcasses that had backfat thicknesses which would indicate a percentage of four lean cuts varying from 50.0 to 53.0. In order to determine grading accuracy, it was necessary to determine the number of carcasses which had percentages of four lean cuts that fell within the limits of the grades, the numbers that fell below or exceeded the limits, and the amount of error as indicated by the number of grades that the carcasses were misplaced. The analysis of grading accuracy for the Grade Standards X, A, and B is shown in Table 18. According to this tabulation Standards A and B exhibited no apparent significant

TABLE 17 -- DISTRIBUTION OF 592 CARCASSES AS CLASSIFIED BY THREE DIFFERENT GRADE STANDARDS.

Grade Standard	Distribution of Carcasses by Grades 1C	1B	1A	2	3	Total
Tentative Grade Standard X	65	156	182	129	60	592
Grade Standard A	75	138	190	138	51	592
Grade Standard B	75	171	168	142	36	592

TABLE 18 -- ANALYSIS OF GRADING ACCURACY BY DIFFERENT GRADE STANDARDS.

Grade Standard	Number and Per cent of Carcasses: Under-Graded Number of Grades 2	Under-Graded 1	Graded Accurately 0	Over-Graded Number of Grades 1	Over-Graded 2	Total
			Number			
Tentative Grade Standard X	5	91	344	142	10	592
Grade Standard A	5	91	353	136	7	592
Grade Standard B	7	88	356	136	5	592
			Per Cent			
Tentative Grade Standard X	0.8	15.4	58.1	24.0	1.7	100
Grade Standard A	0.8	15.4	59.6	23.0	1.2	100
Grade Standard B	1.2	14.9	60.1	23.0	0.8	100

difference in relative accuracy, but both of them were superior to Tentative Standard X. Standard X had previously been rejected as impractical for use in a grading system. The suggested Standard B proved superior by this test since it placed 60 per cent of the carcasses accurately within grades by carcass weight and backfat thickness.

Comparison of Dispersions. As indicated previously, about 78% of the variability in per cent of four lean cuts could be explained by the so-called theoretical grade standard. When the 592 carcasses were classified according to each of the proposed grade standards, dispersions about the means of the classes or grades could be determined and compared with that of the theoretical regression surface. The measure selected as most suitable for measurement of these dispersions was the standard error of estimate. With the standard deviation of the entire sample known. the correlation ratio for each of the grade standards could be calculated and compared with that of the theoretical regression surface.

TABLE 19 -- COMPARISON OF DISPERSIONS AND CORRELATION RATIOS FOR VARIOUS GRADE STANDARDS FOR HOG CARCASSES.

Standard	Standard Error of Estimate*	Correlation Ratio	Coefficient of Determination
	S_y	η	η^2
Theoretical Regression Surface	1.8008	.8834	78.04%
Tentative Grade Standard X	2.0252	.8499	72.23%
Grade Standard A	1.9926	.8551	73.12%
Grade Standard B	1.9561	.8608	74.09%

*Standard Deviation (σ) of entire sample was 3.84306

The measures of dispersion and of correlation for the grade standards are shown in Table 19. Grade Standard B had placed the greatest number of carcasses accurately within grades which resulted in lower dispersions about the means of the grades and a higher correlation ratio. This would indicate that Standard B had classified the 592 carcasses into groups of more nearly uniform degree of finish. The difference between the two practical standards, Grade Standards A and B, was not significant.

Tentative Standard X provided more precise margins in backfat thickness and refinement of carcass weight classes than the other two standards. Therefore, a lower dispersion with less standard error of estimate would be expected from Standard X due to the fact that grouping of data with less preciseness as in Standards A and B should introduce errors and enlarge the standard error of estimate. However, the range in per cent of four lean cuts defining degree of finish was the controlling factor. In Standard X this range was a constant 3.0% within grades as compared to appropriate variations for the other standards based upon the relationship of backfat thickness and per cent of four lean cuts with increasing carcass weights. Thus, the standard error of estimate of 2.0252 for Standard X was reduced to 1.9561 for the superior Standard B.

