

FURTHER OBSERVATIONS PERTAINING TO CARCASS
MEASUREMENTS AND U. S. BEEF GRADES

by

JOHN M. STULL

B. S., University of Maryland, 1951

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1953

Docu-
ment
LD
2668
T4
1953
S8
C.2

10-21-53

TABLE OF CONTENTS

| | |
|---------------------------------------|----|
| INTRODUCTION | 1 |
| REVIEW OF LITERATURE | 2 |
| METHODS AND PROCEDURE | 16 |
| OBSERVATIONS AND DISCUSSION | 40 |
| SUMMARY | 46 |
| ACKNOWLEDGEMENTS | 49 |
| LITERATURE CITED | 50 |
| APPENDIX | 52 |

INTRODUCTION

In an industry where economy of production is important, standardization is one of the essential factors utilized in producing an economic good. Standards have been developed as a means of establishing confidence between a buyer and a seller and to facilitate trading. Items such as shirts are purchased by neck size and sleeve length; bolts, by the number of threads per inch; lumber, by the board-foot, and so forth. These are examples of standardization. Meters, yards, avoirdupois, and other measuring devices can be utilized as instruments in establishing standards such as those cited above. These standards provide a means for describing and evaluating commodities so that all interested individuals have a uniform interpretation. Such methods are known as objective methods. Because objective standards cannot be used conveniently for some commodities, subjective standards must be used. Examples of this type commodity are hay, and beef carcasses.

The United States Government has developed an official set of standards for the grading of beef carcasses. This system consists of grading a carcass based on subjective observations of carcass characteristics as compared to a standard set of desirable merits. As with any visual or subjective measurements, there is a tendency toward human bias that will enter into the determination of the grade by the grader.

There are no purely objective measurements of beef grade. A beef carcass is a difficult item to grade with absolute

exactness. Even though there may be individual differences between them, two carcasses may be placed in the same grade, this grade being based on subjective reasoning. The suggestion has been made that objective standards, based on objective measurements, be developed for the grading of carcass beef.

There are three basic requirements that any grading standard must have if the system is to be successful. These requirements are:

1. They must be logical and workable in that the system fits the needs of the trade and does not run counter to the fundamental practices of the trade.
2. They must be specific and not influenced by individual prejudice.
3. The system must have permanence and cannot be affected by supply, demand, geography, or time.

Through this study an attempt was made to determine the possibility of grading a beef carcass by objective methods. Observations were also made as to the relationship that exists between carcass measurements and the grader's descriptive evaluation of the carcass.

REVIEW OF LITERATURE

Under the system where beef sold in a certain community was slaughtered locally, there was little doubt in the consumer's mind as to the quality of the meat sold in each butcher's shop. There was no need for the grading of meat because

each shop established a reputation for a certain degree of quality. However, as the center of livestock production moved westward, the packing industry followed, and as the distance between the consumer and the packer became greater, the opportunity and feasibility for personal inspection by the wholesaler decreased. Under these conditions, general descriptive terms came into use. "Native" referred to livestock from the Corn Belt or grain fattened stock, and "western" applied to cattle fattened on the grass range. Each of these broad classifications, "native and western", was further broken down into groups known as Choice, Good, and Medium based on their inherent amount of conformation, finish, and quality. The fact that the interpretation of these terms was not uniform on all markets made it apparent that a system of classification and grading on a nation-wide basis was needed.

The first attempt to collect, define, and interpret the names and terms as they were used in the trade was made by Hall (6) at the Illinois Agricultural Experiment Station. The standards suggested by Hall were based on data collected in the wholesale meat markets around Chicago, Illinois and at the Illinois station. The classification suggested was based on the terms in common use by the wholesalers. The initial carcass classes were established independently of the classes of livestock from which they came, i.e., the carcass grade showed no correlation with the grade of the live animal. Hall's original investigations became the basis of our present day beef grades.

Some time later, in 1917, the Bureau of Marketing, United States Department of Agriculture (4) proposed a tentative set

of grade standards for dressed beef, based on the Illinois work, to assist them in the reporting of livestock news and market quotations. At first, the Bureau of Marketing was interested primarily in the reporting of the market prices of live animals, but at the request of those persons dealing in dressed meats, they extended their reports to include quotations on carcass meat. It soon became apparent that these standards could be utilized and would be a practical aid in buying and selling carcass beef. When the Bureau of Marketing first tried to report prices on dressed meats in 1917, it was found that various markets interpreted the grading standards differently. An outline of the grades defined in Bulletin 1246 is shown in Table 1.

Table 1. Classes and grade of beef animals.

| Classes (Based on sex condition) | : | Grades (Based on conformation, finish, and quality) |
|-------------------------------------|---|--|
| Steers | : | Prime, Choice, Good, Medium, Common, Butter, and Canner |
| Heifers | : | Prime, Choice, Good, Medium, Common, Cutter, and Canner |
| Cows | : | Choice, Good, Medium, Common, Cutter and Canner |
| Bulls | : | Choice, Good, Medium, Common, Cutter, and Canner |
| Stags | : | Choice, Good, Medium, Common, Cutter, and Canner |

These standards, first published in mimeographed form, were revised and issued in bulletin form in August, 1924.

Until this time, the purpose of classification and grading of beef was to establish uniform methods of determining value. To determine the value of a beef carcass, as with any commodity with heterogeneous characteristics, it was necessary to break them into groups in which all units within a particular group were similar and any variation was negligible. By reducing a large number of carcasses into smaller lots, the value of each individual lot could be more easily determined.

The formation and development of descriptive terms to fit each of these smaller groups was the next step. Each term designated the value or degree of excellence of the lot to which it was assigned, and allowed the derivation of a standard set of values. The set of terms assigned to each lot had to have fixed and limited definitions and these definitions had to be understood throughout the market. Each set of terms was based on fundamental characteristics inherent in the commodity with limits being as restricted as possible. The actual grading now became a system of observation and the matching of the carcass with a given set of standards.

The procedure was to divide the beef carcasses into classes based on sex condition. The classes developed were steers, heifers, cows, bulls, and stags. Following classification, the classes were then subdivided into other groups designated as grade. The grade was determined on the basis of the three factors which influenced the desirability of the carcass. These factors were conformation, finish, and quality. Conformation indicates the relative proportions of meat to bone and muscular

development, compactness, fullness, and thickness. Finish refers to the degree of fatness of the animal. The palatability of the beef is influenced by the quality, quantity, and distribution of the finish. The desirable degree of outside finish calls for smooth, firm, thick, and uniformly distributed layers of fat over the body. Quality is concerned with the nature or character of the flesh and fat of the carcass. The amount of marbling, i.e., fat interspersed in lean tissue, the firmness and color of the lean along with the firmness of the grain of this lean are the main factors contributing to quality. The grades developed from these initial investigations were designated Prime, Choice, Good, Medium, Common, Cutter, and Low Cutter.

During the mid-twenties, there was a general demand by cattlemen, feeders, packers, wholesalers, and others concerned with the beef producing industry for some method of alleviating the situation that caused an over-supply of beef on the market and insufficient money in the hands of the consumer to clear the market. It was postulated that the beef grades developed by the Bureau of Marketing for market reporting could be adopted on a nation-wide basis as a federal grading system, and could assist in moving the back-log of beef off the market. These standards had been promulgated by the Secretary of Agriculture in June, 1926 as the official United States Standards for the Grades of Carcass Beef (12). The standards were not accepted, however, until a number of public hearings were held to give producers, slaughterers, wholesalers, retail meat dealers, and other inter-

ested parties an opportunity to voice their opinions of the proposed grading system and to make suggestions for their improvement. The use of these standards began in May, 1927 on a voluntary and experimental basis. The grading was done by U. S. Government Graders and their services were confined to grading U. S. Prime and U. S. Choice carcasses. These men worked on a free basis and only upon request by the salughterer. In November of 1927, the graders extended their services to include the U. S. Good grade. After one year on this experimental and trial basis, it was agreed by those concerned that this system sufficient merit to be useful.

