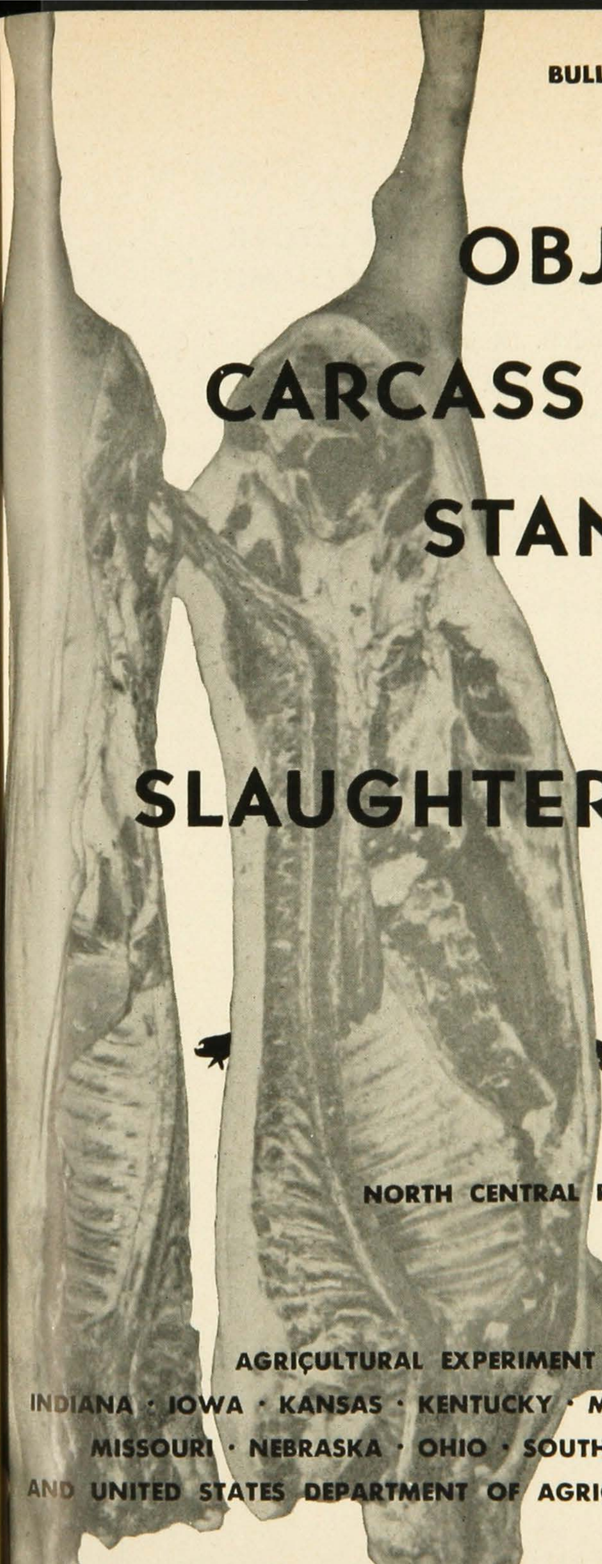
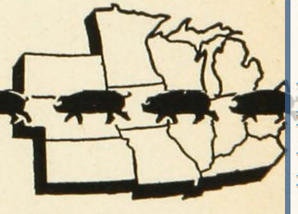
BULLETIN 414 JUNE 1952

OBJECTIVE CARCASS GRADE STANDARDS FOR SLAUGHTER HOGS





NORTH CENTRAL REGIONAL PUBLICATION

NUMBER 30

AGRIÇULTURAL EXPERIMENT STATIONS OF ILLINOIS
INDIANA · IOWA · KANSAS · KENTUCKY · MICHIGAN · MINNESOTA
MISSOURI · NEBRASKA · OHIO · SOUTH DAKOTA · WISCONSIN
AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

Agricultural Experiment Station
University of Minnesota

NORTH CENTRAL LIVESTOCK MARKETING RESEARCH COMMITTEE

Administrative Adviser: I. B. Johnson, South Dakota.

Executive Committee: Austin A. Dowell, Chairman; Knute Bjorka (deceased); Gerald Engelman; James R. Wiley; Geoffrey S. Shepherd; Elliott S. Clifton.

Members from Participating States: Indiana, James R. Wiley; Iowa, Geoffrey S. Shepherd, Elliott S. Clifton; Michigan, Lawrence W. Witt, Lyman Bratzler, Robert C. Kramer; Minnesota, Austin A. Dowell; Missouri, Elmer R. Kiehl; Ohio, George F. Henning.

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United States Department of Agriculture Cooperators: Bureau of Agricultural Economics, Knute Bjorka (deceased), Gerald Engelman; Bureau of Animal Industry, Orville G. Hankins; Production and Marketing Administration—Livestock Branch,* Fred J. Beard.

* The Livestock Branch of the Production and Marketing Administration, United States Department of Agriculture, assisted in the formulation of cutting procedures, advised on the type of carcass measurements taken, and graded certain of the pork cuts included in the study.

CONTENTS

Approved for publication April 28, 1952

10M—4-52

FOREWORD

FOR MANY YEARS the livestock industry has been interested in grade standards for slaughter hogs that might be marketed on foot or on a carcass weight and grade basis. Livestock producers, county agents, and farm groups have requested more detailed information about marketing slaughter livestock by carcass weight and grade, and state and federal agencies have been asked to obtain more facts about this system.

Four of the state experiment stations in the cornbelt have conducted research in this field. However, these stations, as well as others in the cornbelt, felt that the problem required a regional approach, since type, quality, and condition of livestock vary from area to area. Consequently in 1948 the North Central Livestock Marketing Research Committee initiated a regional research approach to the problem, obtaining the cooperation of some of the packers.

The Regional Committee recognized first of all that objective grade standards had to be developed so that differences in the quality and value of hog carcasses could be measured. The research dealing with slaughter hogs has been conducted by the experiment stations in Indiana, Iowa, Michigan, Minnesota, Missouri, and Ohio, with the United States Department of Agriculture cooperating.

This publication offers facts that can be used in the improvement of grade standards for slaughter hogs, either live or in the carcass. These grade standards and the observations of committee members, both here and abroad, are discussed in Part I. The more technical analytical procedures of the objective grade research constitute Part II.

I. B. JOHNSON
Administrative Adviser

Objective Carcass Grade Standards

FOR SLAUGHTER HOGS

by the North Central Livestock Marketing Research Committee

SUMMARY

WITHIN THE SAME weight range butcher hogs usually sell at about the same price per hundredweight at given markets in the United States. Because little attention is given to quality in pricing hogs, producers have little incentive to improve the hogs they market.

Grade standards have been proposed at various times for barrows and gilts and for pork carcasses and cuts. But unlike the standards for beef, veal, and lamb the grade specifications for hogs, pork carcasses, and pork cuts have had only a very limited acceptance in the trade. This may be because relatively few pork carcasses enter the wholesale trade as carcasses in this country. In most cases they are disassembled into wholesale cuts before sold by packers.

One reason standards for the pork cuts have not found acceptance is the fact that a large proportion of pork meets consumer demand for quality. Consumers are more likely to object to pork with excess fat than they are to pork inadequately finished—of which they see very little.

Without satisfactory carcass standards it is difficult to have satisfactory live standards, since live grades only reflect the expected carcass grades.

This study was limited largely to developing objective carcass grade standards which would classify hog carcasses into relatively homogeneous groups based on the physical characteristics which determine value.

Individual carcass data were obtained on more than 3,200 hog carcasses from six packing plants cooperating with the states of Indiana, Iowa, Michigan, Minnesota, Missouri, and Ohio. Measurements recorded by all states included body length and average backfat thickness, and a number of states took other measurements. After measuring, each carcass was cut out to determine the proportion of each of the various wholesale cuts and trimmings to the carcass as a whole.

Detailed statistical analyses were applied to these data to determine which measure or measures could be used to estimate the percentage of high-value lean cuts: hams, loins, butts, and picnics, in the carcass. These cuts comprise approximately half of the carcass weight and in recent years have contributed about two-thirds of the composite carcass value.

In each of the six states average backfat thickness proved to be the best single measure in explaining variations

[1] This report was prepared by Gerald Engelman in close cooperation with the Executive Committee and in collaboration with all members of the North Central Livestock Marketing Research Committee.

in the percentage of lean cuts. Body length appeared to be second, and other measures were less important. At any specific carcass weight the use of average backfat thickness and body length gave little improvement over the use of backfat alone in predicting the percentage of lean cuts. For that reason major emphasis in this study was placed on backfat thickness and carcass weight in the determination of objective specifications for the grade standards suggested for butcher hog carcasses.

On the basis of the relationships between percentage of lean cuts and average backfat thickness at varying carcass weights, tables were prepared showing the expected percentages of lean cuts for all weights of hog carcasses within the normal marketing range and for all variations of backfat thickness at these carcass weights.

A tentative carcass standard was prepared by combining carcass weights and backfat thicknesses into weight and grade groups, each with a specified range of carcass weights and backfat thicknesses. This standard objectively classifies carcasses into five categories of finish: Grade 8 carcasses are very fat with a relatively low percentage of lean cuts. Grade 9 carcasses are moderately overfinished. Grade 10 is the presumably optimum grade as far as finish is concerned.

Grade 10 carcasses are generally more valuable than Grade 8 and 9 carcasses because they yield more high-value lean cuts and less fat, which usually has a lower relative value as lard. Grades 11 and 12 are the underfinished and extremely underfinished grades respectively. They will yield a higher proportion of lean cuts than Grade 10 carcasses, but increased proportions of these cuts will lack adequate finish.

The economic significance of carcass standards depends on the differences in carcass value between the several weight and grade groupings. These differences will depend on the average carcass composition within each of these groupings and the relative prices of the several wholesale cuts and trimmings which make up the carcass. In general, the greater the margin between lard prices and prices of the high-value lean cuts, the greater will be the discounts for the overfinished grades. Similarly the greater the discounts for the heavier weights of certain wholesale cuts, such as hams, loins, bellies, and picnics, the greater will be the discounts for the heavier weights of carcasses. Among the more than 3,200 carcasses included in the study, the value differences between the overfinished grades and the presumably optimum grade averaged 75 cents per hundredweight per grade at 1949 average prices for the several wholesale cuts and trimmings.

Hog carcass grade standards, such as those developed in this study, could be used as the basis of an improved system of marketing hogs by live grade at livestock markets. They could also be used as the basis for marketing hogs by carcass weight and grade.

Part I. Principal Findings

Part I of this bulletin discusses the principal findings of the study. Part II gives a more technical discussion of the analytical procedures.

INTRODUCTION

SLAUGHTER HOGS are commonly sold in the United States by liveweight groups with relatively little emphasis given to quality in the bargaining process. There is a rather general tendency for all hogs of the same weight range, except for gilts and sows advanced in pregnancy and hogs with obvious defects, to sell at about the same price per hundredweight. Hogs of less than average value are carried along by those above average in value and nearly at the same price.

Under such conditions hogs producing high-value carcasses often do not command the appropriate differential over less valuable animals. The producer of hogs is not given an adequate incentive to improve the quality of the product brought to the market place.

Efforts at Improvement

Developing Standards

Efforts to improve the marketing of hogs through the use of grade standards have been made for some time. During the last half of the nineteenth century work on standards was carried on by private individuals and organizations who prepared current market reports and wished to make these reports intelligible to other marketing interests over the entire market area. During the present century public agencies, including state agricultural experiment stations and several bureaus of the United States Department of Agriculture, have also undertaken this work. Throughout the entire period considerably more emphasis has been placed on the development of classifications for live hogs than for hog products, but since the first World War an increasing amount of attention has been given to pork carcasses and wholesale pork cuts.

The specifications for the tentative standards which were developed and proposed during the period up to World War II were primarily subjective or descriptive in nature. These tentative standards for wholesale pork cuts, pork carcasses, and slaughter hogs found little acceptance among market interests.

Objective standards for pork carcasses were first proposed by the United States Department of Agriculture in 1949. In 1951 standards were proposed for slaughter barrows and gilts and their carcasses, based primarily on carcass measurements. While only tentative standards have been actually issued for pork cuts, pork carcasses, and slaughter hogs official United States standards have been issued for beef, veal, calf, lamb, yearling mutton, and mutton carcasses, and for slaughter cattle, vealers, calves, and slaughter lambs, yearlings, and sheep.

One of the reasons grade standards for pork cuts have not been in demand by the trade is the fact that, unlike the situation with respect to beef, veal, and lamb, a large proportion of these pork cuts meets the minimum standards of quality and finish consumers desire.

After a certain point is reached the added finish on pork cuts is no longer associated with increased palatibility, tenderness, or flavor of the meat. Consumers are more likely to object to pork with excess fat deposited within and around the muscle tissues than they are to pork inadequately finished, which they seldom see on the market.

Another reason that pork carcass standards have not come into general usage in the United States is the fact that very little of the processed pork enters the wholesale trade in the form of carcasses, as is typical for beef, veal, and lamb carcasses. Most of the carcasses from slaughter hogs are disassembled into a number of wholesale cuts and trimmings in the same plant in which the animals are killed. These products, rather than carcasses, are merchandised in the wholesale trade.

And without adequate carcass standards it is difficult to have satisfactory live hog grade standards. To serve its purpose effectively a grade standard must classify commodity units, which may vary widely, into classes or groups that have similar characteristics. One necessary attribute of a good grade standard is that it must be consistent: any two individuals grading the same objects should place them in the same grades. In fact, grades should not differ among individual graders, geographical areas, or periods of time. Grading on the basis of a subjective standard, however, does not always succeed in being consistent. The development of an objective grade standard, therefore, was one of the prime considerations of this study.

In the case of beef, veal, and lamb, live standards are essentially a reflection of carcass standards. It follows that if live standards for market hogs are to have economic significance they must be based on hog carcass standards which are of economic significance.

In evaluating live animals graders attempt to estimate the resulting carcass grade when the animals are slaughtered. The evaluation process is more difficult on the live animal than on the carcass because the live animal is one step further removed from the wholesale products which determine value. Differences in the relative proportions and qualities of the several wholesale cuts can be more easily detected by examining the carcasses than by looking at the live hog.

An added complication in the evaluation process on live hogs is the variation of carcass yields among hogs that appear to be quite similar in conformation, finish, and quality. These differences in yields are also difficult to detect by looking at the live hog.

Some Alternative Methods of Sale

A few attempts have been made to improve on the usual liveweight method of marketing hogs in this country. One such attempt was sale on the basis of guaranteed yield.

In 1923 a federation of county livestock marketing cooperatives in Ohio and Indiana initiated the sale of hogs to eastern slaughterers on the basis of guaranteed yields. Different owners' hogs were assembled, sorted into fairly uniform lots, commingled, and shipped in full double-deck carloads direct to eastern slaughterers. Each carload was sold at a specific price for a particular yield, and this yield was guaranteed by the managers of the local associations. Carcasses were weighed by employees of the plants in which the hogs were slaughtered. Final settlement was made for each shipment on the basis of a previously decided adjustment for any divergence between the guaranteed and actual yields.

This plan proved to be popular for a time and appeared to be an improvement in some respects over the usual liveweight method of sale. Nevertheless it was ultimately discontinued in the 1930's. One difficulty arose because the local managers were unable to estimate dressing yields accurately. Yields in excess of the guaranteed yields were accepted by farmers as desirable windfalls, but yields below the estimates of the managers were often resented. Since the yield was generalized over the entire load, which usually included hogs from several owners, some farmers who believed they delivered high-yielding hogs to the association felt they did not receive all that was due them.

Furthermore, since a representative of the seller was not present at the time the carcasses were weighed, some of the owners who had expected higher than reported yields tended to question the accuracy of the carcass weights. This method of sale was relatively short-lived.

Another attempt to improve hog marketing methods was initiated by a southern Minnesota meat-packing company in 1933. At first, payment was made to farmers for hogs on the basis of the value of the wholesale cuts. The method required that the wholesale cuts from each lot of hogs be segregated, weighed, and recorded. Since this process reduced the speed of cutting operations and increased processing costs, the plan was considered to be impractical and was discontinued during the same year.

The following year this company began to buy hogs experimentally by carcass weight and grade. On the basis of their experience, in 1940 this firm established four subjective carcass grades: No. 1—Prime or top grade, No. 2—Overfinished, No. 3—Underfinished, and No. 4—Scalawag or scrub.

No. 1 carcasses were moderately well finished and had a relatively high percentage of the high-value cuts of the carcass. The No. 2 overfinished carcasses were discounted because they carried a higher percentage of fat and a relatively smaller percentage of the high-value cuts. The No. 3 and No. 4 underfinished carcasses were discounted because they yielded hams, loins, bellies, and other cuts so lacking in quality that they had to be merchandised as inferior brands or in some cases utilized as trimmings.

This subjective grade standard represents the first effort in the United States to classify hog carcasses on the basis of a relationship between the degree of finish and the value of the carcass. Underfinished carcasses, although they had a high proportion of lean, were discounted because they tended to yield wholesale cuts lacking in quality. Carcasses with a desirable degree of finish yielded cuts of first grade quality and did not yield an excessive amount of lard. Overfinished carcasses, on the other hand, were to be discounted, not primarily because their cuts lacked quality but because they yielded a high proportion of relatively low-value lard in relation to the yield of high-value wholesale cuts.

The proportion of hogs purchased on the carcass weight and grade method by this packer was always quite small. The actual numbers, however, increased regularly each year until the plan was discontinued in 1943 because price ceilings established by the World War II price-control agency did not permit a premium on No. 1 carcasses. This firm believed that the subjective grade standards did not adequately reflect value differences in hogs, and that greater precision was desirable in grade standards, perhaps embodying objective, quantitative criteria as determinants of carcass grade.