The suggested standard, Grade Standard B, proved to be superior by the two selected tests of performance. This standard placed 60 per cent of the carcasses in the correct grade classification with 38 per cent of the remaining carcasses placed only one grade in error. In the comparison of the dispersions the standard performed satisfactorily. The Theoretical Regression Surface is used as the criterion of comparison since it is the best possible estimate of the final criteria of carcass merit. The amount of the total variability of the percentage of four lean cuts which is accounted for by each of the grade standards is shown in the third column of Table 19. Grade Standard B explained 74% of the variability as compared to 78% for the Theoretical Regression Surface. This reduction of only 4.0% in the coefficient of determination due to accepted errors from grouping of the data would seem to indicate that Grade Standard B does a statistically satisfactory job of classifying hog carcasses according to their degree of finish.

SUMMARY

The objective of this study was to establish and evaluate objective carcass grade standards for slaughter hogs which would classify hog carcasses into relatively homogeneous groups on the basis of physical composition.

The data from which objective grade standards were developed in this study were obtained from 592 carcasses which were individually measured and then subjected to a detailed cut-out test to establish the component composition of each carcass. Carcasses were divided into twelve 10-pound weight groups, with a carcass weight range from 95 to 215 pounds. Within each weight group carcasses were selected with as wide a range of physical variation in finish as possible. The range in finish varied from 20 millimeters to over 60 millimeters of backfat thickness.

Relationships between the several measures and combinations of high value cuts were analyzed. The average backfat thickness maintained an outstanding superiority over the other measures in predicting carcass merit. The four lean cuts (hams, loins, picnics, and butts) were chosen as the basic criterion of carcass merit.

The average simple correlation coefficient of average backfat thickness to the percentage of four lean cuts for the twelve weight groups was —.8426. The backfat thickness was therefore selected as the objective measure to be used with carcass weight as the primary determinant of carcass merit.

Computations provided data which indicated that the percentage yield of four lean cuts could be determined at different carcass weights

and backfat thicknesses. The selected formulae were capable of explaining 78.04% of the total variability in per cent of four lean cuts using only two measures, the average backfat thickness and the carcass weight.

An objective hog carcass grade standard was developed with five grade classifications using a combination of numerical and letter designations. There were four primary weight groups between 90 and 260 pounds carcass weight. The backfat thickness margins for each grade were specified to the nearest one-tenth inch intervals. Approximately 60% of the carcasses were graded correctly by this standard and of the remaining 40%, 38% were placed only one grade in error. The grade standard explained 74% of the total variability as compared to 78% of the theoretical regression surface.

CONCLUSIONS

From the analyses of these data it was concluded that an objective hog carcass grade standard can adequately sort or classify carcasses according to physical differences and indicated values. With the use of two objective measures, the backfat thickness and carcass weight, more than 70% of the total variability in carcass merit as determined by the yield of high value lean cuts could be explained. The development of objective carcass grade standards may provide a more accurate basis for the development of live slaughter hog grades that would sort slaughter hogs more accurately and objectively than do present tentative live grade standards. Payment for slaughter hogs based more nearly upon the yield of individual hog carcasses would provide a monetary incentive for producers to produce the type of hogs with the desired degree of finish.

This study suggests that there is an economic justification for the pricing of slaughter hogs more accurately on the basis of yield of high value cuts. Major observations supporting this conclusion are:

a. There was a wide variation in the percentage composition of component parts for carcasses within the same weight classification.

b. The correlation was highly significant for the objective measures, backfat thickness and carcass weight, to predict the percentage yield of lean cuts.

Additional studies that are recommended include the following:

a. A determination of the feasibility and effectiveness of relating desirable objective physical characteristics of the carcass to the live hog in the form of live animal grades for slaughter swine. This would be an important contribution for improving the present method of sale of slaughter hogs. The Production and Marketing Administration, Livestock Branch, United States Department of Agriculture, proposed in February, 1950, the first tentative standard for grades of slaughter barrows and gilts based on characteristics of the carcasses. This standard attempts to relate certain objective criteria, namely, backfat thickness and conformation, to the live animal. An analysis of the effectiveness of relating these measures to the live animal by visual observations of buyers and sellers needs to be made.

b. This study was based on selections of the sample during the months of February and March. It would be desirable to determine whether or not there are measurable differences in composition of hog carcasses selected throughout the feeding season.

c. A rather broad study might be desirable to determine differences in hog carcasses from animals produced in different geographical areas.

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APPENDIX A

METHODS OF MEASURING HOG CARCASSES

All measurements in millimeters

Length of Body

Measured from the junction of the last cervical and first thoracic vertebrae to the lowest point (as the carcass hangs) of the aitchbone.