The standards have remained in approximately the same form in which they were initially accepted in 1928, with the exception of a few minor changes. The first amendment to the official standards was made in 1939 to bring forth a single standard for the grading of steer, heifer, and cow beef, thus eliminating the classes of these animals from the grade and allowing the beef to be graded in accordance with similar inherent characteristics, irrespective of class. At the same time, the grade terms Medium, Common, and Low Cutter, as applying to steer, heifer, and cow beef, were changed to Commercial, Utility, and Canner, respectively. Similar alterations were made in the second amendment in November, 1941 when the grades of Medium, Common, and Low Cutter for bull and stag beef were changed to Commercial, Utility, and Canner. The following grade terms are now applied to all beef; Prime, Choice, Good, Commercial, Utility, Cutter, and Canner. A later amendment, October, 1949, eliminated any and all

references to the color of fat. The increase in the amount of beef graded annually is shown in Table 2.

Table 2. The number of pounds graded annually by government graders (1).

| Year | : | Beef in pounds |
|--------|---|----------------|
| 1930 | : | 68,750,000 |
| 1931 | : | 159,433,000 |
| 1932 | : | 207,527,000 |
| 1933 | : | 237,594,000 |
| 1934 | : | 261,798,000 |
| 1935 | : | 367,775,000 |
| 1936 | : | 450,127,000 |
| 1937 | : | 408,353,000 |
| 1938 | : | 605,809,000 |
| 1939 | : | 512,017,000 |
| 1940 | : | 578,436,000 |
| 1941 | : | 789,894,000 |
| 1942* | : | 1,485,197,000 |
| 1943* | : | 6,710,714,000 |
| 1944* | : | 8,355,998,000 |
| 1945* | : | 9,176,756,000 |
| 1946* | : | 6,849,566,000 |
| 1947 | : | 2,931,463,000 |
| 1948 | : | 2,022,295,000 |
| 1949 | : | 2,279,872,000 |
| 1950 | : | 2,262,392,000 |
| 1951** | : | 6,250,130,000 |

* Grading required by O. P. A.

** Grading required by O. P. S.

The most recent amendment to the grades was made in December, 1950 (13). The grades of Prime and Choice were combined and designated as Prime. The here-to-fore Good grade became Choice. The original grade of Commercial was divided into two grades. The beef from younger animals that had fallen into the top half of Commercial was redesignated as Good. The Commercial grade was retained for the beef that graded into the lower half

of the original Commercial grade. This revision included changes in the definitions of the grades involved. Standards for the grades of Utility, Cutter, and Canner were not changed. The following table indicates the relationship of the changes that were made.

Table 3. Changes made in the U. S. Beef Grades in December, 1950.

| Grades as established in 1926 | : | Grades resulting from change in 1950 |
|----------------------------------|---|---|
| Prime | : | Prime |
| Choice | : | Choice |
| Good | : | Good |
| Commercial | : | Commercial |
| Utility | : | Utility |
| Cutter | : | Cutter |
| Canner | : | Canner |

About this time a degree of dissatisfaction with these government grades became evident. Many elements in the meat trade wanted more objective methods of determining grade. It was believed that even though all graders went through the same training program, the graders, after a period of time, began to put their own interpretation on the grades and their definitions subconsciously. It was also believed, especially by the range and

grass men, that the grades were out of proportion to their importance, i.e., the grade of Prime was unworkable with less than one-percent of the cattle on the market falling into this grade. There was need for information regarding the feasibility of objective measurements and their use in grading beef. Through this study, and others like it, an attempt was made to find out if there were some physical measurements that were sufficiently related to grade to be of value.

Hankins and Burk (9) were among the first to investigate the relationship of physical carcass characteristics to the grade of the carcass. The motivating influence behind this study was to ascertain factors that influence the grade of meat animals and to try to determine their relative importance. Over 2,000 cattle were used in this study and the physical factors concerned thickness of external fat, thickness of flesh, uniformity of width, marbling of the lean, firmness of lean, color of lean, firmness of fat, color of fat, and refinement. These investigators found that thickness of external fat, thickness of flesh, and uniformity of width of carcass were the best indicators of carcass grade. These three factors had a multiple correlation coefficient above +0.90. The amount of marbling, the firmness of fat, the firmness of lean, the color of fat and the color of lean revealed correlation coefficients from +0.90 to +0.81 in the order mentioned. There was a slightly significant relationship between the thickness of fat and the degree of marbling. The color of the fat was not significant to grade.

In 1942, Hirzel (10) developed a series of objective meas-

urements to describe the carcasses that were winners in English shows. The measurements he used were the rib eye area, the thickness of fat over the thirteenth rib, and the amount of lean in relation to amount of fat in the rib cut. In this investigation, Hirzel compared the effects of breed, age, and weight with the relative proportions of muscle, fat, and bone. The writer's main observations pertaining to this study were:

1. The majority of the rib eyes lack depth rather than length.
2. As weight increased within any one age group, the depth of rib eye increased more than length of rib eye.
3. The increase in weight with age was mainly a muscular increase.
4. Factors influencing marbling were reported in order of their importance; fatness, breed, and age.

The Canadian Minister of Agriculture (2) reported on the desirability and practicability of marketing slaughter cattle by carcass grade and weight in 1942. After collecting data on more than 3,000 animals, the conclusions of the study were that there was a definite need for revision of the system of marketing cattle by liveweight and that there would be a fairer distribution of return to the producer of higher grade cattle under an objective grading system. It was concluded that the use of average dressing percent does not result in proper returns to the producer because the individual dressing percent varies widely within grades of beef on the hoof and on the rail. The importance of marketing on individual basis rather than by lots of ten to twen-

ty animals was stressed. The development of an objective method of grading would result in the improvement in the quality of beef sold, and in turn, an increase in the amount of beef consumed.

In 1944, Hankins, et al. (8) collected carcass measurements on 135 steer carcasses in an attempt to develop a more precise and definite method of determining differences when grading. These carcasses were uniform in both weight and type. Significant coefficients of correlation were found between the width of the carcass and the grade, and between the edible meat in the rib cut and the grade of the carcass. The average thickness of fat over the eye muscle also showed a significant correlation with carcass grade. Thickness of flesh at the posterior surface of the sixth, seventh, and twelfth rib of the rib cut, the distance from the first rib to the hock joint per unit of empty body weight, and the distance from the stifle joint to the hock joint were, order mentioned, decreasing in significance. It was observed that in carcasses varying widely in weight, breeding, and feeding, the factors that were closely related to grade were liveweight per unit of body length and the fullness of the round. These investigators concluded that with objective measures of conformation and finish, there could be clarification and specificity given to the grade definitions.

Some of the objective measures of carcass evaluation are reviewed by Hankins (7). He lists the following observations as factors contributing to grade; dressing percent, uniformity of conformation, yields of primary cuts, composition with respect

to percentages of fat, muscle and bone, marbling and tenderness. The author concluded that these and other objective carcass characteristics measured the differences in beef carcasses to a greater degree of accuracy than was possible with any system based on subjective observation. The fact that the beef carcass lends itself to linear measurements assists in this objective determination of grade. Further observations were made on relative length, width, depth, thickness of flesh, plumpness of round and the cross-section area of the rib eye in determining grade. One of the main factors of usefulness developed was the weight-length relationship. It was defined as the relationship between the dressed weight and the length of the carcass from rib to hock joint and was expressed as weight per unit of length. This factor was considered to be useful in differentiating between grades as well as between weight groups within grades. The factor of marbling was of considerable importance. Without considering marbling, no system of evaluation would be complete. This physical carcass characteristic was highly indicative of finish, quality, and palatability. An improved objective technique to measure this factor was desired.

The plumpness of round and an index determined by dividing the liveweight by the length from the first rib to the aitchbone were found to be the best physical measurements for estimating beef carcass grades. The ratio between the carcass length and width followed close behind.

The thickness of fat over the "eye" muscle was accepted as a good index of fatness throughout the beef carcass. The area

of a cross-section of this same muscle was known to be a useful guide to muscular development. It has been observed, however, that these two characteristics vary inversely (16).