It is apparent that attempts which have been made in the United States to establish satisfactory criteria of merit for hogs and hog carcasses have not been completely successful. The problem appears to be more difficult than in some other countries such as Canada, the United Kingdom, Denmark, Holland, Sweden, and some other western European countries. There, most of the carcasses move into the wholesale trade in the form of sides rather than in the form of wholesale cuts and processed meats.

In the search for an equitable method of pricing hogs these countries have adopted rail grading and settlement on the basis of carcass weights and grades. Carcasses are graded largely according to objective or quantitative criteria, which include carcass weight, backfat thickness, and in some cases carcass length. They are graded on the rail after the viscera are removed and the back split but before the carcasses are moved from the killing floor to the chill room. In addition to objective or quantitative measures, the grader may also make a subjective or qualitative evaluation of certain characteristics which may influence the grade into which the carcass is finally placed.

OBJECTIVES OF THE STUDY

Satisfactory carcass grades are an essential prerequisite to the improvement of pricing accuracy in marketing hogs, whether they are sold by liveweight or by carcass grade and weight. One approach to the problem in the United States is to develop objective carcass standards that will serve to differentiate carcasses on the basis of the weight and grade of wholesale cuts and trimmings they are expected to yield.

This study will not answer the question of whether or not slaughter hogs should be sold by carcass weight and grade in the United States. The desirability of the carcass method of marketing largely depends on its relative pricing accuracy as compared with the present or an improved liveweight method. Questions of practicability include the problems of identifying, weighing, and grading the carcasses, delay in making settlement with owners, and relative cost.

Relatively little attention was given to several of these problems in this study. The study was limited largely to the establishment of objective carcass grade standards which will make it possible to distribute hog carcasses into relatively homogeneous groups with respect to the characteristics of physical composition which determine value.

Table 1. Number of Carcasses Cut Out by Weight Group from Each of Six States

Carcass weight	States						
	Indiana	Iowa	Michigan	Minnesota	Missouri	Ohio	Total
	number of carcasses						
95-105	40	....	....	....	22	....	62
105-115	55	49	....	....	45	17	166
115-125	57	49	....	79	46	35	266
125-135	59	51	....	85	49	38	282
135-145	58	50	75	75	57	39	354
145-155	62	52	58	75	62	31	340
155-165	71	49	37	95	54	25	331
165-175	57	50	59	82	53	30	331
175-185	73	51	46	72	45	41	328
185-195	63	51	....	50	56	33	253
195-205	59	49	....	45	54	35	242
205-215	47	52	....	37	49	31	216
215-225	....	47	....	....	....	....	47
Total	701	600	275	695	592	355	3,218

SOURCE AND CHARACTER OF THE DATA

Basic data for the analysis underlying development of grade standards for hog carcasses were obtained at six packing plants cooperating with the states of Indiana, Iowa, Michigan, Minnesota, Missouri, and Ohio. Several measurements were taken of carcasses while they were hanging in the coolers. After being measured the carcasses were moved to the cutting floor and subjected to a detailed cut-out procedure (Appendix B).

Selection of Carcasses

Data were obtained on hog carcasses which included a wide range of physical variation. In general each state attempted to cover the range of weights for butcher hogs marketed within the state. Each state selected its carcasses by 10-pound weight groups. The distribution of carcasses by carcass weight from each state is shown in table 1. The purpose of selecting carcasses in this manner was to permit an analysis in which it would be possible to estimate relationships of certain physical measures. One example is the relationship between backfat thickness and the percentage of the four lean cuts, hams, loins, picnics, and butts.

A given change in backfat thickness, for example, can be expected to have considerably more effect on the percentage of high-value cuts on 120-pound carcasses than on 200-pound carcasses. A part of the anticipated problem was to measure that change in relationship.

Since the basic approach contemplated the use of relationships between measurable variables it was necessary to obtain as wide a range and as uniform a distribution of degree of finish within each weight group as possible.

Data were collected by the cooperating states over a period of several years. Most of the Minnesota data used in this study were collected in August and September 1946, but small numbers of carcasses were processed at irregular intervals up to March 1947. Iowa data were collected during June and July 1948, Ohio in June, July, and October 1948 and May 1949, Missouri in February and March 1949, Indiana in March through July 1949, and Michigan in May and June 1949.

Taking state samples at different periods of time and seasons tends to complicate the pooling of the states' data into a single sample. A more thorough discussion of the causes of state differences is in footnote 9, page 32.

Carcass Measurements

All carcass measurements were taken from the cold carcass hanging in the coolers. Measurements recorded by all states included body length and backfat thickness at the first rib, last rib, and last lumber vertebra (see figure 1). Most states also included length of hind leg, length of ham, circumference of ham, width through ham and shoulders, and belly pocket thickness. A detailed description of the various measurements is given in Appendix A. All measurements were recorded in millimeters to simplify analysis.

Cutting the Carcasses

In the several cooperating packing plants hog carcasses were moved through the cutting room at rates varying from 250 to more than 1,100 carcasses per hour. Since in most cases some 14 components of each carcass were weighed and recorded, it was obviously impractical to attempt to collect the information during a regular cutting operation. Because of the speed with which carcasses are disassembled, the points on the carcass at which the cuts were separated from each other vary considerably, resulting in a con-

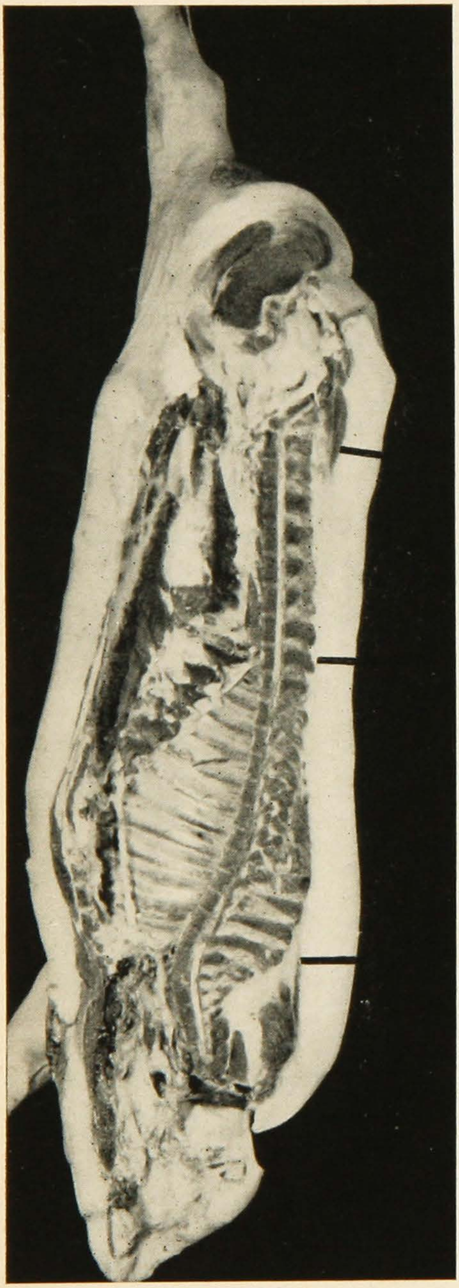

FIG. 1. Backfat thickness was measured at the three points shown above (see Appendix A). Average backfat thickness of any given carcass is the average of these three measurements.

siderable variation in the size or weight of the same cuts from identical carcasses.

This study, however, was concerned with actual physical differences between carcasses rather than with the variation in the accuracy with which hog carcasses are cut in a given packing plant or with the cutting differences between plants. It was therefore considered advisable to standardize the cutting procedure and to apply it to each carcass at a reduced rate of speed. A selected group of skilled workmen performed the cutting job.

A standard cutting procedure, outlined in Appendix B, was prepared with the assistance of representatives of the meat-packing industry. Subsequent analysis indicated that the attempt to enforce a standard cutting method for experimental purposes over a number of widely separated packing plants owned by different firms may have been too ambitious an undertaking. It was apparently difficult for cutters accustomed to a particular system of cutting to alter that method in order to comply with an unfamiliar method. Nevertheless it was believed that the consistency of cutting within any given plant was adequate for purposes of analysis.

Recording Primary Data

Information concerning each carcass was transcribed to a card such as is shown in figure 2. Measurements in millimeters were entered at the left. Weights of the various cuts and trimmings are recorded as well as the carcass percentage of each item. Cuts and trimmings are grouped together according to similarity of type and use. The four lean cuts, skinned hams, loins, picnics, and butts—all high-value cuts—are grouped together.

In the same figure regular lean trimmings and bellies were entered singly. Other groupings included the fat cuts, trimmings, and miscellaneous skeletal cuts. With the exception of data from

NO. 210 SEX B WEIGHT 135 GRADE ______ DATE 14 JAN, 47

LENGTH	
BODY	663
HAM	354
BKFAT THKNESS	
1 ST RIB	68
LAST RIB	45
LAST LUMB.	35
AV.	49
WIDTH HAM R.	136
L.	139
TOTAL	275
WIDTH SHLDR. R.	142
L.	147
TOTAL	289
BELL. POCKET	24

CUTS	WEIGHT	PER CENT	GRADE	PRICE	VALUE
SKD. HAM	24 10	18.3			
PICNIC	13 2	10.1			
B.BUTT	7 13	5.8			
LOIN	21 2	15.7			
SUBTOTAL	66 15	49.9			
REG. TRIM	5 2	3.8			
SQ. BELLY	19 8	14.5			
FAT BACK	13 5	11.4			
D. S. JOWELS	4 8	3.4			
FAT TRIM	13 4	9.9			
SUBTOTAL	33 1	24.7			
SP. RIBS	3 3	2.3			
NECK BONES	2 8	1.8			
FRNT. FEET	1 2	1.2			
HIND FEET	2 2	1.5			
TAIL	6	.3			
SUBTOTAL	9 2	7.1			
TOTAL	134 3	100.0			

FIG. 2. Individual hog carcass data card.

one state the sum of the weights of the various cuts and trimmings was used as the base from which percentages were calculated.

DETERMINING ESSENTIAL RELATIONSHIPS

The primary data for the development of quantitative standards for hog carcasses include the individual carcass measurements and the weights of the several wholesale cuts and trimmings. The problem of analysis is to determine relationships between certain carcass measurements and some combination of the more valuable wholesale cuts which may be used as a criterion of carcass desirability.

Several combinations of high-value cuts were suggested as the primary criterion of carcass merit. They included (1) the four principal lean cuts —hams, loins, Boston butts, and picnics; (2) the four lean cuts and the lean trimmings; (3) the four lean cuts, the lean trimmings, and the bellies; (4) the four lean cuts and the bellies.

All of these combinations have been used as criteria of carcass merit. Available statistical evidence, however, does not conclusively indicate the superiority of any one of these measures over the other three.

The hams, loins, Boston butts, and picnics are high-value lean cuts quantitatively associated with each other when related to the degree of finish. Lean trimmings are usually high in value and are positively associated with the lean cuts. The bellies, although negatively associated with the lean cuts, are nevertheless high-value cuts. However, the trimming of bellies is subject to considerable variability among packing plants. Similarly, various amounts of several types of lean trimmings, ranging from 50 to 95 per cent lean, are processed from hog carcasses at different packing plants.

It was believed that the combination of the four lean cuts offered the

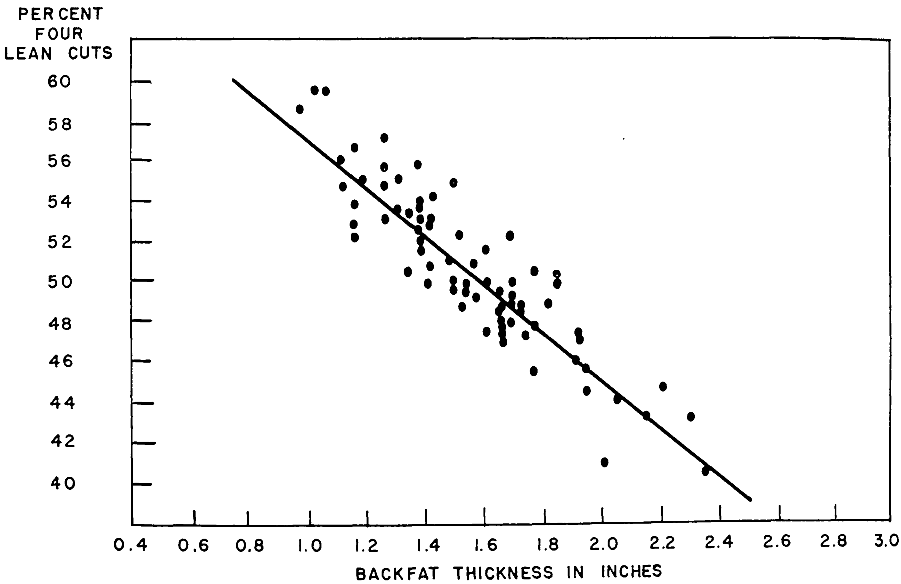

FIG. 3. Relationship between average backfat thickness and the percentage of four lean cuts for a sample 145-155 weight group from one state. Each dot shows the two measurements of one carcass.

greatest possibility for standardization over the region and would be the most consistent statistical measure in the sense that its component members were quantitatively associated with each other with changing degrees of finish. Also, in 1949 the four lean cuts were worth about four times as much per pound as fat rendered into lard.[2]

For these reasons the percentage of four lean cuts was selected as the criterion of carcass merit for the regional analysis. Other combinations might give equally satisfactory results in an analysis of carcasses processed at any one packing plant.

The percentage of the carcass which is made up of the four lean cuts—hams, loins, picnics, and butts—is a quantitative objective measure of the degree of finish. Instead of being described as very fat, fat, moderately fat, moderately lean, or lean, carcasses may be classified by measurable percentages of lean cuts, such as 44.0 per cent, 46.0 per cent, 48.0 per cent, 50.0 per cent, or 52.0 per cent. This measure varies inversely with the degree of finish; that is, fat carcasses have a low percentage of lean cuts while lean carcasses have a high percentage. The problem in establishing objective grade standards is to provide measures for evaluating hog carcasses according to their expected percentages of lean cuts before they have been disassembled on the cutting floor.

As indicated previously a number of carcass measurements were recorded during the collection of data. Several states conducted exploratory investigations into the relative suitability of the different measures. This exploratory work indicated that at any particular

[2] At 1949 prices the weighted value of the lean cuts was 41.8 cents per pound. Fat rendered into lard was worth 9.6 cents per pound.

carcass weight, backfat thickness held a predominant superiority over other measures in its ability to predict the percentage of four lean cuts. Body length appeared to be second to backfat.

However, there was little improvement over the use of backfat thickness alone when body length and backfat thickness were both used to predict the percentage of lean cuts.[3] Consequently the backfat measure was used as the primary determinant of carcass merit in the development of a carcass grade standard for butcher hogs. Correlation coefficients (measures of relationships) between average backfat thickness and percentage of four lean cuts are shown for all 10-pound weight groups in table 2 on this page.

Figure 3 illustrates the relationship between average backfat thickness and per cent lean cuts for the 145–155-pound weight group for one state. The negative relationship is apparent. Backfat thickness ranged from 1.0 to 2.4 inches. Within that range the regression line (the line expressing the average relationship) indicates that the expected or predicted percentage of lean cuts would vary from 40.6 per cent at the 2.4-inch or fat extreme to 58.5 at the 1.0-inch or lean extreme.

This same negative relationship between average backfat thickness and percentage of lean cuts was characteristic of all weight groups included in the study. The relationship did not exist to the same degree in all cases. Within the weight group of any given state, re-

[3] Other measures tested are listed in Appendix A.

Table 2. Correlation Coefficients Between Average Backfat Thickness and Per Cent Lean Cuts, for Each State by Weight Groups

	States													
	Indiana		Iowa		Michigan		Minnesota		Missouri		Ohio		Region	
Weight group	Number	Correlation	Number	Correlation	Number	Correlation	Number	Correlation	Number	Correlation	Number	Correlation	Number	Correlation
95-105	40	.876	......	......	......	......	......	......	22	.756	......	......	......	......
105-115	55	.811	49	.905	......	......	......	......	45	.846	17	.789	......	......
115-125	57	.870	49	.916	......	......	79	.890	46	.864	35	.691	......	......
125-135	59	.765	51	.874	9*	.551	85	.777	49	.812	38	.853	......	......
135-145	58	.873	50	.907	75	.724	75	.925	57	.855	39	.884	......	......
145-155	62	.822	52	.904	58	.666	75	.904	62	.876	31	.688	......	......
155-165	71	.734	49	.923	37	.752	95	.885	54	.839	25	.723	......	......
165.176	57	.878	50	.863	59	.605	82	.896	53	.784	30	.810	......	......
175-185	73	.840	51	.853	46	.715	72	.863	45	.845	41	.792	......	......
185-195	63	.910	51	.923	14*	.772	50	.771	56	.811	33	.498	......	......
195-205	59	.850	49	.904	......	......	45	.710	54	.879	35	.703	......	......
205-215	47	.848	52	.910	......	......	37	.814	49	.857	31	.706	......	......
215-225	......	......	47	.847	......	......	......	......	......	......	10*	.595	......	......
225 and up	......	......	......	......	......	......	......	......	......	......	9*	.919	......	......
Total	701		600		298		695		592		374		3,260	
Average correlation		.841		.895		.688		.864		.838		.756		.840
Coefficient of determination		70.8%		80.1%		47.4%		74.6%		70.2%		57.2%		70.5%

* These weight groups were not included in the analysis underlying the development of the carcass specifications.

gression lines for the heavier weight groups tended to lie to the right of those for the lighter weight carcasses. In other words, at any particular percentage of lean cuts the heavier carcasses had more backfat thickness.