Thickness of Backfat—(All backfat measurements to include skin).

Over First Rib—At the junction of the last cervical and first thoracic vertebrae.

Over Last Rib—At the junction of the seventh and eighth vertebrae below the last lumbar (include the last lumbar vertebrae in the count).

Over Last Lumbar—At the center of the last lumbar vertebrae.

Thickness of Belly Pocket

The thinnest portion of the belly opposite the junction of the second and third vertebrae counting down from the pelvic arch. To be measured with a skewer.

Length of Hind Leg

Measured on inside of leg from coronary band to lower end of aitchbone.

Length of Ham

Measured from lowest point of aitchbone to inside of hock joint on the center of the bony projection which may be felt beneath the skin just above (as the carcass hangs) the center of the hock joint itself.

Circumference of Ham

At the midpoint of the ham length measurement. Three or four points around the ham are located equidistant from a plane through a bony projection of the hock used as the upper terminus for measuring the length of ham.

Width Through Ham

Width from top point of aitchbone to the outside of ham on a line parallel to the floor. This measurement is the length of a line perpendicular to the sagittal plane bisecting the carcass. To be measured from rear of the carcass with calipers. Sum of both measurements is recorded.

Width Through Shoulders

Width from center of first thoracic vertebrae to outside of shoulder on a line parallel to the floor. This measurement is the length of a line perpendicular to the sagittal plane bisecting the carcass. To be measured from the rear of the carcass with calipers. Sum of both measurements is recorded.

APPENDIX B

PROCEDURE FOR CUTTING PORK CARCASSES

1. Separate the shoulder from the middle at right angles to the long axis of the carcass, making a 2-rib shoulder. This cut will leave a very small portion of the third thoracic vertebrae on the middle.
2. Separate ham from middle at a point approximately ¾ the distance from the end of the aitchbone to the rise in the pelvic arch and on a line at right angles to the hind leg.
3. Cutting the shoulder:
   a. Remove the neck ribs and bones.
   b. Separate the jowl from the shoulder along a line which barely leaves all of the shoulder muscle intact. This cut is trimmed as a dry salt jowl.
   c. Separate the shoulder butt from the picnic along the depression resulting from removal of the neck bones. This cut results in a rather wedge-shaped butt (Wider on the loin end) and should cut through the shoulder blade at its smallest point.
   d. Pull butts from the plate with a thin, uniform covering of fat not exceeding ½ inch in thickness, the lean seam (false lean) of which is well exposed. Remove any fat in excess of ½" and bevel the edge neatly down to the lean.
   e. The picnic is trimmed by removing the breast flap and lip, loose muscles and blood clots from the inside of the cut. Fat surface around the outside is beveled at about a 45° angle. The front foot is removed just above the knee joint at a point which does not expose the marrow of the leg bones.

4. Cutting the ham:
Remove tail and smooth the flank. Remove shank just above the center of the hock joint at a point which does not expose the marrow of the leg bones. Skin the ham by leaving not more than 1—¼" of fat on any portion of ham from which skin is removed. The fat should be beveled back at least 3" from the butt. The collar should be 50 per cent of the length of the ham.
5. Cutting the middle:
   a. Loin: Remove loin by scribing along a line which extends from the lower side of the tenderloin muscle on the ham end to a point directly below the edge of the chine bone, or deviation therefrom not to exceed ¾". Remove the loin with a loin knife. The false lean muscle over the blade end of the loin should be exposed from a distance of 4 to 5 ribs and the fat on the ham end of the loin should be beveled to the lean. The center of the loin should be covered with an average of about ½ inch fat. Exposure of lean in the center area should be avoided.
   b. Spare ribs including the breast bone are lifted by leaving all cartilages in the belley.
   c. The fat back should be separated from the belly on a straight line which strikes the edge of the lean but not to exceed 1" beyond the scribe line.
   d. The belly is trimmed as a square cut seedless belly. Trim the flank on a line through the forward point of the "boot jack" and at an angle which makes the belly side ¾" longer than the back side of the belly.

APPENDIX C. -- INDIVIDUAL HOG CARCASS DATA.