In reporting on the value and the need for additional research toward objective methods of grading, Murphy (11) pointed out that the frequently used indicators of high proportions of edible meat to bone, i.e., plumpness of round, shortness of body, fulness of loin, were backed up by little, if any, experimental work. The fact that these indicators are used in packing houses today indicates that carcass grading as it is now, is based on subjective standards. This investigator indicated a need for objective methods of determining the marbling, texture, and firmness for obtaining the amount of quality present. Further methods are needed for identifying the proportions of lean, fat, and bone in a beef carcass. The grading service has recommended the use of a grading chart in the evaluation of the various factors that go to make up the grade of a beef carcass. It was noted that the composite grade was not meant to be an average of the scores given these individual factors, and any discrepancy between the composite grade and the arithmetic average of these factors should be explained by the statistical weights assigned them.

Clifton (3) has made one of the most recent attempts to test the relationship that existed between certain carcass measurements and carcass grades. This investigator measured 355 steer carcasses that were stratified into 50 pound weight groups and into thirds within each government grade with approximately six carcasses in each cell. The correlation coefficients of the

more important measurements are given in Table 4.

Table 4. Correlation of physical carcass characteristics with grade (3).

| Physical Measurements | Correlation Coefficients |
|-----------------------------------|--------------------------|
| Width of fat on rib eye (HN) | +0.77 |
| Width of fat on rib eye (average) | +0.72 |
| Total length | +0.71 |
| Weight (warm carcass) | +0.65 |
| Length of Loin | +0.54 |
| Width of shoulder | +0.43 |
| Width of round | +0.30 |
| Depth of body | +0.30 |
| Circumference | +0.20 |
| Rib eye area | +0.10 |

The correlation coefficients of some of the measurement ratios to grade were also determined. The weight-length ratio (weight divided by length) had a correlation coefficient of +0.78, while the plumpness of round index (circumference of round divided by length of leg) had a correlation of +0.48. An index computed for the rib eye (CD divided by AB) revealed a correlation coefficient of +0.30. (Refer to Plate I for the location of HN, CD, and AB.) A multiple regression analysis was conducted to determine which combinations of these measurements gave the best indicators of grade. The measurements that were thought to be most clearly related to grade were selected. The other measurements were added and tested to see if they contributed any additional value to the analysis. After complete analysis of all factors collected, the physical measurements selected and thought to have the highest relationship to grade were the total

body length, the weight, the fat measure (HN), and the fat measure (HN) squared. The multiple correlation coefficient of these four factors was -0.898 . The author considered these measurements accurate enough to estimate the correct grade to be less than one-third of a standard government grade off two-thirds of the time. It should be noted that two of the long-considered pertinent factors in grade determination failed to add any significance to the multiple analysis. These were the measures of the area of the rib eye muscle and the index of the rib eye muscle. In this study the plumpness of the hindquarter, length of loin, and color of the rib eye muscle failed to be as highly correlated with grade as they were usually considered.

In reporting on an investigation at the Kansas Experiment Station, Stalls (15) found very high correlation coefficients between carcass grade and the following factors: width of the anterior round, width of shoulder, weight, plumpness of the round and the thickness of fat over the eye muscle. Low correlations on other factors could have been due to a small inconsistent spread in the measurements as compared to a reasonably consistent spread in the grades.

METHODS AND PROCEDURE

In order to test the relationship between carcass measurements and grade factors, it was desired that the collected sample include the entire range of carcass weights and grades. A correlation analysis of the relationship of the various factors was made. The chart recommended by "NCM-3, Beef Procedure 2" (5)

with the addition of some modifications (Form I). The following outline, as recommended, gives the sampling procedure, handling of the carcass and measurement details.

I. Sampling procedure.

A. Sex and age of cattle. This study was confined to steers and heifers since the relationship between grade and objective measurement may differ with the age and sex of the cattle. The sex of each carcass measured was recorded.

B. Eight to ten carcasses were the desired number of carcasses in each cell. It was highly probable that some of the extremes would not be filled.

C. Because it was impractical to obtain cold weights in a commercial cooler, the hot weights of the carcasses were recorded.

D. The optimum size of the group used for collecting the data was four men. One man was used to record the data, two men made the carcass measurements, and a United States Government grader to establish the carcass grade.

II. Handling the carcass.

A. Identification of each carcass was achieved by attaching a small numbered tag to the carcass.

B. A government grader graded each carcass to the nearest one-third grade.

III. Methods employed in recording data. All measurements were taken in centimeters with the use of a steel tape, transparent ruler, and a set of large measuring calipers. (Figure 1)

A. Unribbed carcass side.

1. Length of body. The length of body was determined by measuring from the anterior edge of the first thoracic vertebra to the anterior point of the aitch bone.

2. Length of hind leg. The length of hind leg was measured from the anterior point of the aitch bone to the middle of the hock at the point where the lower leg was removed.

3. Total length of carcass. The total carcass length was the sum of the measurements obtained in No. 1 and 2.

4. Length of loin. The length of loin was determined by measuring from the anterior point of the aitch bone to the middle of the thirteenth vertebra on the ventral side. The last named point was located by counting down seven and one half vertebrae from the rise in the backbone.

5. Width of shoulder. The width of shoulder was determined with the use of calipers by measuring from the inside of the carcass at the first thoracic vertebra to the outside of the shoulder. This was done with the calipers held in a median plane to the carcass and parallel to the floor.

6. Width of round (posterior). The width of the round was determined with the use of calipers by measuring from the posterior point of the aitch bone to the outside of the carcass. The calipers were held in a median plane to the carcass and parallel to the floor. The sum of measurements of the left and right were used.

7. Width of round (anterior). The width of the round was determined with the use of calipers by measuring from the anterior point of the aitch bone to the outside of the car-

cass. The calipers were held in a median plane to the carcass and parallel to the floor. The sum of the measurements of the right and left side were used.

8. Depth of body. The depth of body was determined by measuring from the dorsal side of the spinal canal at the fifth thoracic vertebra to the ventral side of the sternum. The tape was held parallel to the floor.

9. Circumference of round. The circumference of the round was measured on a line perpendicular to the long axis of the leg from a point sixty percent of the distance from the hock to the anterior point of the aitch bone. The procedure was as follows: With a tape, locate a straight line from the lowest point of the aitch bone to the highest point of the hock joint; place a shroud pin on this previously established point sixty percent of the distance from the hock. At this point, a flexible ruler was placed at right angles to the tape and points established on this line with shroud pins on the anterior and posterior sides of the round. The circumference was then measured by placing a steel tape below these three mentioned shroud pins after making sure that the tape is taut and touching all three of the pins.

10. Plumpness index of round. This was calculated by dividing the length of hind leg into the circumference of round and multiplying the answer by one hundred.

B. Ribbed down carcass. All carcasses were ribbed down between the twelfth and thirteenth rib (Chicago style). The face of the twelfth rib was photographed according to the

method developed by Stalls (15) and described at a later point in this discussion. Photographs made it possible to reproduce this cut of the carcass and facilitated measuring at a later date.

1. Measurements made. (See Plate I for illustration of these measurements and for locations of points used in the measurements).

a. Area. This measurement was made with an Amsler compensating polar planimeter. The average of three readings from the planimeter was used to determine the total area of the eye muscle.

b. Length. This measurement was the longest distance across the eye muscle.

c. Width. An average of three following widths was used to determine width; a line (CD) perpendicular to AB and one-half the distance from A to B; a line (GH) perpendicular to AB and one-half the distance from B to P; a line (EF) perpendicular to AB and one-half the distance from A to P.

d. Thickness of fat was an average of three measurements (LF, MD, and NH), measured from the outside of the fat where surface of the fat was perpendicular to these points, F, D, and H.

e. Rib eye index. Calculated by dividing rib eye width into rib eye length and multiplying the answer by one hundred.

2. Color of lean was obtained by use of Munsell A Color paddles after the rib eye had been exposed to air for

twenty minutes.