Also, within weight groups the slopes of the lines for the heavier weight groups tended to be less steep than the slopes of the regression lines for the lighter weight groups. A given difference in backfat (such as the difference between 1.5 and 2.0 inches) had a greater effect on percentage of lean cuts in light-weight carcasses than the same difference had in heavy carcasses.[4]

A CARCASS GRADE STANDARD

The primary objective in establishing grade standards is to provide a method of grouping carcasses having similar physical characteristics together in the same grade classification regardless of their difference in weight. The method used for hog carcasses is to establish specifications which may be used to group together hog carcasses which have a similar composition in terms of finish and also percentage of lean cuts—normally the highest-value components of hog carcasses. The regression line in figure 3 demonstrates the relationship between average backfat thickness and per cent lean cuts at a given carcass weight in one state's sample. What is needed is a series of such relationships at various carcass weights, not from one state alone, but the best estimate of these relationships from a sample of hog carcasses taken

[4] These varying relationships between backfat thickness and per cent lean cuts are illustrated in figure 7 of Part II (page 31).

Table 3. Tentative Objective Hog Carcass Grade Specifications*

		Carcass grades*				
		8	9	10	11	12
Per cent lean cuts—at midpoints			47.0	50.0	53.0	
—at margins		45.5	48.5	51.5	54.5	

Carcass weight groups	Midpoint weight	Backfat thickness (8–9, 45.5)	Backfat thickness (9–10, 48.5)	Backfat thickness (10–11, 51.5)	Backfat thickness (11–12, 54.5)
pounds		inches			
90-110	100	1.90	1.66	1.37	1.15
110-130	120	1.99	1.72	1.42	1.17
130-150	140	2.07	1.77	1.46	1.18
150-170	160	2.14	1.81	1.49	1.18
170-190	180	2.21	1.85	1.52	1.18
190-210	200	2.27	1.88	1.54	1.19
210-230	220	2.33	1.91	1.56	1.19
230-250	240	2.38	1.94	1.57	1.19

* Numbers are used to designate the hog carcass grades because a continuous change in a given direction is not related to a continuous increase or decrease in value. In the cases of beef, veal, and lamb carcasses, the most desirable grade, Prime, is at one extreme of the range in terms of finish, conformation, and quality. This is not true with respect to hog carcasses. The most desirable hog carcass grade is somewhere between the extremes of overfinish and compactness on one hand and the extremes of underfinish and ranginess on the other. Under such circumstances neither name grades, such as Prime, Choice, Good, or Commercial, which are used for beef, veal, and lamb, nor the usual number grades such as 1, 2, 3, 4 appear to be appropriate. For that reason the presumably optimum grade was designated as Grade 10. Grade designations under 10 are reserved for those carcasses with excess finish, while grade designations over 10 are for underfinished carcasses.

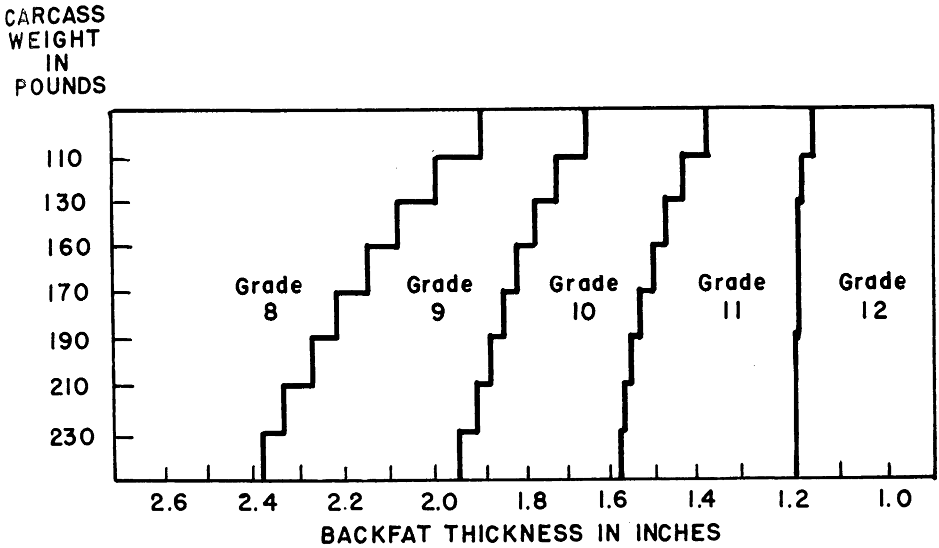

FIG. 4. Tentative objective hog carcass grade specifications illustrated.

from several packing plants in several states.

The manner in which the essential relationships between backfat thickness and per cent lean cuts were used to develop and provide the tabular information on which objective specifications for grade standards could be based is discussed more fully in Part II. A tentative objective hog carcass grade standard, shown in table 3, classifies carcasses into five objective categories of finish through the combined use of average backfat thickness and carcass weight.

Figure 4 is a graphic illustration of the grade standard. Grade 8 carcasses are very fat, as indicated by the backfat specifications. Grade 9 carcasses are moderately overfinished. Grade 10 is the presumably optimum grade as far as finish is concerned. Grades 11 and 12 are the underfinished and extremely underfinished grades respectively. Examples of Grades 8 and 10 are shown in figure 5, and cuts from the various grades are shown in figure 6.

Each grade encompasses a range in finish equivalent to 3.0 per cent lean cuts (except the extreme Grades 8 and 12, which are open-end grades). And each carcass-weight group encompasses a range of 20 pounds carcass weight—roughly equal to 30 pounds on the liveweight basis.

The backfat specifications which separate Grade 8 from Grade 9 carcasses and those which separate Grade 9 from Grade 10 carcasses have been interpolated from table 13, which is presented in Part II.[5] These are the backfat specifications which separate the overfinished carcasses from those with optimum finish and classify overfinished carcasses into two separate grades. The two overfinished margins are the more important since a larger proportion of butcher hogs coming to

[5] For example, the backfat specifications at the margin between Grades 8 and 9 were taken from points midway between the 45.0 and 46.0 per cent columns at the midpoint weight for each carcass weight group. The backfat specifications for the margin between Grades 9 and 10 were selected in a similar fashion.

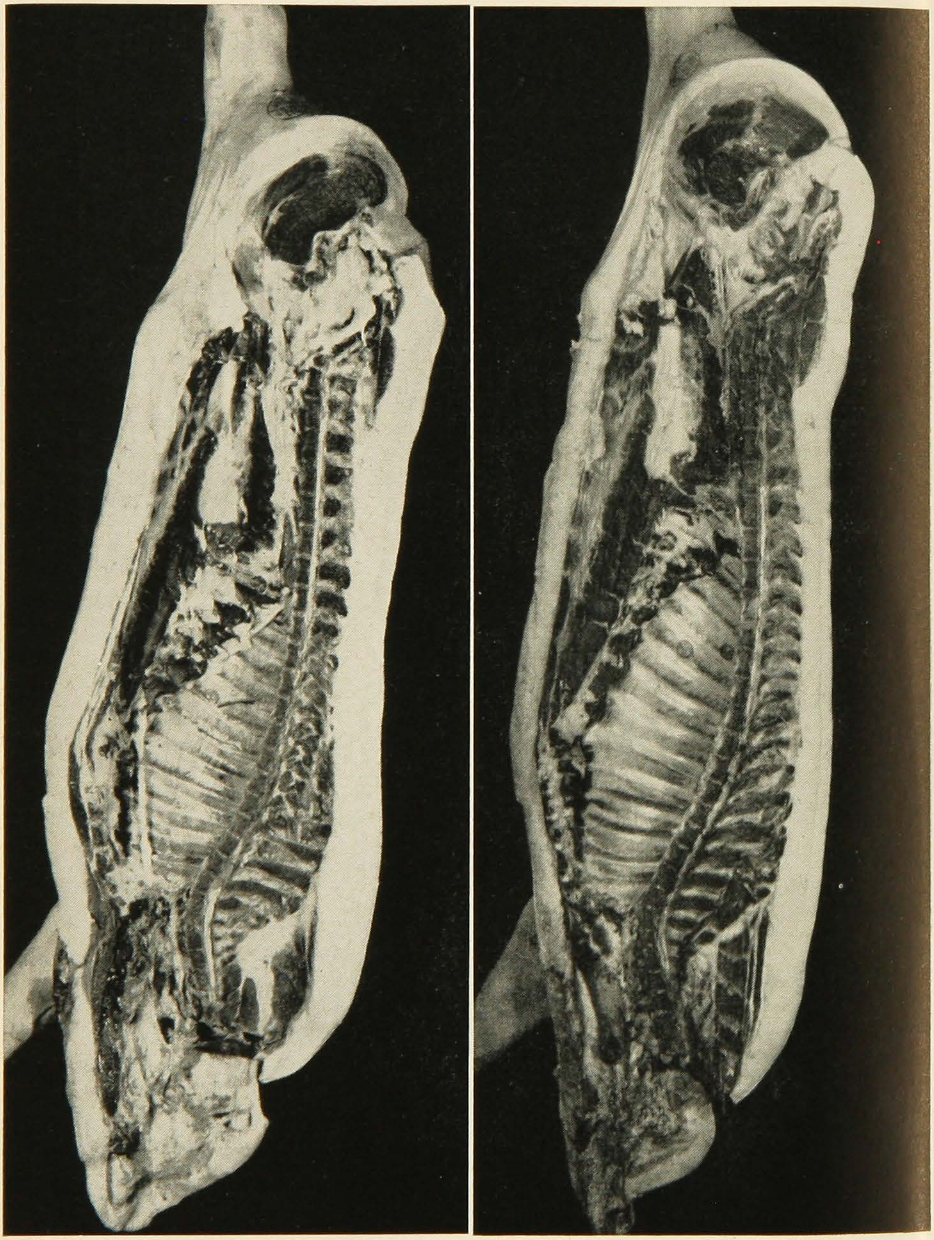

FIG. 5. The very fat Grade 8 carcass on the left weighed 169 pounds, measured 2.30 inches of backfat, and would be expected to yield 44.4 per cent lean cuts (hams, loins, picnics, and Boston butts). The desirable Grade 10 carcass on the right weighed 143 pounds, measured 1.53 inches of backfat, and would be expected to yield 51.0 per cent lean cuts.

FIG. 6. Hams, loins, bellies, and fatbacks produced from hog carcasses in the same weight range. From left to right, Grades 8, 9, 10, 11, and 12.

market will be classified in the overfinished grades than in the underfinished.

The underfinished margins between Grades 10 and 11 and between Grades 11 and 12 were selected in a similar fashion from table 15 in Part II.[6] The margins which set the limits of the underfinished grades may not be as important as the margins on the overfinished side of the grade standard since there are fewer underfinished carcasses.

The margin between Grade 10 and Grade 11 is, however, a critical margin because it should segregate the carcasses having adequate finish from those

[6] The tabulation of backfat specifications in this table was judged to be the closest approximation of a constant degree of finish among weight groups. The backfat specifications for 54.5 per cent in table 15 would be associated with less backfat above 190 pounds. In the grade standard the margins between Grades 11 and 12, which were defined by the constant percentage, were altered slightly above 190 pounds to require a slight added increment in backfat thickness. At 240 pounds the adjustment involved only 0.03 inch. This was a purely arbitrary manipulation to make the backfat specification at this margin somewhat more consistent with a constant degree of finish. It is not an important modification since carcasses of this weight with only 1.2 inches of backfat are extremely rare.

which produce a significant proportion of cuts of less than first-grade quality because of inadequate finish.

The positioning of the margin between Grades 10 and 11 is also critical in the sense that other margins between the other grades are oriented about it. In this tentative grade standard this particular margin has been set at 51.5 per cent lean cuts and other margins have been fixed about it at 3.0 per cent intervals. The optimum grade was therefore defined to range from 48.5 to 51.5 per cent and to center at 50.0 per cent lean cuts. Other grades were similarly oriented about the optimum grade.

Underfinished carcasses—those having a high percentage of lean cuts—yield a low percentage of low-value lard and a high percentage of high-value wholesale cuts. On the strictly quantitative basis they would be more valuable than more highly finished carcasses. They are to be discounted, however, because they tend to yield some cuts which lack firmness of meat and are not acceptable to the wholesale trade as first-quality products. The higher the percentage of lean cuts the greater the likelihood of discounted cuts from the carcass due to lack of finish.

At some point the price discounts caused by lack of finish may more than offset the greater yield of lean cuts. The margin between the optimum grade and the first underfinished grade should be placed on the scale showing per cent of lean cuts where the number of discounted cuts begins to have an appreciable effect on value.

Commercial practices with respect to the grading and pricing of underfinished pork cuts vary widely from packer to packer. Tentative federal standards for grades of fresh pork cuts are available, but they are little used in the trade and no price series are available to show price differentials by grade.

For these reasons it was not possible to appraise adequately the effect of decreasing finish on the expected number of discounted cuts at various points on the scale showing per cent of lean cuts. Lacking this information, the grade standard suggested in table 3 must be regarded merely as a tentative standard. If carcass grade standards were used in the trade for guides to more accurate pricing according to value, some concensus would likely arise as to whether the margin between the optimum and the first underfinished grades can be safely shifted in the direction of leaner carcasses without appreciably increasing the proportion of wholesale cuts discounted for quality.

The Effectiveness of the Standard in Classifying Carcasses

The purpose of a carcass grade standard is to classify widely varying carcasses (in terms of physical differences) into fairly homogeneous groupings.

In earlier discussions it was said that within weight groups, variation in per cent of lean cuts, the physical criterion of merit selected for this study, was associated closely with variation in backfat thickness (figure 3, page 14).

The correlation coefficients, the average correlations, and the coefficients of determination (the measure of the percentage of the variability in per cent lean cuts which was associated with the variation in backfat thickness) for the six states which supplied carcass data for this analysis are shown in table 2. The coefficient of determination was 70.5 per cent.

The effectiveness of the carcass standard in classifying carcasses into homogeneous groups can be measured in a similar manner. The reduction of the variability of per cent lean cuts which is accomplished by the carcass standard is shown for each of the state sample carcasses as well as for the

Table 4. Standard Errors of Estimate, Correlation Ratios, and Coefficients of Determination for the Carcass Standard for Six States and the Region

State	Number	Standard error of estimate	Correlation ratio	Coefficient of determination
Indiana	701	2.01	.823	67.8
Iowa	600	2.00	.851	72.4
Michigan	298	2.00	.696	48.5
Minnesota	695	2.17	.813	66.1
Missouri	592	1.96	.804	64.7
Ohio	374	1.87	.758	57.5
REGION	3,260	2.02	.812	65.9

region as a whole in table 4. The carcass standard accounted for about two-thirds of the variability in per cent lean cuts among the regional sample of 3,260 carcasses.[7]

This test gives evidence that the carcass standard would differentiate carcasses within weight groups according to finish as measured by percentage lean cuts.

Determining Value Differences Between Grades

The preceding sections have been concerned primarily with discovering certain objective factors which may be useful (1) for estimating physical differences between carcasses and (2) for classifying carcasses on the basis of these differences into fairly homogeneous groups or grades. Average backfat thickness and carcass weight were the basic criteria used to classify carcasses into the several weight and grade groups on the basis of the expected percentage of lean cuts.

The next step concerns the measurement of value differences which can be expected among the several carcass grades. Most of the carcasses from butcher hogs in this country will be in Grades 8, 9, and 10. How much of a price differential can be paid for Grade 10 carcasses over Grade 9? Or looking at it from the other direction, what would be the price discount for Grade 8 carcasses as compared with Grade 10?

The answers to these questions will depend on (1) the distribution of cuts or the composition of carcasses within weight-grade groupings and (2) the price relationships of the several component wholesale cuts and trimmings to each other.

Since no two packers follow identical cutting methods, yields of the several wholesale cuts and trimmings will vary from packer to packer. And be-

[7] A discrete series in the analysis of correlation ratios from the carcass standard would be expected to give correlation ratios that would be less than the correlation coefficients. The expected relationship was reversed for the Michigan and Ohio samples of carcass data (see tables 2 and 4). When significance tests were applied, several of the differences between the correlation coefficients and ratios were found to lie within the range of expected variability. The correlation coefficients and ratios were converted to Fisher's Z. The actual difference between the Z for the coefficient and the Z for the ratio of each state and of the region, the standard deviation of the difference between any two Z's, and the 95 per cent confidence limits are shown below.

State	Actual difference ΔZ	Standard deviation of differences $\sigma_{\Delta Z}$	Ninety-five per cent confidence limit $1.96\sigma_{\Delta Z}$
Indiana	.061	.045	.106
Iowa	.186	.058	.114
Michigan	.015	.082	.161
Minnesota	.158	.054	.106
Missouri	.104	.058	.114
Ohio	.005	.073	.143

The Michigan and Ohio differences were well within one standard deviation. The Indiana and Missouri differences were between one standard deviation and the 95 per cent confidence limits for their respective samples. The difference for the region was very close to the 95 per cent confidence level, while differences for Iowa and Minnesota were actually beyond the 99 per cent level of confidence (the standard deviation of differences times 2.576).

cause price relationships are constantly changing, the differences in value between the several grades will change from time to time. In general, the greater the price margin between the lean cuts and lard the greater would be the differential which could be paid for Grade 10 carcasses over Grade 9 and Grade 8 carcasses.