CARCASS NO. 278 SEX Gilt WEIGHT 168 GRADE___ FAT FIRMNESS Hard

DATE____________

		CUTS		WEIGHT	PER CENT	GRADE
Length	(mm.)	Skd Ham		34.8	20.7	2
Body	781	Picnic		15.4	9.2	2
Ham	395	B. Butt		11.8	7.0	
Hind Leg	563	Loin		29.4	17.5	2
Ham Circ.	462	Total Cuts		91.4	54.4	
Bkfat Thkness		L. Trim-85	1.2		0.7	
1st Rib	46	L. Trim-50	2.3		1.4	
Last Rib	30	Total Trim		3.5	2.1	
Last Lumb.	39	Sq. Belly		28.1	16.7	2
Av.	38	Sub-Total*		123.0	73.2	
Width Ham R.	140	Jowls		4.8	2.9	
L.	143	Fatback		12.3	7.3	
Total	283	Cl. Plate	3.4			
Width Shldr R.	148	Cut Fat	13.2			
L.	135	Tot. Fat Trim		16.6	9.9	
Total	283	Tot. Fat Cuts		33.7	20.1	
Belly Pocket	29	Sp. Ribs		3.9	2.3	
		Neck Bones		3.1	1.8	
		Front Feet		1.7	1.0	
		Hind Feet		2.3	1.4	
		Tail		0.4	0.2	
		Tot. Misc. Cuts		11.4	6.7	
		TOTAL		168.1	100.0	

*Total for lean cuts, trim and belly.

APPENDIX D

See Tables 1 to 4 on pages 55 to 58.

APPENDIX D. -- TABLE 1 -- DISTRIBUTION OF GRADES OF HAMS BY PERCENTAGE OF FOUR LEAN CUTS.

	Per cent of Four Lean Cuts																							
Grade	40-40.9	41-41.9	42-42.9	43-43.9	44-44.9	45-45.9	46-46.9	47-47.9	48-48.9	49-49.9	50-50.9	51-51.9	52-52.9	53-53.9	54-54.9	55-55.9	56-56.9	57-57.9	58-58.9	59-59.9	60-60.9	61-61.9	62-62.9	Total
												Number												
No. 1	1		1	1	6	7	16	15	14	23	31	22	16	19	5	4	1	2	1					185
No. 2	1	1	1	3	12	11	20	13	31	35	31	29	25	18	22	18	10	10	2	2				295
No. 3					1	2			4	1	5	5	9	12	7	14	16	14	7	2	4	1	1	105
Cull									1	1			1				1		2	1				7
Total	2	1	2	4	19	20	36	28	50	60	67	56	51	49	34	36	28	26	12	5	4	1	1	592
												Per cent												
No. 1	50.0		50.0	25.0	31.6	35.0	44.4	53.6	28.0	38.3	46.3	39.3	31.4	38.8	14.7	11.1	3.6	7.7	8.3					31.3
No. 2	50.0	100	50.0	75.0	63.1	55.0	55.6	46.4	62.0	58.3	46.3	51.8	49.0	36.7	64.7	50.0	35.7	38.5	16.7	40.0				49.8
No. 3					5.3	10.0			8.0	1.7	7.4	8.9	17.6	24.5	20.6	38.9	57.1	53.8	58.3	40.0	100	100	100	17.7
Cull									2.0	1.7			2.0				3.6		16.7	20.0				1.2
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

APPENDIX D. -- TABLE 2 -- DISTRIBUTION OF GRADES OF LOINS BY PERCENTAGE OF FOUR LEAN CUTS.

Grade	Per cent of Four Lean Cuts 40-40.9	41-41.9	42-42.9	43-43.9	44-44.9	45-45.9	46-46.9	47-47.9	48-48.9	49-49.9	50-50.0	51-51.9	52-52.9	53-53.9	54-54.9	55-55.9	56-56.9	57-57.9	58-58.9	59-59.9	60-60.9	61-61.9	62-62.9	Total
											Number													
No. 1	2		1	2	8	7	18	17	20	30	33	28	22	22	7	7	4	3	1					232
No. 2		1	1	2	11	12	18	11	28	29	30	25	23	18	21	15	9	11	1	1	1			268
No. 3						1			1		4	3	5	8	5	14	14	12	7	3	3	1	1	82
Cull									1	1			1	1	1		1		3	1				10
Total	2	1	2	4	19	20	36	28	50	60	67	56	51	49	34	36	28	26	12	5	4	1	1	592
											Per cent													
No. 1	100		50.0	50.0	42.1	35.0	50.0	60.7	40.0	50.0	49.3	50.0	43.1	44.9	20.6	19.4	14.3	11.5	8.3					39.2
No. 2		100	50.0	50.0	57.9	60.0	50.0	39.3	56.0	48.3	44.8	44.6	45.1	36.8	61.8	41.7	32.1	42.3	8.3	20.0	25.0			45.3
No. 3						5.0			2.0		5.9	5.4	9.8	16.3	14.7	38.9	50.0	46.2	58.4	60.0	75.0	100	100	13.8
Cull									2.0	1.7			2.0	2.0	2.9		3.6		25.0	20.0				1.7
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