IV. Descriptive evaluation. This evaluation of the carcass is recorded on a chart Figure II.

Stalls (15) developed the technique for taking the photographs and making the required measurements of the face of the twelfth rib. The equipment used consisted of a Kodak 35 camera, econo-flash atrobe light, Series VI lens attachment with a one and one-fourth inch adapter ring, +1 portra lens and a frame on which to rest the camera. The lens attachment, adapter ring and the portra lens were required because the photographs were taken at a close focal range of twenty-four inches. The frame was necessary to hold the camera stationary and to insure the same focal range in each photograph. The frame was constructed of coper tubing, consisting of a ten by fifteen inches rectangular bottom piece to rest on the ribbed carcass, and two uprights whick fastened on the camera. The uprights were adjustable as to focal range and position over the carcass. A ruler was taped across the upper end of the frame so that when the pictures were projected on a screen, they could be scaled to actual size. (See Plate II.)

The most satisfactory results were secured by using Pano-tomic X film and a camera adjustment of F/16 lens opening and a shutter speed of 1/100.

A Model 3A Kodaslide Projector was used to project the photograph of the rib cut on a sixteen by twenty-five inch frosted glass field. The actual size of the rib cut was obtained by holding a ruler on the frosted glass, adjusting the

Table 5. Classification and frequency distribution of samples by carcass weight and grade.

| Weight of car- casses | U.S. Prime | | | U.S. Choice | | | U.S. Good | | | U.S. Commercial | | | U.S. Utility |
|-----------------------------|--------------|---------------|------------|--------------|---------------|------------|--------------|---------------|------------|-----------------|---------------|------------|-----------------|
| | Upper 1/3 | Middle 1/3 | Low 1/3 | Upper 1/e | Middle 1/3 | Low 1/3 | Upper 1/3 | Middle 1/3 | Low 1/3 | Upper 1/3 | Middle 1/3 | Low 1/3 | Upper 1/3 |
| 350-399 | | | | 1-0 | | | | | | | | | |
| | | | | 1 | | | | | | | | | |
| 400-449 | | | | 1-0 | 1-1 | | | | | 0-1 | 0-1 | | |
| | | | | 1 | 2 | | | | | 1 | 1 | | |
| 450-499 | 1-0 | 1-0 | 3-1 | 4-0 | 5-1 | 4-1 | 2-0 | | | 0-2 | 1-3 | 0-5 | 0-1 |
| | 1 | 1 | 4 | 4 | 6 | 5 | 2 | | | 2 | 4 | 5 | 1 |
| 500-549 | | 1-2 | 1-0 | 7-4 | 12-3 | 3-2 | 2-1 | | | | 0-1 | 0-3 | |
| | | 2 | 1 | 11 | 15 | 5 | 3 | | | | 1 | 3 | |
| 550-599 | 0-2 | 0-1 | 2-0 | 2-1 | 2-1 | 2-3 | 0-1 | 0-2 | 0-3 | | 0-1 | 0-1 | |
| | 2 | 1 | 2 | 3 | 3 | 5 | 1 | 2 | 3 | | 1 | 1 | |
| 600-649 | | 0-1 | 0-3 | 1-2 | 0-5 | 0-3 | 0-3 | 0-3 | 0-3 | 0-1 | 0-1 | | |
| | | 1 | 3 | 2 | 5 | 3 | 3 | 3 | 3 | 1 | 1 | | |
| 650-699 | 0-1 | | 0-3 | 0-1 | 0-4 | 0-2 | 0-3 | 0-3 | 0-3 | | 0-1 | 0-1 | |
| | 1 | | 3 | 1 | 4 | 2 | 3 | 3 | 3 | | 1 | 1 | |

Table 5. (concl.).

| Weight of car- casses | U.S. Prime | | | U.S. Choice | | | U.S. Good | | | U.S. Commercial | | | U.S. Utility |
|-----------------------------|------------|--------|-----|-------------|--------|-----|-----------|--------|-----|-----------------|--------|-----|-----------------|
| | Upper | Middle | Low | Upper | Middle | Low | Upper | Middle | Low | Upper | Middle | Low | Upper |
| | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 | 1/3 |
| 700-749 | | 0-1 | 0-1 | 0-2 | 0-6 | 0-8 | | 0-2 | | 0-1 | | | |
| | | 1 | 1 | 2 | 6 | 8 | | 2 | | 1 | | | |
| 750-799 | 0-1 | 0-2 | 0-4 | 0-2 | 0-7 | 0-8 | 0-2 | 0-2 | 0-3 | | | | |
| | 1 | 2 | 4 | 2 | 7 | 8 | 2 | 2 | 3 | | | | |
| 800-849 | 0-1 | 0-4 | 0-3 | 0-2 | 0-5 | 0-3 | 0-1 | 0-1 | 0-1 | | | | |
| | 1 | 4 | 3 | 2 | 5 | 3 | 1 | 1 | 1 | | | | |
| 850-899 | | 0-2 | 0-1 | | | 0-1 | | | | | | | |
| | | 2 | 1 | | | 1 | | | | | | | |
| 900-949 | | | | 0-1 | | 0-1 | | | | | | | |
| | | | | 1 | | 1 | | | | | | | |

The number of individuals in each cell are represented as follows: $2\text{-}3\text{-}5$ would indicate two heifer carcasses plus three steer carcasses making a total of five individuals in this weight-grade group. The figure on the left in each cell represents heifers and the figure on the right represents steers. The lower represents the total of the two.

Figure I. Form Used in Recording Carcass Measurements.

| | | | | |
|-----------|---|---|---|---|
| Carcass | : | : | : | : |
| number | : | : | : | : |
| Classifi- | : | : | : | : |
| cation | : | : | : | : |
| Carcass | : | : | : | : |
| weight | : | : | : | : |
| U. S. | : | : | : | : |
| Grade | : | : | : | : |
| Length | : | : | : | : |
| of leg | : | : | : | : |
| Circum- | : | : | : | : |
| ference | : | : | : | : |
| of round | : | : | : | : |
| Width of | : | : | : | : |
| round-p | : | : | : | : |
| Width of | : | : | : | : |
| round-a | : | : | : | : |
| Length of | : | : | : | : |
| loin | : | : | : | : |
| Length of | : | : | : | : |
| body | : | : | : | : |
| Total | : | : | : | : |
| length | : | : | : | : |
| Width of | : | : | : | : |
| shoulder | : | : | : | : |
| Depth of | : | : | : | : |
| Body | : | : | : | : |
| Plumpness | : | : | : | : |
| of round | : | : | : | : |
| Rib eye | : | : | : | : |
| area | : | : | : | : |
| width | : | : | : | : |
| length | : | : | : | : |
| Width of | : | : | : | : |
| fat | : | : | : | : |
| Rib eye | : | : | : | : |
| index | : | : | : | : |
| Color | : | : | : | : |
| Paddle | : | : | : | : |

Figure II. Form Used in Recording the Grader's Descriptive Evaluation of the Carcass.

| | | | | |
|-----------|---|---|---|---|
| Carcass | : | : | : | : |
| number | : | : | : | : |
| Comforma- | : | : | : | : |
| tion | : | : | : | : |
| Compact- | : | : | : | : |
| ness | : | : | : | : |
| Thick- | : | : | : | : |
| ness | : | : | : | : |
| Rib eye | : | : | : | : |
| Loin | : | : | : | : |
| Round | : | : | : | : |
| Finish | : | : | : | : |
| Thick- | : | : | : | : |
| ness | : | : | : | : |
| Distri- | : | : | : | : |
| bution | : | : | : | : |
| Kidney | : | : | : | : |
| knob | : | : | : | : |
| Marbling | : | : | : | : |
| Quality | : | : | : | : |
| Grain of | : | : | : | : |
| lean | : | : | : | : |
| Firmness | : | : | : | : |
| Color of | : | : | : | : |
| lean | : | : | : | : |
| Color of | : | : | : | : |
| fat | : | : | : | : |

projector until the ruler in the projected negative coincided with the ruler on the glass. Tracings were made of the rib cut in the projected negative by taping a sixteen by sixteen inches sheet of parchment paper on the rough side of the frosted glass facing the projector and tracing the outline of the rib cut and its component parts on the parchment paper. The measurements of the rib eye and external fat were made from this tracing.