The distribution of wholesale cuts and trimmings of 98 carcasses within the 150- to 170-pound weight group classified by the tentative grade standard is shown in table 5. All were taken from one of the state samples included in the study. Average backfat thicknesses and average carcass values for the carcasses within each grade are indicated at the bottom of the table.

As would be expected, the total percentage of lean cuts increased from the relatively fat grades to the relatively lean grades. Grade 8 carcasses yielded 44.3 per cent lean cuts while Grade 10 yielded 50.2 per cent, a difference of almost six per cent.

Most of the important wholesale cuts and trimmings are related in some manner to the percentage of lean cuts, although in different directions and to different degrees. Each of the lean cuts (hams, loins, picnics, and butts) is negatively related with finish. That is, as backfat increases the percentage yields of these individual cuts declines. The various types of lean trimmings and the miscellaneous or skeletal cuts (spare ribs, neck bones, feet, and tail) are also negatively related with finish. Bellies

Table 5. Percentage Distribution of Wholesale Cuts and Trimmings, Number of Carcasses, Average Backfat Thickness, and Carcass Value by Grades Within the 150-170-Pound Weight Group from One State Sample

	Grade				
	8	9	10	11	12
Skinned hams	17.65	17.73	19.57	20.56	21.91
Loins	12.37	13.51	14.63	15.54	16.44
Picnics	7.70	7.97	8.57	9.08	9.93
Butts	6.60	6.83	7.46	7.76	7.96
Total lean cuts	44.32	46.04	50.23	52.94	56.24
Regular lean trim (50 per cent lean)	2.82	3.32	2.95	3.51	4.57
Special lean trim (85 per cent lean)	.44	.40	.49	.65	1.07
Bellies	19.06	18.63	18.33	16.54	13.63
Fatbacks	11.19	9.65	7.47	5.60	4.44
Fat trimmings	12.49	12.09	10.40	9.85	8.43
Dry salt jowls	3.82	3.80	3.34	3.34	3.04
Spare ribs	2.06	2.12	2.44	2.68	3.00
Neck bones	1.25	1.37	1.50	1.75	2.04
Front feet	1.14	1.17	1.28	1.39	1.54
Hind feet	1.28	1.27	1.40	1.55	1.78
Tail	.13	.14	.17	.20	.22
TOTAL	100.00	100.00	100.00	100.00	100.00
Number of carcasses	13	23	29	24	9
Average backfat thickness (inches)	2.27	1.98	1.67	1.34	.98
Average carcass value (dollars per hundredweight)*	28.36	28.93	30.27	30.70†	31.62†

* Based on 1949 prices.
† No consideration given for discounts for lack of quality.

are the only relatively high-value items positively associated with finish.

The remaining fat cuts and trimmings (fatbacks, fat trimmings, and jowl butts) are all relatively low-value items which are positively associated with the finish of the carcasses. The combined yield of fatbacks and fat trimmings, from which lard is rendered, comprised 23.6 per cent of the carcass among Grade 8 carcasses and 17.9 per cent among Grade 10 carcasses—a difference of about 6 per cent. On the basis of an 80 per cent lard-yield factor in the rendering process, this would be equivalent to a five-pound difference in the yield of lard per 100 pounds carcass weight.

The effect of carcass composition on carcass value is shown at the bottom of table 5. The 1949 average wholesale prices at Chicago were used to compute composite carcass values. These prices are shown in Appendix C. Appreciable differences in value among carcass grades are apparent in this sample of carcasses.

It must be emphasized that value differences in this table reflect differences only in carcass composition. Differences in carcass value which might be due to differences in quality of the cuts could not be satisfactorily determined from the available data and therefore could not be considered.

If the wholesale marketing mechanism properly reflected consumer preferences for wholesale cuts of varying degrees of finish back to the packer the values of the underfinished Grades 11 and 12 would be somewhat less than indicated in table 5. This is because

Table 6. Number and Average Composite Carcass Values Per Hundredweight for Specified Carcass Grades and Weights, 3,252 Carcasses from Six States*

		Carcass grades				
Weight groups		8	9	10	11†	12†
pounds						
90-110	Number	....	7	43	45	39
	Carcass value per hundredweight	....	30.38	30.60	31.53†	32.48†
110-130	Number	21	68	152	163	102
	Carcass value per hundredweight	28.66	29.70	30.65	31.47†	32.31†
130-150	Number	45	152	227	184	53
	Carcass value per hundredweight	28.67	29.36	30.17	31.21†	31.93†
150-170	Number	75	184	227	122	26
	Carcass value per hundredweight	28.21	29.01	29.82	30.48†	31.20†
170-190	Number	91	239	224	91	8
	Carcass value per hundredweight	27.63	28.38	29.18	29.97†	30.34†
190-210	Number	113	201	128	48	....
	Carcass value per hundredweight	27.11	27.94	28.62	29.42†	....
210-230	Number	49	71	46	8	....
	Carcass value per hundredweight	26.73	27.47	27.67	28.03†	....

* These values are based upon the average price relationship for the component cuts and trimmings in relation to each other during 1949 at Chicago. Hog prices at Chicago averaged $19.77 per hundredweight during 1949 for 220- to 240-pound butchers.

† Values shown for Grades 11 and 12 reflect only physical differences in the proportion of high- and low-value cuts yielded by these carcasses. They do not take into consideration discounts applied to certain cuts for lack of quality. Information was not available in this study to evaluate properly the effects of discounted cuts on carcass value.

increasing proportions of the wholesale cuts would be discounted for lack of finish as the percentage of lean cuts is increased within the range included in the underfinished grades. The composite value of Grade 12 carcasses would probably be less than the value of Grade 10 carcasses.

On the other hand the value differences between Grades 8, 9, and 10 would probably be greater than those shown in this tabulation. This is because many of the cuts yielded from the overfinished Grades 8 and 9 would carry more fat than is desired by consumers. This is especially true of bellies, and is also true of the lean cuts.

Although much of the exterior fat around each of the lean cuts can be removed in the cutting room of the packing plant, the excess internal fat within and between the muscle tissues and around the bones cannot be removed as easily. The consumers' objection to this excess untrimmable fat is reflected in a lessened demand for pork as a whole.

Cutting methods vary from packer to packer. Because yields differ, the composite carcass values shown in table 5 would not be exactly the same for all packers, even if the same prices were applied to the yields of cuts and trimmings. Packers wishing to have information on yields appropriate to their own cutting methods need to conduct cutting tests by grade groups as they now do for weight groups.

The same essential relationships between grade and yield of the several individual cuts and trimmings and between grade and carcass value prevailed among all of the six samples studied in this analysis. It is reasonable to assume therefore that they would apply to cutting information obtained by other packers as well as those studied.

The average composite carcass values from the six state samples are shown by weight and grade groupings in table 6. This tabulation of carcass values was constructed from tables of carcass composition similar to that of table 5 for all of the 20-pound weight groups within the six state samples.[8]

Several important tendencies are apparent in this table. Within any given weight group Grades 8 and 9 carcasses have a lower carcass value than Grade 10 carcasses. This is because they yield a larger percentage of low-value lard and a smaller percentage of high-value lean cuts.

Carcass value differences per hundredweight between Grade 8 and Grade 10 average $1.50. Comparable value differences between Grades 9 and 10 average 76 cents. Value differences among these grades will vary with ratio of lard prices to prices of lean cuts. As long as lard sells for less than lean cuts, Grade 10 carcasses will be worth some premium over carcasses in Grades 8 and 9. Grades 11 and 12 would likely be discounted for absence of quality.

Another obvious tendency shown is the decline in value associated with an increase in weight within grades. This is due solely to the discounts at which the heavier weights of hams, loins, bellies, picnics, and fatbacks are usually sold in the wholesale markets.

These discounts vary from time to time. During the early fall of the year when heavyweight butcher hogs are scarce in the total slaughter, the discounts against heavy weights of cuts sometimes disappear completely and occasionally are even reversed. At such times value differences among carcass weights within the same weight group would become negligible.

At other seasons of the year when heavyweight butcher hogs and packing

[8] Differences in cutting results among the various state samples made it necessary that this table be constructed by computing value differences among grades within states. Weighted averages of value differences among the several grade constituencies for all states provided the basis for the tabulation.

sows are predominant in marketings, discounts for the heavier weights of cuts increase and would be reflected in larger differentials among weight groups than those shown in table 6 on page 23.

POSSIBLE APPLICATIONS OF THIS RESEARCH

The general objective of any grading system is to make the pricing mechanism an effective means of communication by which consumers can indicate their preferences to producers. In the United States consumers have paid higher prices for hams, loins, picnics, butts, and bacon than they have for lard. Without appropriate grade-price differentials farmers in the United States continue producing hogs which yield excessive amounts of lard.

This results in a substantial waste of corn and other feed resources, resources which could be allocated to the production of a larger output of the more highly desired meat cuts.

The only method by which producers can interpret the demand for different grades of hogs is through the pricing mechanism. If approximately the same price is paid for all hogs of the same weight regardless of quality, farmers have little incentive to alter production methods and market the more desirable animals. On the other hand, if consumers' preferences are fully reflected in prices paid for the product delivered, farmers will tend to produce and market the kind of product desired.

Hog carcass grade standards, such as those developed in this study, could be used by the livestock and meat industry to put into operation an improved system of purchasing hogs by live grade at livestock markets. The pricing of hogs on the basis of such standards would take into account differences between hogs yielding high-value carcasses and those yielding carcasses with a lower value.

Under such a system farmers would be paid a price differential for producing hogs of high value. This could very well be an initial step which marketing agencies and packers could adopt to improve hog marketing over the present method of purchasing hogs on an average cost basis within given weight groups.

Hog carcass grade standards such as those developed in this study could also be used as the basis for marketing butcher hogs by carcass weight and grade in this country. If the carcass method of marketing more accurately reflects consumer preferences back to producers than the liveweight method, farmers would have a greater economic incentive to produce more highly desired types of carcasses. An improvement in the general level of quality of market hogs would be encouraged, and the productive resources in agriculture would be more effectively allocated to satisfy consumer wants.

Payments Distributed According to Value

One result that could be expected from the adoption of an improved method of marketing is that farmers would be paid more nearly the true market value of their hogs than under the present system.

Hogs vary in value to the packer because of (1) the variation in the dressing percentage or carcass yield, (2) the variation in weight of wholesale cuts from hogs of different weights, and (3) the variation in the relative proportions of high-value cuts and low-value lard yielded from hogs of different carcass type (conformation, finish, and quality).

The present method of buying gives major consideration to liveweight groups. Selling on the basis of live grades would in addition give some consideration to value variations arising out of differences in carcass type, insofar as the eventual carcass value can be estimated before slaughter.

By basing the price to be paid on the carcass grade, however, the carcass method would minimize the value variations contributed by differences in carcass type. And by basing the price on the weight of the carcass, the carcass method would also go one step further and completely remove all value variations which are due to differences in carcass yield.

Returns to producers would be distributed differently. Farmers who marketed superior products would be more likely to receive higher returns, while farmers who marketed inferior animals would be more likely to receive less than under the present system. Producers as a group would not necessarily receive larger total returns for the hogs they market unless marketing efficiency were increased or the general level of quality of hogs improved.

Sale by Description

One of the reasons why hogs have been sold at about the same price within weight groups has been the difficulty of detecting differences in value by inspection of butcher hogs on foot.

If hogs were sold on a live grade or carcass grade basis buyers could make their bids with greater confidence, as some of the more important sources of value variation would have been removed.

Sale by the objective carcass weight and grade method would provide a more accurate language for price quotations, too. Sellers would have more information about the worth of their marketable product, and alternative outlets over a wider market area could be more readily compared.

Bargaining

In marketing hogs by live weight and grade the producer or his selling agent would bargain with the buyer in terms of price per 100 pounds live weight. Under the carcass weight and grade method bargaining would be in terms of a price per 100 pounds carcass weight. The bargaining could take place at the farm, at the local market, or at the public stockyards just as it does under the present liveweight method. There would be no necessary change in the time or place at which the price is agreed on. The agreement would be made before, not after, the animals pass out of the sellers' hands. To this extent, the bargaining power of producers would not be affected.

Under the carcass method the character of the bargaining, however, would be changed. Bargaining about the probable carcass yield, the degree of fill, and the relative carcass value would be eliminated, for the scales and the carcass grader would determine the carcass weight and grade after slaughter.

Assuming that the same weight and grade designations will be used at all markets, producers could compare alternative outlets over a wider area and select the one which pays the highest net price. Bargaining power of the producer would not be weakened under either method.

Reducing Excessive Fill Before Selling

In many cases hogs are fed and watered at markets before they are sold. This increases the sales weight on which the price is paid. Feeding immediately before sale is justified to the extent that this practice tends to minimize tissue shrinkage before slaughter. But excessive filling before sale is generally considered to be an economic waste.

Differences in carcass yield are difficult to detect on foot. Buyers tend to generalize their bids for hogs of approximately equal weight, offering about the same price for hogs with considerable variation in fill. Under the present system producers who sell hogs with more than average fill receive greater returns than those whose hogs are filled less. Sellers therefore have an economic incentive to fill their hogs as much as possible before they are sold on the liveweight basis.

Sale on the carcass basis would remove the incentive to fill hogs excessively before they are sold. Under this method the amount of fill would not affect the over-all returns for the lot, since prices paid would be based on the carcass weight rather than liveweight. Feed could be saved and marketing cost could be reduced.

Handling Condemnations

Under the liveweight method of sale, losses from diseased and bruised animals are initially borne by the packer unless some defect is noted before purchase and the hogs are bought "subject to inspection." Over a period of time, however, a packer can predict what his over-all losses from condemnation and bruising will be and take these losses into consideration in arriving at the prices to be paid for hogs. Such losses are therefore generalized and are shared by all producers. Since in most cases the identity of the hogs is lost the farmer seldom learns about the condition in which his hogs are brought to market.

Under the carcass method of marketing it would be possible to identify the farmers who have marketed diseased animals. Even though the method of sharing the losses might be continued, whether by the present method or by a specified insurance charge, the farmers could be advised of the condition of the animals so that steps could be taken to prevent future losses.

Similarly, losses from bruising would be brought out in the open under the carcass method. In some cases, however, it would be difficult to determine whether the producer, the trucker, or the yardmen were responsible for particular bruising losses.

Nevertheless, since it would be a matter of record that bruising losses had occurred on particular lots or shipments, bruising-loss prevention programs could be carried out more successfully than under a liveweight method of marketing. If certain truckers consistently delivered bruised animals, steps could be taken to determine the practices which were responsible. If certain management or handling practices on the farm were responsible, this would be shown in the higher percentage of bruised animals consistently received from certain producers. Steps could be taken to inform truckers and/or producers of the specific practices which were responsible for the greater bruising loss among the hogs which they handled.

SOME PROBLEMS IN MARKETING BY GRADE

Identification

One of the additional requirements of a carcass method of marketing over the liveweight method would be the maintenance of the identity of hogs until the carcasses are weighed and graded. This information is recorded for use in calculating the proceeds of the sale for the producer.

In Canada, where all hogs are bought on the carcass basis, this problem appears to have been met satisfactorily by tattooing hogs on the shoulder at time of purchase. The tattoo is clearly visible on the carcass and is recorded along with the carcass grade on the automatic scale ticket. These tickets show the number and weight of carcasses in each weight-grade classification for each producer's hogs.

A few packers in the United States maintain the identity of various lots of hogs through the slaughtering process. Then they weigh the carcasses to determine the carcass yields of hogs purchased from different farmers, dealers, or markets. For most packers, keeping identity of the hogs would require additional labor.

Weighing

When hogs are sold on the liveweight basis they are weighed either in the presence of the seller, his representative, or an impartial weighmaster. Usually the weighing is done on scales that are government tested for accuracy at regular intervals. Liveweights might be desired under the carcass method for two purposes: to permit subsequent calculation of yields or to approximate more closely the dressed weight of the carcasses if this information is needed to evaluate bids made by different buyers for carcasses of various weights.

Accurate carcass weights, however, are essential to the carcass method of marketing. Since in most cases the seller would not be present when his carcasses are weighed, the services of an impartial weighmaster would certainly be desirable, if not indispensable, for the successful operation of the marketing method. In this case the weighmaster would move to the killing floor instead of operating in the yards as at present.

Electrically operated scales have been developed which automatically record the weight in duplicate on a heavy, durable card, which is hung on the carcass after the tattoo number is recorded. Space is also available on the weight card for the carcass grade and also for comments by the grader.

Scales of this type are available which handle up to 600 to 700 carcasses an hour. In plants which engage in interstate trade within the United States and have meat inspection (this includes all of the larger plants), carcasses are permitted to move on the rail past the inspectors up to the rate of 600 an hour. Packers which kill at a faster rate operate two separate chains on the killing floor. Weighing of carcasses within the plant would involve adjustments in packing operations.

Grading

Hog carcasses are not graded in the United States under usual circumstances as are beef, veal, and lamb carcasses. The carcass method of marketing would require that graders be placed inside the packing houses to grade carcasses, probably just after the carcasses are dressed and before they are moved into the coolers.

It has not been demonstrated how rapidly carcasses could be graded in this country. In Canada hogs can be graded at a rate as high as 500 to 600 an hour, but after an hour or two of continuous work graders need a few minutes rest. In some plants in the United States where carcasses move into the coolers at speeds faster than 500 per hour, it may be necessary to have two graders working simultaneously. Each could take alternate carcasses, and an extra grader could be on hand to relieve the other graders.