APPENDIX D. -- TABLE 3 -- DISTRIBUTION OF GRADES OF PICNICS BY PERCENTAGE OF FOUR LEAN CUTS.

Grade	Per cent of Four Lean Cuts																							Total
	40-40.9	41-41.9	42-42.9	43-43.9	44-44.9	45-45.9	46-46.9	47-47.9	48-48.9	49-49.9	50-50.9	51-51.9	52-52.9	53-53.9	54-54.9	55-55.9	56-56.9	57-57.9	58-58.9	59-59.9	60-60.9	61-61.9	62-62.9	
												Number												
No. 1			1	1	4	7	15	14	11	27	31	25	25	21	5	6	4	4	1					202
No. 2	2	1	1	3	14	11	19	14	35	29	32	24	20	16	19	15	8	11	2	2				278
No. 3					1	2	2		4	3	4	7	5	12	10	15	15	11	8	2	4	1	1	107
Cull										1			1				1		1	1				5
Total	2	1	2	4	19	20	36	28	50	60	67	56	51	49	34	36	28	26	12	5	4	1	1	592
												Per cent												
No. 1			50.0	25.0	21.0	35.0	41.7	50.0	22.0	45.0	46.2	44.6	49.0	42.9	14.7	16.6	14.3	15.4	8.3					34.1
No. 2	100	100	50.0	75.0	73.7	55.0	52.8	50.0	70.0	48.3	47.8	42.9	39.2	32.6	55.9	41.7	28.6	42.3	16.7	40.0				47.0
No. 3					5.3	10.0	5.5		8.0	5.0	6.0	12.5	9.8	24.5	29.4	41.7	53.6	42.3	66.7	40.0	100	100	100	18.1
Cull										1.7			2.0				3.5		8.3	20.0				8
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

APPENDIX D. -- TABLE 4 -- DISTRIBUTION OF GRADES OF BELLIES BY PERCENTAGE OF FOUR LEAN CUTS.

	Per cent of Four Lean Cuts																							
Grade	40-40.9	41-41.9	42-42.9	43-43.9	44-44.9	45-45.9	46-46.9	47-47.9	48-48.9	49-49.9	50-50.9	51-51.9	52-52.9	53-53.9	54-54.9	55-55.9	56-56.9	57-57.9	58-58.9	59-59.9	60-60.9	61-61.9	62-62.9	Total
												Number												
No. 1				1	5	5	17	14	14	26	36	25	22	18	5	5	3	1	1					198
No. 2	2	1	2	3	12	14	15	11	28	30	24	27	20	16	16	11	6	7	1	1				247
No. 3					2	1	4	3	8	3	7	4	8	13	12	19	16	18	5	1	3	1	1	129
Cull										1			1	2	1	1	3		5	3	1			18
Total	2	1	2	4	19	20	36	28	50	60	67	56	51	49	34	36	28	26	12	5	4	1	1	592
												Per cent												
No. 1				25.0	26.3	25.0	47.2	50.0	28.0	43.3	53.7	44.6	43.1	36.7	14.7	13.9	10.7	3.9	8.3					33.4
No. 2	100	100	100	75.0	63.2	70.0	41.7	39.3	56.0	50.0	35.8	48.2	39.2	32.7	47.1	30.5	21.4	26.9	8.3	20.0				41.7
No. 3					10.5	5.0	11.1	10.7	16.0	5.0	10.5	7.2	15.7	26.5	35.3	52.8	57.2	69.2	41.7	20.0	75.0	100	100	21.8
Cull										1.7			2.0	4.1	2.9	2.8	10.7		41.7	60.0	25.0			3.1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100