The accuracy of the photographic method was checked against measurements made from original tracings by Stalls (15). Table 6 gives the measurements and the correlation coefficients obtained. A correlation coefficient of +0.982 between the two methods indicates that the photographic method can be used with confidence. Plate II illustrates the use of the equipment in taking photographs of the rib of a beef carcass.

Table 6. Correlation between photographic method and the original tracing.

| Carcass Number | X Measurements obtained from projected negative Square Inches | Y Measurements obtained from original tracing |
|----------------------------|--|---|
| 1 | 9.55 | 9.39 |
| 2 | 10.46 | 10.77 |
| 3 | 9.45 | 9.46 |
| 4 | 8.82 | 8.97 |
| 5 | 10.17 | 10.22 |
| 6 | 9.55 | 9.75 |
| 7 | 7.43 | 7.73 |
| 8 | 9.26 | 9.46 |
| 9 | 8.36 | 8.60 |
| 10 | 10.60 | 10.33 |
| S (X ²) | 885.5425 | S (Y ²) |
| Coefficient of correlation | +0.982 | 903.5418 |

A further test on the accuracy of the photographic methods was conducted by Stalls (15). Ten parchment paper tracings and ten photographs were taken of the same rib cut. The error variance and the coefficients of variability of the two methods were determined. The results are tabulated in Table 7. The coefficients of variability are extremely low, rendering both methods equally accurate and highly reputable.

Table 7. Error variance and coefficients of variability of the two methods of measuring the eye muscle.

| No. of tracing | : X : Measurements obtained : <u>from projected negative</u> | : Y : Measurements obtained : <u>from standard method</u> |
|----------------|--|---|
| | Square Inches | |
| 1 | 12.12 | 12.26 |
| 2 | 12.06 | 12.45 |
| 3 | 12.19 | 12.30 |
| 4 | 12.33 | 12.18 |
| 5 | 11.97 | 12.33 |
| 6 | 12.14 | 12.12 |
| 7 | 12.12 | 12.18 |
| 8 | 12.30 | 12.09 |
| 9 | 11.97 | 12.06 |
| 10 | 12.19 | 12.00 |

Error variance = .37

Coefficient of variability = 0.9% and 1.1%

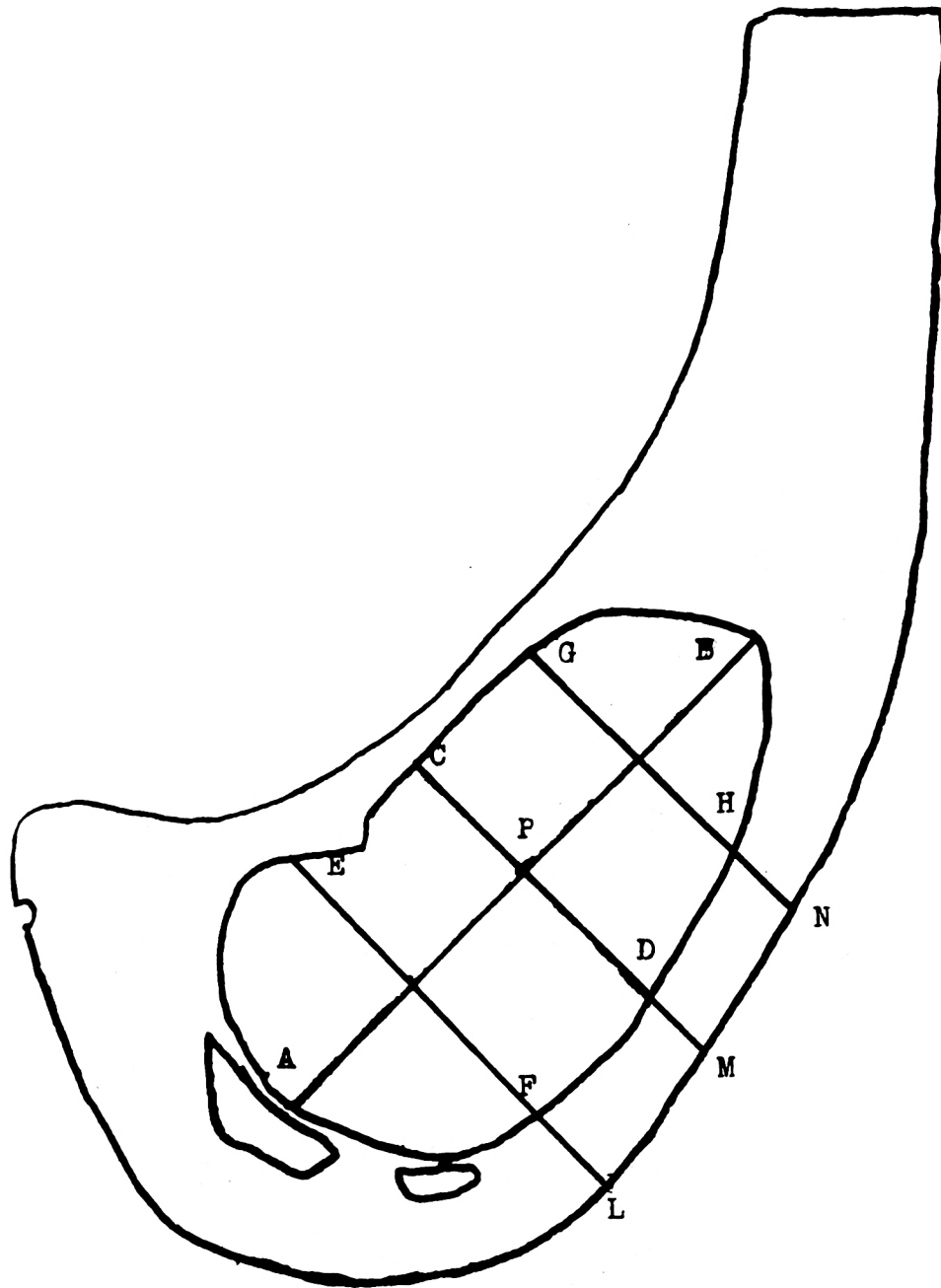
The carcass data were collected in the beef coolers of two packing companies. A three man crew collected the data at a rate of about fifteen carcasses per hour. One man recorded measurements; one man, using a sixfoot ladder, took measurements that could not be reached from the floor and one man assisted with the measurements on the floor. After the measurements from the unribbed side were recorded, the side was

ribbed. The photographs of the rib cut, color readings of the rib eye, carcass grade, and the grader's descriptive evaluation of the carcass were obtained at this time.

The carcass data collected appear in the Appendix. International Business Machine equipment was used to facilitate the analysis of the carcass data. The coding system used to identify the carcass data is outlined in Form I.