It is essential that the carcasses be graded by competent and impartial graders. Without competent and impartial grading it is not likely that the confidence of farmers and packers in the carcass method could be maintained over a wide area for any length of time. The use of uniform standards would be needed to enable farmers to compare prices from different outlets over a wide area.

Relation of By-Product Credit to Carcass Weight and Grade

In buying hogs by carcass weight and grade, prices would be quoted on specific weights and grades of carcasses. In the packer style of dressing common in the United States, the head, leaf fat, ham facings, and other valuable internal by-products are removed on the killing floor.

Under current packing-house practice these items do not comprise a part of the carcass. Therefore, under the carcass system they would not enter into the weight of the carcass on which the price to the farmer would be based. By-product credits would be taken into account in the price offered per 100 pounds carcass weight, just as credits for these items are considered in the price offered per 100 pounds liveweight under the present system.

Since by-product credits are involved under both systems of sale, no new problem would necessarily arise on this score. Most packers compute differential by-product credits by classes and by weight groups. Additional by-product information would be needed for the different grades if hogs are to be sold by grade, either on a live or carcass basis. And under the carcass method these credits would have to be computed per 100 pounds carcass weight rather than per 100 pounds liveweight.

Settlement

When hogs are sold liveweight, settlement in full is usually made immediately after the animals are weighed. In the case of local sales or of nearby shipments consigned for sale through commission agents, the owner may deliver his hogs, see them weighed, and return home with the buyer's check in his pocket.

Under the carcass method the hogs might be killed, the returns computed, and the check mailed on the day of delivery. The owner would not receive his check in the mail until the following day.

If the hogs were killed on the day following delivery, or two days after delivery as would happen on Saturday deliveries, payment would be delayed an additional one or two days. And if the returns could not be computed on the day of slaughter another day's delay would be involved.

Thus it appears that the payment might be delayed from one to four days, depending on how quickly hogs can be slaughtered after delivery and the returns to the farmer computed by the packing company. In cases where hogs are purchased by order buyers for distant slaughtering plants which are 500, 1,000, or perhaps 1,500 miles away, payment would be delayed further by the time required to transport the hogs to the distant slaughtering plant.

Some farmers will object to the delay in payment involved in marketing hogs by carcass weight. In such cases, however, it might be possible to make an advance payment of from 75 to 90 per cent of the estimated value at time of delivery and pay the remainder after slaughter.

Relative Costs of the Live and Carcass Methods

No attempt was made in this study to measure the relative costs of marketing under the present liveweight and possible carcass weight and grade marketing methods. Some of the costs of marketing would be increased under the carcass method, but others might be reduced. An appraisal of the net effect on marketing costs was impossible to make at this time.

Other Problems

This discussion of marketing hogs by liveweight and grade and carcass weight and grade is not intended to be complete or exhaustive. Many other problems could be discussed. A few of these are (1) tissue shrinkage on hogs held over in the yards or shipped long distances before slaughter, (2) price determination, and (3) acceptability to hog producers, packers, marketing agencies, and consumers of pork.

Exhaustive studies would be required before valid conclusions could be made concerning these problems.

Part II. Analytical Procedures

AS WAS INDICATED in Part I the basic analytical approach in establishing hog-carcass grade standards was an attempt to arrive at some functional relationship between certain physical measures and some criterion of carcass merit. The physical measure chosen as the one having the predominant influence was average backfat thickness, a measure which could be expressed in objective and absolute terms. The criterion of carcass merit selected for the analysis was the percentage of the carcass which consisted of the four lean cuts: hams, loins, picnics, and butts. The latter is a proportional concept but is also measurable in physical terms.

Six states provided samples of hog carcasses of varying weight and finish. For purposes of analysis each state sample was divided into 10-pound weight groups in order to isolate, insofar as possible, the joint effect of carcass weight and backfat thickness on the percentage of lean cuts. The entire regional analysis was therefore based on 62 separate regression analyses covering a total of 3,218 carcasses, as indicated in table 1 on page 10.

The regression line in figure 3 shows the average relationship between backfat and per cent lean cuts for one particular weight group from only one state. The basic analytical problem in developing grade standards is to determine how these regression lines can be expected to differ, both as to position and slope at different carcass weights. Figure 7 shows the regression lines of five different weight groups, again from one state, separated at their midpoints by approximately 20-pound intervals. Each of these regression lines is similar to the one shown in figure 3, in that each expresses the average relationship for a different weight group.

This figure gives some insight into the manner in which the regression lines can be expected to differ according to carcass weight. Regression lines for the heavier-weight carcasses tend to be to the right of the lighter-weight carcasses, at least within most of the range of the data from which each regression relationship is computed. In other words, among carcasses of unlike weight but of similar degree of finish, as measured by the constant percentage of lean cuts, the heavier carcasses have larger dimensions and accordingly have more backfat thickness.

The slopes of the regression lines of the heavier-weight groups tend to be less steep than the slopes of the lines of the lighter-weight groups. This was expected since a given absolute change in backfat thickness should have considerably more influence on the percentage of lean cuts on 120-pound carcasses than on 200-pound carcasses.

The information in figure 7 suggests that at a given degree of finish, as shown by percentage of lean cuts, average backfat thickness increases with carcass weight but probably at a decreasing rate. It also suggests that the regression relationship of per cent lean cuts to backfat thickness declines as

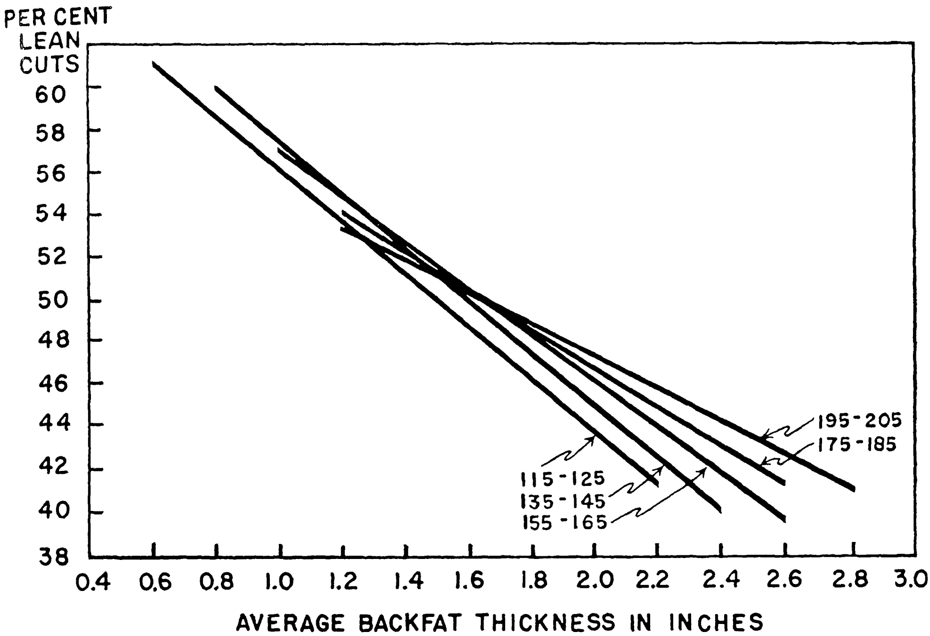

FIG. 7. Regression of the percentage of lean cuts on backfat thickness for five weight groups of hog carcasses separated by approximately 20-pound intervals.

carcass weight increases and also at a decreasing rate.

The analytical problem at this point is (1) to measure the rate of increase in backfat thickness associated with increasing carcass weight for carcasses having a constant percentage of lean cuts, and (2) to measure the rate of decrease in the regression relationship between backfat thickness and per cent lean cuts as carcass weight is increased.

Determining the Relationship Between Backfat Thickness and Carcass Weight at a Constant Percentage of Lean Cuts

In order to determine the relationship which could be expected between backfat thickness and carcass weight at a constant degree of finish it was necessary to determine the expected backfat thickness at some particular standardized percentage of lean cuts for each of the weight groups used in the study.

In terms of figure 7 this procedure would be comparable to drawing a horizontal line at some particular percentage point (preferably near the midpoint of the several regression lines, such as at the 49 per cent point) intersecting all of the regression lines. These intersection points would be the expected backfat thicknesses for different carcass weights at the standardized percentage of lean cuts. They could be plotted against carcass weight (the midweight of each weight group) to determine the relationship between the backfat thickness of standardized carcasses and the carcass weight.

When this procedure was attempted for the region as a whole it was discovered that the percentage of lean cuts apparently was not a comparable measure of degree of finish among the several state samples. At the same carcass weight and backfat thickness, carcasses from the separate samples differed appreciably in the percentage of lean cuts they could be expected to yield.

As indicated previously each packing plant had attempted to cut the carcasses according to the specifications of a standard cutting procedure in order to achieve consistency with the whole region. Indications are that this consistency of cutting among state samples was difficult to achieve. For example, the trimming of fat from the hams, loins, picnics, and butts was rigidly specified in the prescribed cutting procedures. Nevertheless it is entirely possible that cutting-crew members in certain plants left more fat on these primal cuts than others left.

Where more of the exterior fat was left on the lean cuts in the trimming operation, the lean cuts would obviously weigh more and comprise a higher percentage of the carcass. Conversely, in plants where these cuts were trimmed more closely the lean cuts would weigh less and comprise a lesser percentage of the carcass.[9]

The differing percentages of lean cuts among hogs of like weight and finish from the different state samples require that each state's data (in terms of the dependent variable, per cent lean cuts) be adjusted to some common denominator for the region as a whole. At 160 pounds carcass weight, the approximate average carcass weight for the entire region, and 43.6 millimeters of backfat, the weighted average backfat thickness for the region, the following percentages of lean cuts were derived. These percentages equate each state's data with those from other states and with those from the region as the whole:

Indiana	48.7
Iowa	49.0
Michigan	46.6
Minnesota	49.3
Missouri	51.1
Ohio	49.8

It has been assumed that the state differences in the percentage of four lean cuts for a given backfat measurement are due largely to cutting procedures.

On the basis of this assumption, 48.7 per cent lean cuts in Indiana represents the same degree of finish at 160 pounds carcass weight that 49.8 per cent does in Ohio, and 46.6 per cent in Michigan represents the same degree of finish that 51.1 per cent does in Missouri. The weighted average of the sev-

[9] Several alternative explanations of the differing yields of lean cuts from different states might be suggested. At the outset it was believed that the large numbers in each of the respective state samples ruled out sampling variations as an explanation of these differences. Another explanation may have some validity, however. It is possible that geographic, genetic, feeding, or seasonal differences in the hog population exert some influence. In other words, from different areas, genetic types, feeding practices, or seasons of the year, hogs of a given percentage of lean cuts (with consistent cutting) may carry varying amounts of backfat. Packers often report that hogs of a given weight slaughtered in different seasons of the year cut out differently.

In terms of our analysis, however, the packer is thinking of an average percentage yield line which happens to intersect the regression line (figure 3) at a different level. During a particular season hogs of the same weight may average a higher degree of finish (greater backfat thickness) and therefore yield a smaller percentage of lean cuts. The problem which concerns the analysis at this point, however, is not where the mean line intersects the regression line, but is rather the differing positions of the regression lines from the several state samples.

Although it is believed that differences in the cutting and trimming of the carcasses is a more logical explanation of the differing yields of lean cuts from the several states than differing characteristics of the hog population, it was not possible to determine precisely the relative importance of the two explanations from the data at hand. Nor was it believed to be important to make such an evaluation as long as within any given packer's supply of the hog population the same basic relationships apparently exist between weight and backfat on the one hand and the percentage of lean cuts on the other. These measures can still be used to sort the supply of hog carcasses into homogeneous groupings—the essential purpose of a grade standard.

Table 7. Backfat Thicknesses Standardized at 49.3 Per Cent Lean Cuts on the Regional Basis, Six States, 62 Weight Groups

Weight group	Indiana—48.7		Iowa—49.0		Michigan—46.6		Minnesota—49.3		Missouri—51.1		Ohio—49.8	
	Average wt.	Backfat	Average wt.	Backfat	Average wt.	Backfat	Average wt.	Backfat	Average wt.	Backfat	Average wt.	Backfat
pounds	pounds	millimeters	pounds	millimeters	pounds	millimeters	pounds	millimeters	pounds	millimeters	pounds	millimeters
95-105	100.35	39.93	....	....	....	....	....	....	100.46	41.46	....	....
105-115	110.58	41.25	108.4	37.25	....	....	....	....	109.86	39.83	110.76	40.76
115-125	120.37	43.70	120.1	40.95	....	....	120.7	39.85	120.97	42.30	120.18	44.11
125-135	130.11	43.20	130.4	42.64	....	....	129.5	42.59	129.67	44.04	130.33	41.45
135-145	139.94	44.10	139.7	42.99	140.89	42.27	139.4	42.33	140.97	44.88	140.08	41.80
145-155	150.20	43.96	150.0	43.64	150.59	43.21	150.2	41.98	148.91	42.41	149.12	43.56
155-165	159.98	43.55	160.2	45.60	160.89	42.60	159.8	43.72	159.92	44.36	160.33	44.24
165-175	170.11	44.26	170.1	45.24	171.03	44.89	170.6	44.19	170.38	46.00	170.82	41.98
175-185	179.14	45.47	180.1	44.85	180.24	44.18	179.3	44.83	179.60	43.07	180.26	44.25
185-195	190.41	44.70	189.7	45.40	....	....	189.4	46.65	189.86	43.98	190.51	43.43
195-205	200.15	42.59	200.1	45.88	....	....	199.1	45.67	199.94	44.61	199.91	43.68
205-215	209.27	43.76	210.2	45.64	....	....	214.6	46.32	209.55	42.84	209.14	47.25
215-225	....	....	222.6	45.09	....	....	....	....	....	....	....	....

States and their respective comparable percentages of lean cuts

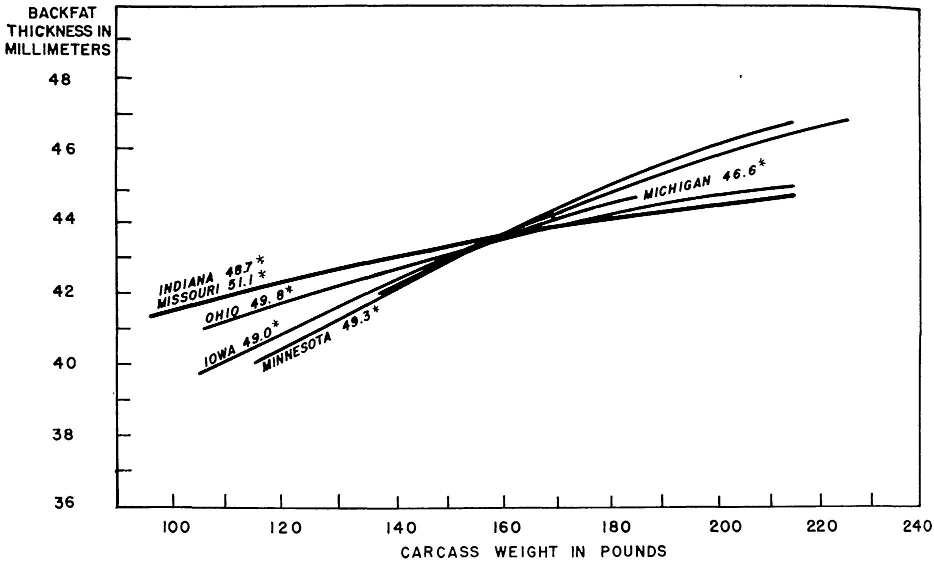

FIG. 8. Regression of backfat thickness on carcass weight at comparable percentages of lean cuts for each state, equations: $Y = a + b \text{ Log } X$. (*Per cent lean cuts equivalent to region at 49.3.)

eral percentages was 49.3 per cent. This is the percentage which was used as the regional base at which the backfat thicknesses of carcasses varying in weight but standardized at a common degree of finish were determined.

The next step in computing the theoretical backfat thicknesses was to standardize the backfat thickness for each of the weight groups within a state sample at the respective percentage of lean cuts which represents the degree of finish comparable with other state data. The standardized backfat thicknesses for each state which are comparable to 49.3 per cent lean cuts on the regional basis are shown in table 7. In the case of Indiana, for example, the comparable percentage was 48.7. The backfat thicknesses shown for the several weight groups from Indiana data, for example, indicate the magnitudes of the backfat thickness variable where the several regression lines (in terms of figure 7) would intersect a horizontal line placed at 48.7 per cent.

The curvilinear equation $Y = a + b \text{ Log } X$[10] was applied separately to each state's data after backfat thickness had been standardized to the percentage of lean cuts comparable with 49.3 on the regional basis (table 7). The data for all states were combined, and a regression relationship was calculated on the basis of 62 separate weight-group observations. The "a" and "b" values for each state and for the region are tabu-

[10] Where Y = expected backfat thickness when the percentage of lean cuts is equal to 49.3 (regional base)
and X = carcass weight.
This semilogarithmic expression was used because it provided a satisfactory fit for the curvilinearity of regional data. Since a dimension (backfat thickness) is being related to mass (weight of carcasses standardized at a constant per cent of lean cuts) the mathematical expression must allow for an increase at a decreasing rate of the dimension variable as the mass variable is increased by constant intervals.

Table 8. Origins and Regression Coefficients for Backfat Thickness on Carcass Weight at Equivalent Percentages of Lean Cuts for Region*

State	Weight groups	Standardized percentage of lean cuts	Origin at zero "a"	Regression coefficient "b"
Minnesota	10	49.3	—10.499	24.562149
Iowa	12	49.0	— 5.582	22.352817
Michigan	5	46.6	— 1.766	20.502409
Ohio	11	49.8	+15.552	12.645556
Indiana	12	48.7	+22.265	9.685087
Missouri	12	51.1	+22.753	9.435632
REGION	62	49.3	+10.949	14.832075

* $Y = a + b \text{ Log } X$.

lated in table 8, with states ranked in the order of their regression coefficients.