EXPLANATION OF PLATE I

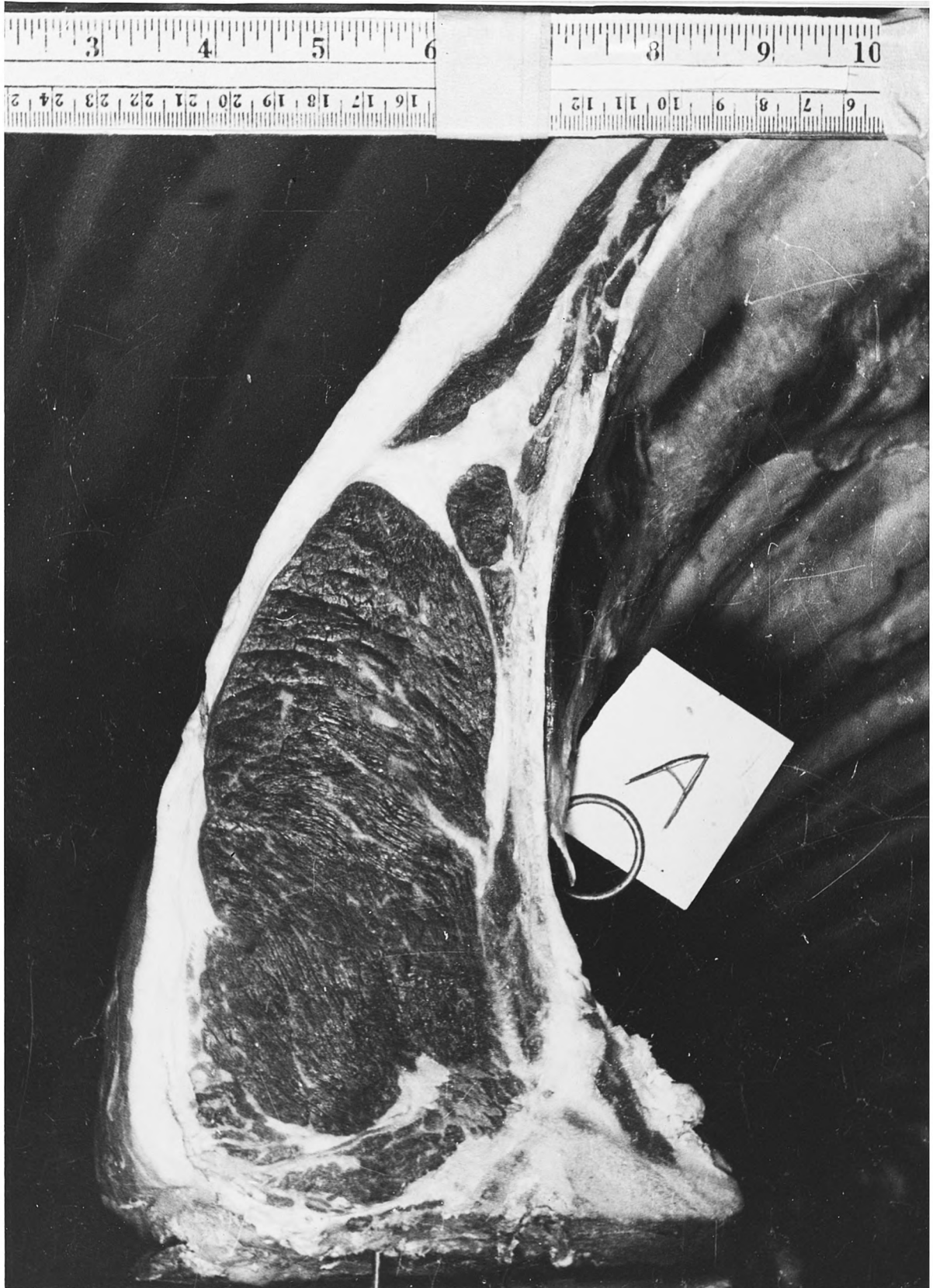
Illustration of the measurements taken of the rib cut and location of the points used in taking the measurements.



EXPLANATION OF PLATE II

One of the photographs taken of the rib cut
of a beef carcass.

PLATE II



EXPLANATION OF PLATE III

Illustration of the use of the equipment in taking photographs of the rib cut of a beef carcass.

PLATE III



Form I. Outline Used in Coding the Carcass Data for Analysis.

| Item | Numerical Values assigned to the data | Col. No. |
|--------------------------|--|-------------|
| <u>Number of carcass</u> | Actual number | 1,2,3,4 |
| <u>Sex</u> | | |
| Steer | 1 | 5 |
| Heifer | 2 | |
| <u>Grade</u> | | |
| Prime - High | 02 | 6,7 |
| Average | 04 | |
| Low | 06 | |
| Choice - High | 08 | |
| Average | 10 | |
| Low | 12 | |
| Good - High | 14 | |
| Average | 16 | |
| Low | 18 | |
| Commercial - High | 20 | |
| Average | 22 | |
| Low | 24 | |
| Utility - High | 26 | |
| Average | 28 | |
| Low | 30 | |
| <u>Weight</u> | Actual Weight | 8,9,10 |
| <u>Length of leg</u> | Actual Measurement | 11,12,13 |
| <u>Length of body</u> | Actual Measurement | 14,15,16 |
| <u>Total length</u> | Actual Measurement | 17,18,19 |
| <u>Length of loin</u> | Actual Measurement | 20,21,22 |
| <u>Width of shoulder</u> | Actual Measurement | 23,24,25 |
| <u>Depth of body</u> | Actual Measurement | 26,27,28 |

| | | |
|-----------------------------------|--------------------|-------------|
| <u>Width of round</u> (posterior) | Actual Measurement | 29,30,31 |
| <u>Width of round</u> (anterior) | Actual Measurement | 32,33,34 |
| <u>Circumference of round</u> | Actual Measurement | 35,36,37,38 |
| <u>Plumpness of round</u> | Actual Measurement | 39,40,41,42 |
| <u>Rib eye</u> | | |
| <u>Area</u> | Actual Measurement | 43,44,45,46 |
| <u>Width</u> | Actual Measurement | 47,48 |
| <u>Length</u> | Actual Measurement | 49,50,51 |
| <u>Thickness of fat</u> | Actual Measurement | 52,53 |
| <u>Rib eye index</u> | Calculation | 54,55,56 |
| <u>Color reading</u> | | |
| A1 | 01 | |
| A2 | 02 | |
| A3 | 03 | |
| A4 | 04 | |
| A5 | 05 | |
| A6 | 06 | |
| A7 | 07 | |
| A8 | 08 | |
| A9 | 09 | |
| A10 | 10 | |

ConformationCompactness 59

| | |
|--------------------|---|
| Very Compact | 1 |
| Compact | 2 |
| Moderately Compact | 3 |
| Modestly Compact | 4 |
| Slightly Rangy | 5 |
| Rangy | 6 |
| Very Rangy | 7 |

Thickness of Carcass 60

| | |
|------------------|---|
| Very Thick | 1 |
| Thick | 2 |
| Moderately Thick | 3 |
| Modestly Thick | 4 |
| Slightly Thin | 5 |
| Thin | 6 |
| Very Thin | 7 |

Rib eye (lean) 61

| | |
|------------------|---|
| Very large | 1 |
| Large | 2 |
| Moderately large | 3 |
| Modestly Large | 4 |
| Slightly Small | 5 |
| Small | 6 |
| Very Small | 7 |

Loin 62

| | |
|------------------|---|
| Very thick | 1 |
| Thick | 2 |
| Moderately Thick | 3 |
| Modestly Thick | 4 |
| Slightly Thin | 5 |
| Thin | 6 |
| Very Thin | 7 |

Round 63

| | |
|--------------------|---|
| Plump | 1 |
| Full | 2 |
| Moderately Full | 3 |
| Modestly Full | 4 |
| Slightly Deficient | 5 |
| Deficient | 6 |
| Very Deficient | 7 |

FinishThickness of Fat (external) 64

| | |
|------------------|---|
| Very Thick | 1 |
| Thick | 2 |
| Moderately Thick | 3 |
| Modestly Thick | 4 |
| Slightly Thin | 5 |
| Thin | 6 |
| Very Thin | 7 |

Distribution of Fat (external) 65

| | |
|--------------------|---|
| Very Uniform | 1 |
| Uniform | 2 |
| Moderately Uniform | 3 |
| Modestly Uniform | 4 |
| Slightly Uneven | 5 |
| Uneven | 6 |
| Very Uneven | 7 |

Kidney Knob 66

| | |
|-------------------------|---|
| Very Large Amount | 1 |
| Large Amount | 2 |
| Moderately Large Amount | 3 |
| Modestly Large Amount | 4 |
| Slightly Deficient | 5 |
| Deficient | 6 |
| Very Deficient | 7 |

Marbling (Rib eye) 67,68

| | |
|---------------------|----|
| Very Abundant | 1 |
| Abundant | 2 |
| Moderately Abundant | 3 |
| Slightly Abundant | 4 |
| Moderate | 5 |
| Modest | 6 |
| Small Amount | 7 |
| Slight Amount | 8 |
| Traces | 9 |
| Practically Devoid | 10 |
| None | 11 |

QualityGrain of Lean

69

| | |
|-----------------|---|
| Very Fine | 1 |
| Fine | 2 |
| Moderately Fine | 3 |
| Modestly Fine | 4 |
| Slightly Coarse | 5 |
| Coarse | 6 |
| Very Coarse | 7 |

Firmness of Lean

70

| | |
|-----------------|---|
| Very Firm | 1 |
| Firm | 2 |
| Moderately Firm | 3 |
| Modestly Firm | 4 |
| Slightly Soft | 5 |
| Soft | 6 |
| Very Soft | 7 |

Color of lean

71

| | |
|--------------------------|---|
| Dark Pink | 1 |
| Very Light Cherry Red | 2 |
| Light Cherry Red | 3 |
| Slightly Dark Cherry Red | 4 |
| Moderately Dark Red | 5 |
| Dark Red | 6 |
| Very Dark Red | 7 |

Color of Fat

72

| | |
|-----------------|---|
| White | 1 |
| Creamy White | 2 |
| Creamy | 3 |
| Slightly Yellow | 4 |
| Yellow | 5 |
| Very Yellow | 6 |
| Fiery | 7 |

OBSERVATIONS AND DISCUSSIONS

The methods of simple correlation and multiple correlation as described by Snedecor (14) were used for statistical treatment of the data.