The separate regression lines of relationship between a standardized backfat thickness and carcass weight are plotted in figure 8, while the regional regression line and the scatter diagram of the various weight group observations are shown in figure 9. The computed backfat thicknesses at 49.3 per cent lean cuts for weights from 90 to 250 pounds, the data given in figure 9, are given in table 9.

It perhaps should be emphasized at this point that the regression lines discussed in this section illustrate the relationship between standardized backfat thickness and carcass weight. They show how backfat thickness of carcasses yielding 49.3 per cent lean cuts (regional basis) is associated with carcass weight. These regression relationships are not to be confused with the more basic regression relationships discussed earlier between backfat thickness and per cent lean cuts (figure 3).

In the particular type of curvilinear relationship illustrated in figures 8 and 9, backfat thickness increases with carcass weight but at a decreasing rate. Thus for the region as a whole the difference in backfat thickness between 100 and 120 pounds carcass weight

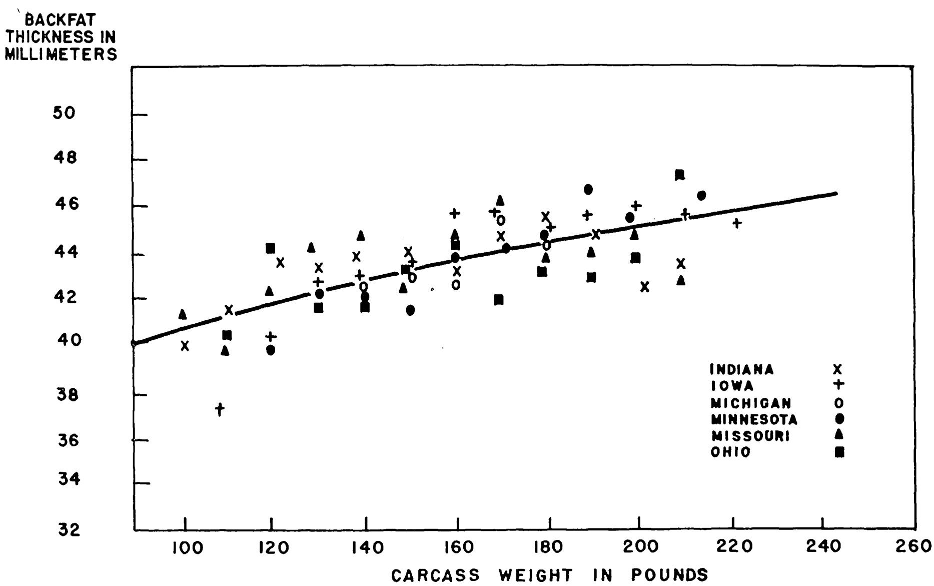

FIG. 9. Relationship between backfat thickness and carcass weight at 49.3 per cent lean cuts, equation: $Y = a + b \text{ Log } X$.

would be 1.2 millimeters. But in the case of a similar 20-pound interval between 200 and 220 pounds, the comparable difference would be only 0.6 millimeters.

It will be noted in table 8 and in figure 8 that when each state's data are standardized to a comparable degree of finish there appears to be two families of curves. The Iowa, Michigan, and Minnesota regression lines lie fairly close to each other and generally have a steeper slope. That is, backfat increases more as carcass weight is increased.

On the other hand, the Indiana and Missouri lines are practically superimposed on each other and have less slope. The Ohio line lies very close to the Indiana and Missouri lines. The regression values shown in table 8 indicate the family groupings even more strikingly than does the figure. The regression coefficients (the average rates of change) for Minnesota, Iowa, and Michigan vary from 20.5 to 24.6, while in the Ohio, Indiana, and Missouri group they vary from 9.4 to 12.6.

One possible explanation for these two diverging tendencies concerns the relative closeness of the trimming of the lean cuts yielded from different weights of carcasses. In general the specifications for trimming the exterior fat from the lean cuts were expressed in absolute terms (see Appendix B). Thus "any fat in excess of ½ inch" was to be removed from butts. "Not more than 1¼ inch of fat" was to be left on any portion of the ham where skin was removed, and "the center of the loin should be covered with an average of ½ inch fat."

It should be noted that these absolute specifications call for relatively closer trimming on cuts from heavier-weight carcasses than from lighter-weight carcasses. One-half inch of fat on 16-pound loins is considerably less fat than it is on eight-pound loins. If proportional trimming had been specified, the covering of fat on loins and on other lean cuts would have been proportional to the size of the cut.

It has been indicated previously that consistency of cutting and trimming

Table 9. Relationship Between Backfat Thickness and Carcass Weight at 49.3 Per Cent Four Lean Cuts—Region*

Carcass weight in pounds	Backfat thickness: millimeters	Backfat thickness: inches	Carcass weight in pounds	Backfat thickness: millimeters	Backfat thickness: inches
90	39.93	1.5721	175	44.22	1.7410
95	40.28	1.5859	180	44.40	1.7481
100	40.61	1.5989	185	44.58	1.7552
105	40.93	1.6115	190	44.75	1.7619
110	41.23	1.6233	195	44.92	1.7686
115	41.51	1.6343	200	45.08	1.7749
120	41.79	1.6454	205	45.24	1.7812
125	42.05	1.6556	210	45.39	1.7871
130	42.30	1.6654	215	45.54	1.7930
135	42.55	1.6753	220	45.69	1.7989
140	42.78	1.6843	225	45.84	1.8048
145	43.01	1.6934	230	45.98	1.8103
150	43.23	1.7021	235	46.12	1.8158
155	43.44	1.7103	240	46.25	1.8210
160	43.64	1.7182	245	46.39	1.8265
165	43.84	1.7261	250	46.52	1.8316
170	44.03	1.7335			

* $Y = 10.949 + 14.832075 \text{ Log } X$.
Y = Backfat thickness in millimeters when per cent lean cuts equals 49.3.
X = Carcass weight.

among the several states was not accomplished. The data given in table 8 and illustrated in figure 8 suggest that the same relationship between closeness of trimming and carcass weight may not have been achieved among the several states. It is possible that in the cases of Minnesota, Iowa, and Michigan the trimming departed from the absolute specifications in the direction of proportional trimming. In other words, heavier cuts may have been trimmed with more fat remaining than was the case for lighter cuts in these states.[11]

Determining the Expected Regression Relationships Between Backfat Thickness and Per Cent Lean Cuts at Different Carcass Weights

An explanation has been developed of the expected relation of backfat thickness to carcass weight when per cent of lean cuts is held constant (table 9 and figure 9). The next step is to determine how the relation of the per cent of lean cuts to backfat thickness (figures 3 and 7) differs at different carcass weights. In other words how does the effect of a given change in backfat thickness on the percentage of lean cuts at 120 pounds carcass weight differ from the effect at 200 pounds carcass weight?

Table 9 shows the backfat thicknesses of standardized carcasses at five-pound intervals in carcass weight. The task of this portion of the analysis is to determine the expected regression coefficients (the expected average rates of change) of the per cent of lean cuts in relation to backfat thickness at these same five-pound intervals.

The data in figure 7 suggested that lighter-weight groups had higher regressions than the heavier-weight groups. The lighter-weight group regression lines had steeper slopes. This was expected since a given *absolute* change in backfat thickness, for example a five-millimeter (0.2 inch) increase in backfat, should have a greater effect on the *percentage* of lean cuts on 120-pound carcasses than on 200-pound carcasses. Regressions should be expected to decline with increasing carcass weight.

It was also expected that regressions would decline to a greater extent from 120 to 130 pounds than from 200 to 210 pounds carcass weight. This is because a given 10-pound change in weight is *relatively* greater at 120 pounds than it is at 200 pounds. Regression coefficients should decline by successively smaller amounts as carcass weight is increased by constant amounts. Our basic logical principle, therefore, is that decreases in regression are associated with increases in carcass weight, but that these increases take place at a declining rate.

Table 10 shows the separate regressions and the average carcass weights for the 62 weight groups in the analysis. These regression coefficients are

[11] At this point it appears that the assumption that comparable degrees of finish can be specified by the same percentage of lean cuts at different carcass weights must be rejected. The regression lines shown in figure 8 therefore do not necessarily indicate the same constant degree of finish at different weights. They simply indicate the amount of backfat required to produce a given constant percentage of lean cuts at different carcass weights for the several states. If the trimming of the exterior fat from the wholesale cuts had been done in proportion to the size of the cut, a constant percentage of lean cuts would have a considerably steeper slope than any of the regression lines shown.

Because of the two diverging tendencies among the state samples the regression line for the region will be more properly called a compromise between the two groups rather than an average of the two groups. As indicated in table 8, however, the regression coefficient for the region is much closer to the regression for the Ohio-Indiana-Missouri groupings. This is partly due to the fact that this group of states has more weight groups and hence more degrees of freedom than the other group. But it is also true that a general regression of a sample will be lower than an average of the regressions of several subsamples Each state in this study is in effect a subsample of the larger regional sample.

plotted in figure 10. The theoretical or expected regressions of the per cent lean cuts to backfat thickness are given at five-pound intervals in columns 4 and 5 of table 11. The relationship between carcass weight and the regression of backfat to per cent lean cuts is graphically illustrated in figure 10 as the solid line.[12]

The Regression Surfaces

On the basis of the computed backfat thickness at a standardized 49.3 per cent lean cuts (table 9) and the theoretical regression coefficients (table 11), the combined effect of backfat thickness and carcass weight on per cent lean cuts can be shown in tabular form, as in table 12. At 1/10-inch intervals of backfat thickness the expected per cent of lean cuts can be read for carcass weights from 90 pounds to 250 pounds at 10-pound intervals.

The regression coefficients (the changes in the per cent of lean cuts associated with a one-inch change in backfat thickness) are given in the second column of the table. At 100 pounds a difference of one inch in backfat is associated with a difference of 12.5 per cent lean cuts, while at 200 pounds a one-inch difference is associated with 7.7 difference in the percentage of lean cuts.

Each of the lines in the table represents an assumed regression line for the entire population of hog carcasses (as compared with actual regression lines shown in figures 3 and 7). The table as a whole may be conceived as a curvilinear regression surface.

One of the more fundamental objectives of this analysis has been to provide a means by which similar carcasses can be grouped together in the same grade classification, even though they may differ considerably in weight.

In order to set up the upper and lower limits of each grade, some method is required for specifying at each carcass weight the average backfat

[12] The basic equation selected to express this relationship was as follows:

$y = \frac{1}{x} \cdot 15.4241865$ (constant)

where y = expected coefficient at a given carcass weight
and x = a hypothetical backfat thickness of carcasses with a constant degree of finish at the same given carcass weight.

This equation is that of a rectangular hyperbola and is an expression of inversely proportionate relationships. Regression coefficients are not inversely proportional to carcass weight, however. They are inversely proportional to the backfat thickness of different-weight carcasses standardized at a constant degree of finish. For example, if standardized carcasses having one inch of backfat are compared with carcasses with the same degree of finish but having two inches of backfat (obviously much heavier carcasses), a given change in backfat thickness, such as 0.2 inch, would have twice the effect on the one-inch standardized group than on the two-inch group. This should be true since the change represents one-fourth of the backfat in the first group but only one-eighth of the backfat in the second. In other words a given *increase* in the hypothetical backfat thickness of carcasses standardized at a constant degree of finish should be associated with a proportionate *decrease* in the regression of backfat to the per cent lean cuts.

Two problems of solution were involved: (1) the selection of some equation to describe the backfat thicknesses of carcasses with a constant degree of finish at different weights and (2) the calculation of the constant. Since the assumption of equivalence between a constant degree of finish and a constant percentage of lean cuts at different carcass weights was rejected, the backfat thicknesses shown in table 4 ($Y = a + b \text{ Log } X$) do not supply the required data. A double log equation with the origin at zero seemed to give the most satisfactory results for this purpose. $\text{Log } Y = b \text{ Log } X$, where Y equals backfat thickness and X equals carcass weight of carcasses standardized at 49.3 per cent lean cuts. The equation was applied to the backfat thicknesses shown in table 7 and plotted in figure 9. The computed hypothetical backfat thicknesses shown in column 2 of table 11 were derived from this equation.

According to the basic equation, $y = \frac{1}{x} \cdot c$, the constant must be equal to all values of the cross product, xy. The calculation of the constant provides the solution to the equation. Each regression coefficient in table 10 was multiplied by the computed hypothetical backfat thickness ($\text{Log } Y = b \text{ Log } X$) of its associated average weight. The average of these cross products was the regression constant.

This equation was used as the basis for computing the theoretical regressions shown in column 3 of table 11 and illustrated by the dotted line in figure 10. This particular fit overstated the decline in regression as weight increased and was therefore adjusted by calculating deviations for trend. A simple linear regression analysis was used to obtain the final, corrected line of best fit. The corrected regressions are those in columns 4 and 5 of table 11, and which are graphically illustrated by the solid line in figure 10.

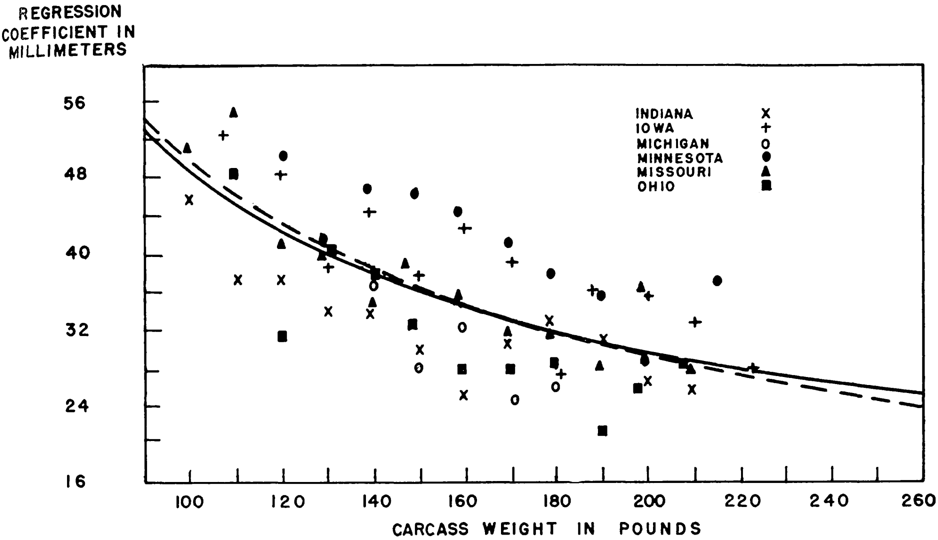

FIG. 10. Regression of regression coefficients (between backfat thickness and per cent lean cuts) on carcass weight.

thickness which has the greatest likelihood of predicting a certain percentage of lean cuts. Table 13 was prepared for this purpose. It indicates the backfat thicknesses which can be expected to produce any given percentage of lean cuts from 39.0 to 60.0 at carcass weights from 90 to 250 pounds.

These tables substantiate the belief that cuts from heavier carcasses were trimmed more closely in proportional terms than those from lighter-weight carcasses. If per cent of lean cuts were equivalent to degree of finish, the percentage of lean cuts at any given backfat thickness would increase as carcass weight increased. If two carcasses differing in carcass weight have the same backfat thickness, the heavier carcass is obviously less well finished and would be expected to have a higher percentage of lean cuts.

In table 12 this condition appears to be met for backfat thicknesses of 1.5 inches or more. At 1.4 inches, however, the per cent of lean cuts increases only slightly beyond 150 pounds and levels off at 200 pounds. At 1.3 inches the percentage decreases after a carcass weight of 120 pounds is reached. At backfat thicknesses of less than 1.3 inches the per cent of lean cuts declines over the entire range of carcass weight included in the table.

The same tendency is apparent in the portion of table 13 which describes the relatively lean carcasses. In this table each column presents the backfat thicknesses which would most likely predict a given constant per cent of lean cuts at different weights.

At 53.0 per cent lean cuts the backfat required to predict a constant percentage reaches a peak between 120 and 130 pounds and thereafter declines. At 54.0 per cent and more the backfat required declines continuously throughout the range of carcass weights included in the table. If the trimming of lean cuts had been done in proportion to weight, a constant percentage of lean cuts would be equivalent to a constant degree of finish. In addition, the backfat thickness required for any

Table 10. Average Weights and Regression Coefficients of the Regression Coefficients on Carcass Weight—Six States, 62 Weight Groups

	States											
	Indiana		Iowa		Michigan		Minnesota		Missouri		Ohio	
Weight group	Average weight	Regression	Average weight	Regression	Average weight	Regression	Average weight	Regression	Average weight	Regression	Average weight	Regression
pounds	pounds	millimeters	pounds	millimeters	pounds	millimeters	pounds	millimeters	pounds	millimeters	pounds	millimeters
95-105	100.35	.4606	....	....	....	....	....	....	100.46	.5120	....	....
105-115	110.58	.3706	108.4	.522	....	....	....	....	109.86	.5549	110.76	.4993
115-125	120.37	.3711	120.1	.483	....	....	120.7	.5005	120.97	.4137	120.18	.3113
125-135	130.11	.3448	130.4	.387	....	....	129.5	.4186	129.67	.4051	130.83	.4113
135-145	139.94	.3432	139.7	.445	140.89	.3620	139.4	.4791	140.97	.3452	140.08	.3765
145-155	150.20	.3042	150.0	.388	150.59	.2842	150.2	.4727	148.91	.3987	149.12	.3212
155-165	159.98	.2585	160.2	.426	160.89	.3226	159.8	.4433	159.92	.3523	160.33	.2846
165-175	170.11	.3122	170.1	.395	171.03	.2493	170.6	.4170	170.38	.3160	170.82	.2839
175-185	179.14	.3323	180.1	.282	180.24	.2688	179.3	.3849	179.60	.3166	180.26	.2843
185-195	190.41	.3138	189.7	.357	....	....	189.4	.3563	189.86	.2973	190.51	.2193
195-205	200.15	.2678	200.1	.355	....	....	199.1	.2911	199.94	.3773	199.91	.2687
205-215	209.27	.2680	210.2	.330	....	....	214.6	.3747	209.55	.2847	209.14	.2857
215-225	....	....	222.6	.282	....	....	....	....	....	....	....	....

constant percentage of lean cuts would increase with weight at all points in the table.