The results of the simple correlation between the carcass measurements and grade are given in Table 8. The plumpness of the round had the highest correlation to grade with a correlation coefficient of -0.621 . The following carcass measurements indicated a significant relationship to grade; width of posterior round; width of shoulder; depth of body; total body length; width of fat over the eye muscle; width of round; and weight. Their significance decreased in the order mentioned. The correlation coefficients of the depth of body, the plumpness of the round, the width of the carcass, as determined by the width of the posterior round and the width of shoulder, the depth of body, and the width of fat over the rib, eye indicate that these measurements could be useful indices of grade.

The measurements with the two lowest correlation coefficients in Table 8., i.e., weight of carcass and width of anterior round, could not be considered useful indices of grade. The fact that the measurements had such a small inconsistent variation as compared to a much greater consistent variation in the grades, i.e., no correlation, may explain these low correlation coefficients.

The results of the simple correlations between the descriptive evaluation of the carcass and the grade are given in Table 9. In this study, as compared with the investigation by

Stalls (15), someone other than the official grader made the descriptive evaluations. This was thought advisable because of the observed tendency of the grader to score each individual carcass characteristic in relation to the predetermined grade rather than strictly on its actual development. Every one of the descriptive evaluations has high correlation coefficients with grade. The range was from +0.873 for marbling to +0.575 for the kidney knob. It is probable that the higher correlation coefficients of the descriptive evaluations over the carcass measurements were the result of the descriptive evaluations having a wider consistent spread with an equally wide consistent spread in the grades.

The correlation coefficients between the carcass measurements and the descriptive evaluations are given in Table 10. The correlation coefficient between the calculated plumpness of round index and the descriptive evaluation of the plumpness of round had the highest relationship. This correlation coefficient was -0.626. The correlation coefficient of -0.155 between the thickness of external fat by descriptive evaluation and the measured width of fat over the eye muscle was not significant. The descriptive evaluation of the carcass width had a significant relationship to the measured width of shoulder and the measured width of anterior and posterior round.

Table 8. The coefficients of correlation between carcass measurements and grade.

| Carcass Measurements | Correlation Coefficient |
|----------------------------|-------------------------|
| Weight | -0.212 |
| Total body length | -0.373 |
| Width of shoulder | -0.497 |
| Depth of body | -0.413 |
| Width of round (posterior) | -0.513 |
| Width of round (anterior) | -0.283 |
| Plumpness of the round | -0.621 |
| Width of fat | -0.314 |

Table 9. The coefficients of correlation between the descriptive carcass evaluation and grade.

| Carcass Evaluation | Correlation Coefficients |
|------------------------------|--------------------------|
| Compactness | +0.824 |
| Thickness of carcass | +0.815 |
| Rib eye (lean) | +0.768 |
| Thickness of loin | +0.784 |
| Plumpness of round | +0.777 |
| Thickness of external fat | +0.802 |
| Distribution of external fat | +0.747 |
| Kidney knob | +0.575 |
| Marbling | +0.873 |
| Grain of lean | +0.723 |
| Firmness of lean | +0.757 |

Table 10. The coefficients of correlation between carcass measurements and descriptive evaluation.

| Carcass Measurement | Descriptive Carcass Evaluation | Correlation Coefficients |
|---------------------|--------------------------------|--------------------------|
| Width of fat | Thickness of external fat | -0.155 |
| Plumpness of round | Round plumpness | -0.626 |

Table 10. (concl.).

| Carcass Measurement | Descriptive Carcass Evaluation | Correlation Coefficients |
|-------------------------------|--------------------------------|--------------------------|
| Width of shoulder | Thickness of carcass | -0.492 |
| Width of round (anterior) | Thickness of carcass | -0.304 |
| Width of round (posterior) | Thickness of carcass | -0.512 |
| Total length | Carcass compactness | +0.353 |

The results of the correlation analysis of the data collected by Stalls (15) and the writer are compared in Tables 11, 12, and 13. In Table 11, it is noted that the results of the two sets of data are not similar. With the exceptions of the correlation coefficients between grade and width of shoulder; between grade and depth of body; and between grade and width of fat covering over the eye muscle, there is a significant difference between the two sets of data. Those measurements collected by Stalls (15) that show a higher and more significant relationship to grade than those collected by the writer are the weight of the carcass and the width of the anterior round. The measurements in the second group that are more highly correlated to grade are total body length, width of posterior round, and the plumpness of the round.

An examination of the correlation coefficients in Table 12 reveals a highly significant difference between the two sets of data. All of the correlation coefficients in the second group indicated a higher relationship of the descriptive evaluations to grade than those in the first group. The only evalua-

tions in the second that were not more highly significant than those of the first group were the thickness of loin and the thickness of the external fat. The increased significance of the second group over the first may be due to two factors:

A. The descriptive evaluations in the second group were made by someone other than the official grader.

B. The second group of data covers a wider range of weights and grades.

The difference between the correlation coefficients of the carcass measurements and the descriptive evaluations for the two groups of data is shown in Table 13. In the second group there was a higher relationship between the two sets of factors in all cases except where the width of fat over the rib eye was correlated with the estimated thickness of external fat, in which case, the first group shows the higher relationship.

The reason that the correlation coefficients for the measurements (Table 11) did not show a significant difference as high as found in the descriptive evaluation coefficients may be due to the manner in which they were made or collected. Between the two groups of data there was no change in the method employed in making the measurements. However, as previously stated, there was a change in the procedure for collecting the descriptive evaluations.

Table 11. The coefficients of correlation between carcass measurements and grade

| Carcass Measurements | Correlation Coefficients | |
|----------------------------|--------------------------|--------|
| | Stalls | Stull |
| Weight | -0.48 | -0.212 |
| Total body length | -0.15 | -0.373 |
| Width of shoulder | -0.49 | -0.497 |
| Depth of body | -0.28 | -0.413 |
| Width of round (posterior) | -0.17 | -0.513 |
| Width of round (anterior) | -0.56 | -0.283 |
| Plumpness of the round | -0.42 | -0.621 |
| Width of fat | -0.42 | -0.314 |

Table 12. The coefficients of correlation between the descriptive carcass evaluation and grade.

| Carcass Evaluation | Correlation Coefficients | |
|------------------------------|--------------------------|--------|
| | Stalls | Stull |
| Compactness | +0.62 | +0.824 |
| Thickness of carcass | +0.58 | +0.815 |
| Rib eye (lean) | +0.45 | +0.768 |
| Thickness of loin | +0.60 | +0.784 |
| Plumpness round | +0.54 | +0.777 |
| Thickness of external fat | +0.65 | +0.802 |
| Distribution of external fat | +0.55 | +0.75 |
| Kidney Knob | +0.30 | +0.575 |
| Marbling | +0.61 | +0.873 |
| Grain of lean | +0.47 | +0.723 |
| Firmness of lean | +0.47 | +0.757 |

Table 13. The coefficients of correlation between carcass measurements and descriptive evaluation.

| Carcass Measurement: | Descriptive Evaluation | Correlation Coefficients | |
|----------------------------|---------------------------|--------------------------|--------|
| | | Stalls | Stull |
| Width of fat | Thickness of external fat | -0.33 | -0.155 |
| Plumpness of round | Round Plumpness | -0.42 | -0.626 |
| Width of shoulder | Thickness of carcass | -0.20 | -0.492 |
| Width of round (anterior) | Thickness of carcass | -0.03 | -0.304 |
| Width of round (posterior) | Thickness of carcass | -0.19 | -0.512 |
| Total length | Carcass compactness | +0.03 | +0.353 |

SUMMARY

The physical measurements showed a relationship to grade in the following decreasing order: plumpness of round, width of round, width of shoulder, depth of body, total body length, width of fat over the loin, and the hot body weight.

The measurements that could be useful in determining grade are: plumpness of round, width of posterior round, width of shoulder, and the depth of body.

All of the descriptive evaluations of the carcass showed a higher relationship to grade when made by someone other than the official grader. All of these evaluations had highly significant relationships to grade.

The descriptive evaluations that showed the highest cor-

relation coefficients to grade were: marbling, compactness, thickness of carcass, and thickness of external fat.

There was significant relationship between the descriptive evaluation of the carcass and the carcass measurements for the following factors: plumpness of round index and the round plumpness evaluation; the width of the posterior round and the thickness of the carcass; and the width of shoulder and the thickness of carcass.

The resulting difference between the two groups of data indicate that neither sample was large enough, and that together, the numbers were still too small. A larger sample would be required to obtain a more sensitive evaluation.

The factors having the highest correlation coefficients could be used as indices of grade under an objective system, or they could be used to substantiate the present subjective grading system.

However, while several of the factors showed a high correlation to grade their application in practical grading is doubtful.

In actual grading practices, four of the main factors observed by the grader are compactness, thickness of carcass, thickness of fat covering, and marbling. In this study, these factors showed a high correlation with grade, and when evaluated by someone other than the grader, might be used as the basis for the assumption that the graders did a more accurate job of grading than was generally expected.

Because it was both difficult and expensive to collect

data such as are presented here, this sample is perhaps not as large as might be desired. Therefore, the conclusions drawn here are not to be understood as final on the subject of development of an objective grading system.

ACKNOWLEDGEMENTS

The author wishes to acknowledge Mr. D. L. Mackintosh, Professor Animal Husbandry, for his valuable supervision and assistance in planning this study; to Mr. Henry Tucker, Professor of Mathematics, for his statistical analysis of the data collected; and to Mr. C. P. Wilson, Professor of Marketing, for his suggestions and helpful criticisms of this manuscript.

The author acknowledges the cooperation of the following packing companies: Dugdale Packing Company, St. Joseph, Missouri; and Swift and Company, Kansas City, Kansas.

LITERATURE CITED

- (1) Agricultural Statistics. U. S. Dept. Agr. 1951. U. S. Government Printing Office, Washington 25, D. C.
- (2) Canadian Ministry of Agriculture. The Practicability of Selling Cattle by Carcass Grade and Weight. Report of the Sub-Committee of the National Advisory Beef Committee. Ottawa, Canada. 1942.
- (3) Clifton, E. C.
Some beef carcass measurements as related to grade. Proceedings of the Fifth Annual Reciprocal Meat Conference. National Livestock and Meat Board. Chicago, 1952.
- (4) Davis, W. C. and C. V. Whalin.
Market classes and grades of dressed beef. U. S. Dept. Agr. Bul. 1246. 1924.
- (5) Developing Objective specifications for beef carcass grade standards. NCM-3, Beef Procedure 2. North Central Livestock Marketing Research Committee. Chicago, May 1950.
- (6) Hall, Louis D.
Market classes and grades of meat. Ill. Agr. Expt. Sta. Bul. 147. 1910.
- (7) Hankins, O. G.
Evaluation of beef carcass quality. Paper presented at the Conference of Technical Committee for RMA projects for beef cattle breeding at Miles City, Montana. July 7, 1949.
- (8) Hankins, O. G., F. J. Beard, and R. L. Hiner.
Measurement of carcass grade in meat animals. Jour. Anim. Sci. 3:444. 1944.
- (9) Hankins, O. G. and L. B. Burk.
Some relationships among factors in the production and grades of beef. Amer. Soc. Anim. Prod. Proc. 25:358-364. 1932.
- (10) Kirzel, R.
Factors affecting quality in mutton and beef with special reference to the production of muscle, fat, and bone. In conference on cooperative meat investigation. Report of the Review Committee. National Livestock and Meat Board, Vol. IV, Grades and Measurements, Ref. No. 25. Chicago, 1942.

- (11) Murphy, Charles E.
Report to the committee for beef carcass evaluation. Reciprocal Meats Conference. National Livestock and Meat Board. 1951. (unpublished).
- (12) Official United States Standards for Grades of Dressed Beef. U. S. Dept. Agr. P.M.A. Service and Regulatory Announcements No. 99. 1926.
- (13) Rules and Regulations. Production and Marketing Administration, U. S. Dept. Agr., Subchapter C, Part 53. 102-103. December, 1950.
- (14) Snedecor, George W.
Statistical methods. Ames, Iowa. Iowa State College Press. 4th Ed. 1950.
- (15) Stalls, William D.
Some observations pertaining to carcass measurements and U. S. beef grades. Master's Thesis, Kansas State College. 1952.
- (16) U. S. Bureau of Animal Industry. Report of the Chief of the B. A. I. to the Sec. of Agriculture. 1947.

APPENDIX



or

Tabular form of the carcass data

KAROLTON KLASP—6½ x 9½
MADE BY
THE AMERICAN ENVELOPE CO.
WEST CARROLLTON, OHIO

FURTHER OBSERVATIONS PERTAINING TO
CARCASS MEASUREMENTS AND U.S. BEEF GRADES

by

JOHN M. STULL

B. S., University of Maryland, 1951

ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Husbandry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1953

Through this study, an attempt was made to determine the possibility of grading a beef carcass by objective methods. Observations were also made as to the relationship that exists between carcass measurements and a descriptive evaluation of the carcass.

Under the present system of government grading for dressed beef, a subjective evaluation of the inherent characteristics of a carcass as compared with an established set of standards, there is a tendency for human bias to influence the determination of the grade.

Because a dressed beef carcass can be measured with relative simplicity, a group of carcass measurements were selected and used to see if they would be of value in determining grade in an objective manner. Definite measurements and descriptive evaluations of 246 beef carcasses were collected at two packing houses. The collections were limited to steer and heifer carcasses in grades ranging from U.S. Prime to U.S. Utility and weighing from 350 to 950 pounds.

The carcass measurements were: length of carcass, length of hind leg, total carcass length, length of loin, depth of loin, depth of body, width of shoulder, width of anterior and posterior round, rib eye muscle area, length of rib eye, width of rib eye, and thickness of the external fat over the eye muscle. Other factors collected were the carcass grade, weight, sex, and descriptive evaluations.

Statistical treatment of this data was used to determine any correlations between them and the U.S. grade. The plumpness

of round index had the highest significant correlation with grade (-0.62) followed by the width of the posterior round (-0.513), the width of the shoulder(-0.497), and the depth of body (-0.413). Factors that had a smaller degree of significance were the weight, total body length, width of anterior round, and the width of fat over the rib eye. The first four mentioned factors could be useful as indices of grade.

The correlation coefficients between the grade and the descriptive evaluations indicate significant relationships. The range of coefficients were from +0.575 for the evaluation of the kidney knob to +0.873 for the evaluation of degree of marbling.

The relationship between descriptive evaluation and the actual measurements had correlation coefficients over a wide range. A coefficient of -0.626 was obtained for the relationship between the plumpness of round index and the evaluation of the round plumpness.

The factors having the highest correlation coefficients could be used as indices of grade under an objective system, or they could be used to substantiate the present subjective grading system. However, while several of the factors show a high correlation to grade, their application in practical grading is doubtful.

In actual grading practices, four of the main factors observed by the grader, compactness, thickness of carcass, thickness of fat covering, and marbling are utilized. In this study these factors show a high correlation with grade and may be used as the basis for the assumption that the graders do a more ac-

curate job of grading than is generally expected.

Because it is both difficult and expensive to collect data such as is presented here, this sample is perhaps not as large as might be desired. Therefore, the conclusions drawn here are not to be understood as final on the subject of development of an objective grading system.