In figure 11 the constant per cent columns of table 13 are graphically shown as constant per cent lines. This figure also illustrates the changing increments of backfat required with additional weight as the leaner portion of the degree of finish scale is reached. At the extreme left of the figure the backfat required to maintain a constant percentage of lean cuts increases sharply. Constant per cent lines change their direction of drift at 53 and 54, while at 55 and above the lines move continuously toward less backfat as weight is increased.

These tendencies have been elaborated on in some detail because of the problems they will pose in establishing backfat specifications for objective grade standards. The constant percentage columns of table 13 (or some interpolation between the columns) are to be used to provide the boundaries between grades.

An example is the establishment of the boundary between the optimum finished grade and the first overfin-

Table 11. Relationship Between the Theoretical Regression Coefficients and Carcass Weight—Region

		Theoretical regression coefficients		
Carcass weight	Computed back-fat thickness*	Regression†	Corrected for deviation from trend	
pounds	millimeters	millimeters	millimeters	inches
90	28.61	.539119	.530872	13.483491
95	29.79	.517764	.510106	12.956060
100	30.95	.498358	.491289	12.478132
105	32.10	.480504	.474024	12.039622
110	33.23	.464165	.458275	11.639617
115	34.35	.449030	.443729	11.270167
120	35.45	.435097	.430385	10.931246
125	36.55	.422002	.417879	10.613609
130	37.63	.409891	.406357	10.320964
135	38.71	.398455	.395510	10.045464
140	39.77	.387835	.385479	9.790689
145	40.82	.377859	.376092	9.552271
150	41.87	.368383	.367205	9.326552
155	42.90	.359538	.358949	9.116860
160	43.93	.351108	.351108	8.917708
165	44.95	.343141	.343730	8.730316
170	45.96	.335600	.336778	8.553744
175	46.97	.328384	.330151	8.385426
180	47.96	.321605	.323961	8.228208
185	48.95	.315101	.318046	8.077974
190	49.94	.308854	.312388	7.934268
195	50.91	.302970	.307093	7.799782
200	51.88	.297305	.302017	7.670857
205	52.84	.291904	.297205	7.548639
210	53.80	.286695	.292585	7.431296
215	54.76	.281669	.288149	7.318627
220	55.70	.276915	.283984	7.212842
225	56.64	.272320	.279978	7.111094
230	57.58	.267874	.276121	7.013131
235	58.51	.263616	.272452	6.919943
240	59.43	.259535	.268960	6.831251
245	60.35	.255579	.265593	6.745733
250	61.27	.251741	.262344	6.663212

* Log Y = + .745323 Log X. For method of computation see footnote 6, page 19.
† Regression = 15.4241865 ÷ computed backfat thickness (column 2).

Table 12. Percentages of Four Lean Cuts at Specified Backfat Thickness by Carcass Weights—Region

Carcass weight	Regression coefficient	Backfat at 49.3 per cent	Backfat thickness in inches									
			3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4
pounds	inches	inches	percentages of four lean cuts									
90	13.062786	1.5721	....	....	....	....	....	....	....	....	....	....
100	12.478132	1.5989	....	....	....	....	....	....	....	....	....	39.30
110	11.639617	1.6233	....	....	....	....	....	....	....	....	39.09	40.26
120	10.931246	1.6454	....	....	....	....	....	....	....	....	39.96	41.06
130	10.320964	1.6654	....	....	....	....	....	....	....	39.65	40.68	41.71
140	9.790689	1.6843	....	....	....	....	....	....	39.36	40.34	41.32	42.30
150	9.326552	1.7021	....	....	....	....	....	....	39.99	40.93	41.86	42.79
160	8.917708	1.7182	....	....	....	....	....	39.65	40.54	41.43	42.33	43.22
170	8.553744	1.7335	....	....	....	....	39.33	40.18	41.04	41.89	42.75	43.60
180	8.228208	1.7481	....	....	....	....	39.83	40.65	41.47	42.29	43.12	43.94
190	7.934268	1.7619	....	....	....	39.48	40.27	41.06	41.86	42.65	43.44	44.24
200	7.670857	1.7749	....	....	....	39.90	40.66	41.43	42.20	42.97	43.73	44.50
210	7.431296	1.7871	....	....	39.55	40.29	41.03	41.78	42.52	43.26	44.00	44.75
220	7.212842	1.7989	....	....	39.91	40.63	41.35	42.08	42.80	43.52	44.24	44.96
230	7.013131	1.8103	....	39.55	40.25	40.95	41.66	42.36	43.06	43.76	44.46	45.16
240	6.831251	1.8210	....	39.88	40.56	41.24	41.93	42.61	43.29	43.97	44.66	45.34
250	6.663212	1.8316	39.52	40.18	40.85	41.51	42.18	42.85	43.51	44.18	44.85	45.51

Table 12—continued

Backfat thickness in inches															
2.3	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
percentages of four lean cuts															
39.48	40.83	42.18	43.53	44.88	46.22	47.57	48.92	50.27	51.62	52.97	54.32	55.66	57.01	58.36	59.71
40.55	41.80	43.04	44.29	45.54	46.79	48.03	49.28	50.53	51.78	53.03	54.27	55.52	56.77	58.02	59.26
41.42	42.59	43.75	44.91	46.08	47.24	48.41	49.57	50.73	51.90	53.06	54.23	55.39	56.55	57.72	58.88
42.15	43.24	44.33	45.43	46.52	47.61	48.71	49.80	50.89	51.99	53.08	54.17	55.27	56.36	57.45	58.54
42.75	43.78	44.81	45.84	46.87	47.91	48.94	49.97	51.00	52.03	53.07	54.10	55.13	56.16	57.19	58.23
43.28	44.26	45.23	46.21	47.19	48.17	49.15	50.13	51.11	52.09	53.07	54.05	55.03	56.00	56.98	57.96
43.72	44.66	45.59	46.52	47.45	48.39	49.32	50.25	51.19	52.12	53.05	53.98	54.92	55.85	56.78	57.71
44.11	45.00	45.89	46.78	47.68	48.57	49.46	50.35	51.24	52.14	53.03	53.92	54.81	55.70	56.59	57.49
44.46	45.31	46.17	47.02	47.88	48.73	49.59	50.45	51.30	52.16	53.01	53.87	54.72	55.58	56.43	57.29
44.76	45.59	46.41	47.23	48.05	48.88	49.70	50.52	51.35	52.17	52.99	53.81	54.64	55.46	56.28	57.11
45.03	45.82	46.62	47.41	48.20	49.00	49.79	50.58	51.38	52.17	52.96	53.76	54.55	55.34	56.14	56.93
45.27	46.03	46.80	47.57	48.34	49.10	49.87	50.64	51.40	52.17	52.94	53.71	54.47	55.24	56.01	56.77
45.49	46.23	46.98	47.72	48.46	49.21	49.95	50.69	51.44	52.18	52.92	53.67	54.41	55.15	55.90	56.64
45.68	46.40	47.12	47.85	48.57	49.29	50.01	50.73	51.45	52.18	52.90	53.62	54.34	55.06	55.78	56.50
45.86	46.56	47.27	47.97	48.67	49.37	50.07	50.77	51.47	52.18	52.88	53.58	54.28	54.98	55.68	56.38
46.02	46.71	47.39	48.07	48.76	49.44	50.12	50.81	51.49	52.18	52.86	53.54	54.22	54.91	55.59	56.27
46.18	46.84	47.51	48.18	48.84	49.51	50.18	50.84	51.51	52.18	52.84	53.51	54.17	54.84	55.51	56.17

Table 13. Backfat Thickness in Inches at Specified Percentages of Four Lean Cuts and Carcass Weights—Region

Carcass weight	Regression coefficient	Backfat at 49.3 per cent	Percentages of four lean cuts						
			39.0	40.0	41.0	42.0	43.0	44.0	45.0
pounds	inches	inches				inches			
90	13.483491	1.5721	2.336	2.262	2.188	2.113	2.039	1.965	1.891
100	12.478132	1.5989	2.424	2.344	2.264	2.184	2.104	2.024	1.943
110	11.639617	1.6233	2.508	2.422	2.336	2.250	2.165	2.079	1.993
120	10.931246	1.6454	2.588	2.496	2.405	2.313	2.222	2.130	2.039
130	10.320964	1.6654	2.663	2.567	2.470	2.373	2.276	2.179	2.082
140	9.790689	1.6843	2.736	2.634	2.532	2.430	2.328	2.226	2.123
150	9.326552	1.7021	2.807	2.699	2.592	2.485	2.378	2.270	2.163
160	8.917708	1.7182	2.873	2.761	2.649	2.537	2.425	2.312	2.200
170	8.553744	1.7335	2.938	2.821	2.704	2.587	2.470	2.353	2.236
180	8.228208	1.7481	3.000	2.878	2.757	2.635	2.514	2.392	2.271
190	7.934268	1.7619	3.060	2.934	2.808	2.682	2.556	2.430	2.304
200	7.670857	1.7749	3.118	2.987	2.857	2.727	2.596	2.466	2.335
210	7.431296	1.7871	3.173	3.039	2.904	2.769	2.635	2.500	2.366
220	7.212842	1.7989	3.227	3.088	2.950	2.811	2.672	2.534	2.395
230	7.013131	1.8103	3.279	3.136	2.994	2.851	2.709	2.566	2.423
240	6.831251	1.8210	3.329	3.182	3.036	2.890	2.743	2.597	2.450
250	6.663212	1.8316	3.377	3.227	3.077	2.927	2.777	2.627	2.477

Table 13—continued

Percentages of four lean cuts														
46.0	47.0	48.0	49.0	50.0	51.0	52.0	53.0	54.0	55.0	56.0	57.0	58.0	59.0	60.0
							inches							
1.817	1.743	1.668	1.594	1.520	1.446	1.372	1.298	1.223	1.149	1.075	1.001	.927	.853	.778
1.863	1.783	1.703	1.623	1.543	1.463	1.382	1.302	1.222	1.142	1.062	.982	.902	.822	.741
1.907	1.821	1.735	1.649	1.563	1.477	1.391	1.305	1.220	1.134	1.048	.962	.876	.790	.704
1.947	1.856	1.764	1.673	1.581	1.490	1.398	1.307	1.215	1.124	1.032	.941	.849	.758	.667
1.985	1.888	1.791	1.695	1.598	1.501	1.404	1.307	1.210	1.113	1.016	.919	.822	.726	.629
2.021	1.919	1.817	1.715	1.613	1.511	1.408	1.306	1.204	1.102	1.000	.898	.796	.694	.591
2.056	1.949	1.842	1.734	1.627	1.520	1.413	1.305	1.198	1.091	.984	.877	.769	.662	.555
2.088	1.976	1.864	1.752	1.640	1.528	1.415	1.303	1.191	1.079	.967	.855	.743	.630	.518
2.119	2.002	1.886	1.769	1.652	1.535	1.418	1.301	1.184	1.067	.950	.833	.716	.600	.483
2.149	2.028	1.906	1.785	1.663	1.542	1.420	1.298	1.177	1.055	.934	.812	.691	.569	.448
2.178	2.052	1.926	1.800	1.674	1.548	1.422	1.296	1.170	1.043	.917	.791	.665	.539	.413
2.205	2.075	1.944	1.814	1.684	1.553	1.423	1.293	1.162	1.032	.901	.771	.641	.510	.380
2.231	2.097	1.962	1.828	1.693	1.558	1.424	1.289	1.155	1.020	.886	.751	.616	.482	.347
2.256	2.118	1.979	1.841	1.702	1.563	1.425	1.286	1.147	1.009	.870	.731	.593	.454	.315
2.281	2.138	1.996	1.853	1.711	1.568	1.425	1.283	1.140	.998	.855	.712	.570	.427	.285
2.304	2.158	2.011	1.865	1.719	1.572	1.426	1.279	1.133	.987	.840	.694	.547	.401	.255
2.327	2.177	2.027	1.877	1.727	1.576	1.426	1.276	1.126	.976	.826	.676	.526	.376	.226

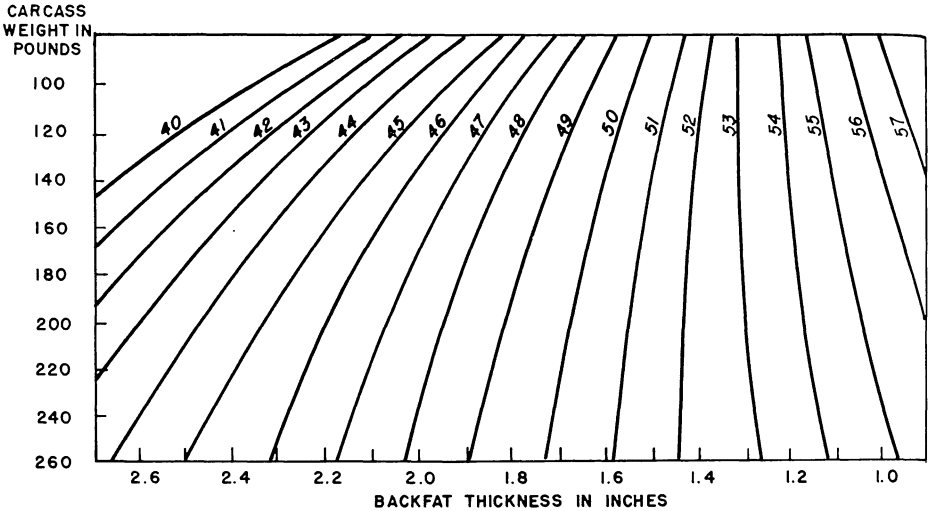

FIG. 11. Relation of carcass weight and backfat thickness to per cent lean cuts—region.

ished grade. Either the 48.0 per cent column, the 49.0 per cent column, or some percentage between these columns such as 48.5 might be used to establish the upper limits in backfat for the optimum grade and the lower limits for the first overfinished grade.

Similarly, in establishing the margin between the two overfinished grades either the 45.0 per cent column, the 46.0 per cent column, or some percentage between these two columns might be used to specify the backfat thicknesses which separate the moderately overfinished carcasses from the extremely overfinished carcasses.

Within the overfinished portion of the range of the per cent lean cuts, backfat specifications established on the basis of table 13 would appear to separate the carcasses satisfactorily into classifications or grades. Differences in value among carcasses described in this area of table 13 are caused primarily by differences in the quantitative ratio of the percentage yield of the high-value lean cuts to the percentage yield of the low-value fat and lard.

For the entire region this tabulation of backfat thicknesses, associated with constant percentages of lean cuts at different carcass weights, can do the most satisfactory job of classifying carcasses into fairly homogeneous groupings. This grouping is done according to per cent lean cuts and therefore according to value, insofar as value is determined by the percentage of lean cuts.

A constant per cent of lean cuts, however, is not equivalent to a constant degree of finish. On the underfinished side of the entire range of finish, particularly beyond 51.0 per cent, the constant-percentage columns probably understate the degree of finish on lighter-weight carcasses and overstate the degree of finish on heavier-weight carcasses. In other words at 51.0 per cent lean cuts (table 13 and figure 11) a 100-pound carcass at 1.46 inches of backfat is more highly finished than a 200-pound carcass at 1.55 inches of backfat.

This makes the use of constant percentage of lean cuts, as it is expressed in table 13, a somewhat less than satisfactory device for separating the underfinished from the satisfactory carcasses and for classifying the underfinished carcasses into two separate grades.

However, relatively small proportions of hogs at usual marketing weights are underfinished. A much larger proportion carry fat in excess of amounts required to produce first-quality wholesale cuts. The per cent lean cuts appears to be an effective criterion for differentiating these overfinished carcasses. Hence there are ample reasons for not discarding this criterion as an equalizing device among carcass weights when setting up backfat specifications for grades.

In the discussion of table 8 and figure 8 it was noted there were two different groupings of curves showing the relationship of backfat thickness of standardized carcasses to carcass weight. Within the samples from Iowa, Michigan, and Minnesota the backfat thickness of carcasses standardized at 49.3 per cent lean cuts (regional equivalent) increased appreciably more as carcass weight increased than was the case in the sample from Indiana, Missouri, and Ohio, or from the region as a whole.

In the earlier discussion it was suggested that the cutting procedures actually applied in the former states may have departed from the absolute specifications for trimming exterior fat from the lean cuts in the direction of proportional trimming. This would mean that constant-percentage lines over a range of carcass weights constructed from data from these state samples would more closely approximate a constant degree of finish than do the similar lines for the region as a whole shown in figure 11.

On the basis of a separate analysis made on the Iowa, Michigan, and Minnesota data, tables 14 and 15 were constructed. Table 14 gives the percentages of lean cuts from different combinations of backfat and weight (comparable to table 12 for the region). Table 15 gives the backfat required to predict certain constant percentages of lean cuts at different carcass weights (comparable to table 13 for the region). Constant-percentage lines taken from these tables are shown in figure 12.

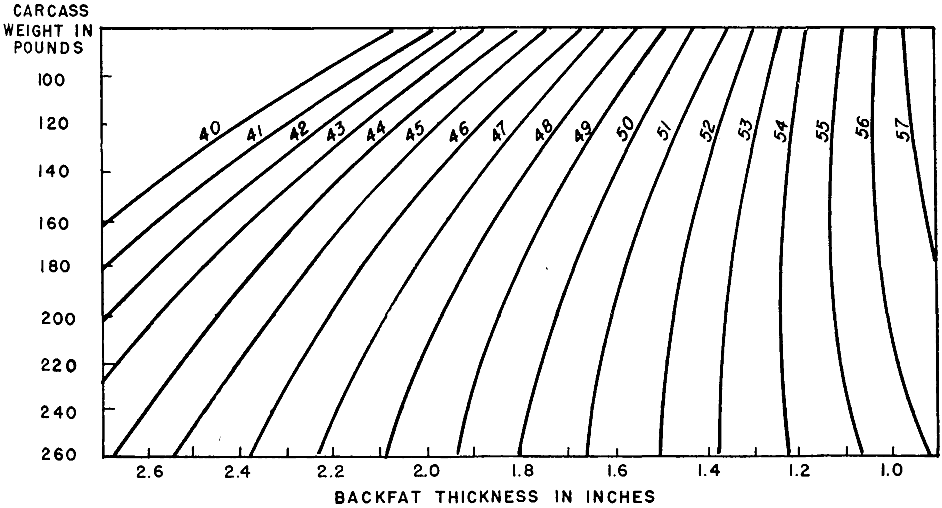

FIG. 12. Relation of carcass weight and backfat thickness to per cent of lean cuts—Iowa, Michigan, and Minnesota.

Table 14. Percentages of Four Lean Cuts at Specified Backfat Thicknesses by Carcass Weights—Iowa, Michigan, and Minnesota

Carcass weight	Regression coefficient	Backfat at 49.3 per cent	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
pounds	inches	inches	percentages of four lean cuts										
90	14.695215	1.4906	....	....	....	....	....	....	....	....	....	....	....
100	13.596846	1.5324	....	....	....	....	....	....	....	....	....	....	38.86
110	12.673271	1.5698	....	....	....	....	....	....	....	....	....	38.78	40.05
120	11.890252	1.6040	....	....	....	....	....	....	....	....	....	39.84	41.03
130	11.215991	1.6355	....	....	....	....	....	....	....	....	39.61	40.73	41.85
140	10.624683	1.6650	....	....	....	....	....	....	....	39.37	40.43	41.49	42.55
150	10.107234	1.6922	....	....	....	....	....	....	39.11	40.12	41.13	42.14	43.15
160	9.646780	1.7174	....	....	....	....	....	....	39.82	40.78	41.75	42.71	43.68
170	9.234786	1.7414	....	....	....	....	....	39.53	40.45	41.38	42.30	43.22	44.15
180	8.864269	1.7639	....	....	....	....	39.23	40.11	41.00	41.89	42.77	43.66	44.55
190	8.529539	1.7851	....	....	....	....	39.79	40.64	41.50	42.35	43.20	44.06	44.91
200	8.225948	1.8056	....	....	....	39.47	40.30	41.12	41.94	42.76	43.59	44.41	45.23
210	7.948111	1.8249	....	....	....	39.96	40.76	41.55	42.35	43.14	43.94	44.73	45.53
220	7.693031	1.8430	....	....	39.63	40.40	41.17	41.94	42.71	43.48	44.25	45.02	45.78
230	7.459489	1.8607	....	39.30	40.05	40.80	41.54	42.29	43.03	43.78	44.53	45.27	46.02
240	7.242635	1.8773	....	39.72	40.45	41.17	41.89	42.62	43.34	44.07	44.79	45.52	46.24
250	7.043153	1.8934	39.40	40.10	40.81	41.51	42.21	42.92	43.62	44.33	45.03	45.74	46.44

Table 14—continued

Backfat thickness in inches														
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	0.9	0.8
percentages of four lean cuts														
38.87	40.34	41.81	43.28	44.75	46.22	47.69	49.16	50.63	52.10	53.57	55.04	56.51	57.98	59.45
40.22	41.58	42.94	44.30	45.66	47.02	48.38	49.74	51.10	52.46	53.82	55.18	56.54	57.90	59.26
41.32	42.58	43.85	45.12	46.39	47.65	48.92	50.19	51.45	52.72	53.99	55.26	56.52	57.79	59.06
42.22	43.40	44.59	45.78	46.97	48.16	49.35	50.54	51.73	52.92	54.11	55.30	56.48	57.67	58.86
42.97	44.09	45.21	46.34	47.46	48.58	49.70	50.82	51.94	53.06	54.19	55.31	56.43	57.55	58.67
43.62	44.68	45.74	46.80	47.87	48.93	49.99	51.05	52.11	53.18	54.24	55.30	56.36	57.43	58.49
44.17	45.18	46.19	47.20	48.21	49.22	50.23	51.24	52.25	53.26	54.27	55.28	56.29	57.31	58.32
44.64	45.61	46.57	47.54	48.50	49.47	50.43	51.39	52.36	53.32	54.29	55.25	56.22	57.18	58.15
45.07	45.99	46.92	47.84	48.76	49.69	50.61	51.53	52.46	53.38	54.30	55.23	56.15	57.07	58.00
45.43	46.32	47.20	48.09	48.98	49.86	50.75	51.64	52.52	53.41	54.30	55.18	56.07	56.95	57.84
45.76	46.62	47.47	48.32	49.17	50.03	50.88	51.73	52.59	53.44	54.29	55.14	56.00	56.85	57.70
46.05	46.88	47.70	48.52	49.34	50.17	50.99	51.81	52.64	53.46	54.28	55.10	55.93	56.75	57.57
46.32	47.12	47.91	48.71	49.50	50.30	51.09	51.88	52.68	53.47	54.27	55.06	55.86	56.65	57.45
46.55	47.32	48.09	48.86	49.63	50.40	51.17	51.94	52.71	53.48	54.25	55.02	55.79	56.56	57.32
46.76	47.51	48.26	49.00	49.75	50.49	51.24	51.99	52.73	53.48	54.22	54.97	55.72	56.46	57.21
46.96	47.69	48.41	49.14	49.86	50.59	51.31	52.03	52.76	53.48	54.21	54.93	55.66	56.38	57.10
47.14	47.85	48.55	49.26	49.96	50.67	51.37	52.07	52.78	53.48	54.19	54.89	55.60	56.30	57.00

Table 15. Backfat Thickness in Inches at Specified Percentages of Four Lean Cuts and Carcass Weights—Iowa, Michigan, and Minnesota

Carcass weight	Regression coefficient	Backfat at 49.3 per cent	Percentages of four lean cuts						
			40.0	41.0	42.0	43.0	44.0	45.0	46.0
pounds	inches	inches					inches		
90	14.695215	1.4906	2.123	2.055	1.987	1.919	1.851	1.783	1.715
100	13.596846	1.5324	2.216	2.143	2.069	1.996	1.922	1.849	1.775
110	12.673271	1.5698	2.034	2.225	2.146	2.067	1.988	1.909	1.830
120	11.890252	1.6040	2.386	2.302	2.218	2.134	2.050	1.966	1.882
130	11.215991	1.6355	2.465	2.375	2.286	2.197	2.108	2.019	1.930
140	10.624683	1.6650	2.540	2.446	2.352	2.258	2.164	2.070	1.976
150	10.107234	1.6922	2.612	2.513	2.414	2.316	2.217	2.118	2.019
160	9.646780	1.7174	2.681	2.578	2.474	2.370	2.267	2.163	2.059
170	9.234786	1.7414	2.748	2.640	2.532	2.424	2.315	2.207	2.099
180	8.864269	1.7639	2.813	2.700	2.587	2.475	2.362	2.249	2.136
190	8.529539	1.7851	2.875	2.758	2.641	2.524	2.406	2.289	2.172
200	8.225948	1.8056	2.936	2.815	2.693	2.571	2.450	2.328	2.207
210	7.948111	1.8249	2.995	2.869	2.743	2.617	2.492	2.366	2.240
220	7.693031	1.8430	3.052	2.922	2.792	2.662	2.532	2.402	2.272
230	7.459489	1.8607	3.107	2.973	2.839	2.705	2.571	2.437	2.303
240	7.242635	1.8773	3.161	3.023	2.885	2.747	2.609	2.471	2.333
250	7.043153	1.8934	3.214	3.072	2.930	2.788	2.646	2.504	2.362

Table 15—continued

Percentages of four lean cuts													
47.0	48.0	49.0	50.0	51.0	52.0	53.0	54.0	55.0	56.0	57.0	58.0	59.0	60.0
							inches						
1.647	1.579	1.511	1.443	1.375	1.307	1.239	1.171	1.103	1.035	0.967	0.899	0.831	0.762
1.702	1.628	1.555	1.481	1.407	1.334	1.260	1.187	1.113	1.040	0.966	0.893	0.819	0.745
1.751	1.672	1.594	1.515	1.436	1.357	1.278	1.199	1.120	1.041	0.962	0.883	0.804	0.726
1.797	1.713	1.629	1.545	1.461	1.377	1.293	1.209	1.125	1.040	0.956	0.872	0.788	0.704
1.841	1.751	1.662	1.573	1.484	1.395	1.306	1.216	1.127	1.038	0.949	0.860	0.771	0.681
1.881	1.787	1.693	1.599	1.505	1.411	1.317	1.223	1.128	1.034	0.940	0.846	0.752	0.658
1.920	1.821	1.722	1.623	1.524	1.425	1.326	1.227	1.128	1.029	0.930	0.831	0.733	0.634
1.956	1.852	1.749	1.645	1.541	1.438	1.334	1.230	1.127	1.023	0.919	0.816	0.712	0.608
1.990	1.882	1.774	1.666	1.557	1.449	1.341	1.232	1.124	1.016	0.908	0.799	0.691	0.583
2.023	1.911	1.798	1.685	1.572	1.459	1.346	1.234	1.121	1.008	0.895	0.782	0.670	0.557
2.055	1.938	1.820	1.703	1.586	1.469	1.351	1.234	1.117	1.000	0.882	0.765	0.648	0.531
2.085	1.964	1.842	1.721	1.599	1.477	1.356	1.234	1.113	0.991	0.870	0.748	0.626	0.505
2.114	1.988	1.863	1.737	1.611	1.485	1.359	1.234	1.108	0.982	0.856	0.730	0.604	0.479
2.142	2.012	1.882	1.752	1.622	1.492	1.362	1.232	1.102	0.972	0.842	0.712	0.582	0.452
2.169	2.035	1.901	1.767	1.633	1.499	1.365	1.231	1.097	0.963	0.828	0.694	0.560	0.426
2.195	2.057	1.919	1.781	1.643	1.504	1.366	1.228	1.090	0.952	0.814	0.676	0.538	0.400
2.220	2.078	1.936	1.794	1.652	1.510	1.368	1.226	1.084	0.942	0.800	0.658	0.516	0.374

The important difference to be noted in these tables and figure is the fact that the backfat thickness required to predict any particular percentage of lean cuts increased more (or decreased less in the underfinished range) as carcass weight increased than was the case in the tabulations constructed from all states in the region. This, of course, was the reason for the separate analysis.

It logically followed that in figure 12 the area in which backfat declined was less than in figure 11. In figure 12 this area began to the left of the 54 per cent constant, and in figure 11 it began just to the right of the 52 per cent constant.[13] It appears that the latter tabulations may be more satisfactory for use in establishing margins for the underfinished grades.

The data in table 3 suggested a tentative carcass standard based on backfat specifications derived from tables 13 and 15. Each grade (except the open-end grades, Grades 8 and 12) encompasses a range in finish equivalent to 3.0 per cent lean cuts.

The backfat specifications separating Grade 8 carcasses from Grade 9 carcasses and those separating Grade 9 carcasses from Grade 10 carcasses were interpolated from table 13. These specifications separate the overfinished carcasses from those which have adequate but not excessive finish and separate the overfinished carcasses into two grades. The specifications which are used for the same purpose with respect to the underfinished grades, Grades 11 and 12, were interpolated from table 15.

The use of the data for only three of the six states to differentiate the underfinished carcasses gives less validity to this part of the grade standard. Since large numbers of underfinished hogs are not marketed, this is not a serious defect in the grade standard.

The tentative carcass standard suggested in table 3 relies on per cent lean cuts as the primary criterion classifying hog carcasses at a particular carcass weight according to value. Per cent lean cuts is a quantitative measure of the physical composition of carcasses—an expression of the ratio of high-value cuts to low-value lard, fat cuts, and trimmings.

This quantitative factor has the predominant influence on value in that area of the grade standard in which carcasses are judged to have adequate or more than adequate finish. In that area, the margins between grades for weight groups were set at a particular constant percentage of lean cuts on the basis of the best prediction in terms of backfat thickness and carcass weight for the entire region.

This quantitative influence also carries out to the underfinished portion of the carcass standards. In this underfinished portion, however, the degree of finish begins to assume some qualitative characteristics which have a different influence on carcass value. In this area the lower the degree of finish (and the higher the percentage of lean cuts), the greater the expected frequency of cuts which must be discounted in price.

At any particular carcass weight, per cent of lean cuts is probably a fairly good measure of the degree of finish. The higher the percentage of lean cuts, the lower the degree of finish. But this converse relationship does not hold between carcass weights to the degree that it does at any one car-

[13] Another difference to be noted is the fact that the theoretical regressions are higher in the Iowa, Michigan, and Minnesota analysis than in the region as a whole. At 150 pounds carcass weight the regional regression would indicate that one-tenth inch difference in backfat would account for a 0.93 difference in per cent lean cuts. For the three states the same one-tenth inch difference in backfat would account for 1.01 per cent differences in lean cuts. Because of the higher regression coefficients in the three-state analysis the constant per cent lines of figure 12 are closer together than in figure 11. With higher regressions a smaller change in backfat is required to predict an equivalent difference in the percentage of lean cuts.

cass weight. Because per cent lean cuts was not necessarily conversely equivalent to degree of finish, the margins separating the underfinished grades from those with adequate finish were modified until they were somewhat consistent with a constant degree of finish. Tabulations developed from Iowa, Michigan, and Minnesota provided the basis for modifying the backfat specifications at the underfinished margins.

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 vertabrae 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 eight vertebrae below the last lumbar (include the last lumbar vertebra in the count).
Over last lumbar—At the center of the last lumbar vertebra.

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 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 the 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 the rear of the carcass with calipers. Sum of both measurements is recorded.

Width through shoulders

Width from center of first thoracic vertebra 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 vertebra 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 edges 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 1¼″ 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 for a distance of four to five 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 belly.
   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.

* These cutting procedures were developed by a group designated by the regional research committee and by the American Meat Institute.

APPENDIX C. AVERAGE WHOLESALE PRICES: PORK CUTS AND TRIMMINGS, CHICAGO, 1949*

Wholesale cuts	Weights	Prices
	pounds	cents per pound
Fresh skinned hams	10-12	46.39
	12-14	45.76
	14-16	45.47
	16-18	44.68
	18-20	44.12
	20-22	42.69
	22-24	41.72
	24-26	39.14
	25-30	36.51
Fresh loins	8-10	47.06
	10-12	47.06
	12-16	44.74
	16-20	40.36
Fresh bellies	6- 8	33.66
	8-10	33.21
	10-12	31.60
	12-14	29.60
	14-16	27.96
	16-18	26.50
	18-20	25.61
Green fatbacks	6- 8	09.64‡
	8-10	09.75‡
	10-12	09.93‡
	12-14	10.73
	14-16	10.93
	16-18	11.38
	18-20	11.44

Wholesale cuts	Weights	Prices
	pounds	cents per pound
Fresh picnics	4- 6	30.25
	6- 8	28.74
	8-10	26.66
	10-12	25.84
	12-14	25.21
Boston butts	4- 8	38.76
D. S. jowl butts		11.34
Spare ribs (under 3 pounds)		37.99
Neck bones		11.59
Front feet		07.40
Regular pork trim—50 per cent lean		20.49
Sp. pork trim—85 per cent lean		39.64
Ex. pork trim—95 per cent lean		46.66
Refined lard (tierces p.s. lard)		12.03

Conversion of fat to lard (12.03 X conversion factor†)

Cut or trimmings	Weight	Factor	Price
Fat trimmings and fatbacks	Under six pounds	80.00%	09.62
Fatbacks‡	6- 8	81.50%	09.80
	8-10	82.25%	09.89
	10-12	83.50%	10.05
	12-14§	84.50%	10.17
	14-16§	85.50%	10.29
	16-18§	86.25%	10.38

* The average prices for all cuts and trimmings other than loins and Boston butts were calculated from data taken from *The National Provisioner,* the weekly trade magazine of the packing industry. The average prices for loins and Boston butts were calculated from the *Chicago Wholesale Meat Situation,* furnished by the Production and Marketing Administration in the United States Department of Agriculture.

† The factors for converting fat to lard were copied from *The National Provisioner,* May 31, 1947, page 25.

‡ During this year it will be observed that on the average it was profitable to convert fatbacks up to 12 pounds into lard.

§ All fatbacks over 12 pounds could most profitably be merchandised as fatbacks in the wholesale trade.