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 Document LD 2668 T4 1953 S8, c.2

TABLE OF CONTENTS

INTRODUCTION	•	•	•	•	•	•	•	•	•	•	1
REVIEW OF LITE	RATU	IRE		•	٠	•	•	•	•	•	2
METHODS AND FR	OCED	URE	٠	٠	٠	•	٠	٠	•	•	1.6
OBSERVATIONS A	ND D	ISC	USS	ION	•		•	٠	• •	•	40
SUMMARY .	•	•		•	•		•		•	•	46
ACKNOWLEDGEMEN	TS	•	•	•	•		•		•	•	49
LITERATURE CIT	ED	•	٠	•	•	•	•	•	٠	•	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.

Dome 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 Grades Grades Grades Grades Grades
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 interpersed 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 demond 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 in sufficient 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 1931 1933 1933 1935 1935 1935 1935 1938 1939 1941 1944 1944 1944 1948 1949 1950 1951**	68,750,000 159,433,000 207,527,000 237,594,000 261,798,000 367,775,000 450,127,000 408,353,000 605,809,000 512,017,000 578,436,000 789,894,000 1,485,197,000 6,710,714,000 8,355,998,000 9,176,756,000 6,849,566,000 2,931,463,000 2,022,295,000 2,279,872,000 2,262,392,000 6,250,130,000
required by (

ber, 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 1926	in	Grades	resulting from change in 1950
Prime			Prime
Choice		-	
Good			Choice
	1000 0100 1000 0100 0100		Good
Commercial			Commercial
Utility			Utility
Cutter		e dense south south deliber	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 deisred.

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 I)
 - 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 bine 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. hotographs 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 Panotomic 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		s. Pri		. U.S	S. Choi	Ce	: : U.	S. Goo	d	. U.S. (Commer	cial	: U.S. :Utility
of car- casses	: 1/3	: Middl : 1/3	:1/3	Upper 1/e	: 1/3	:1/3	: upper : 1/3	: 1/3	:1/3	1/3	1/3	:1/3	: Upper : 1/3
350-399				1-0									
370-377				1									
400-449					1-0	1-1					0-1	0-1	
100-119					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
1,01,7	1	1	4	1+	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		7	7	

Table 5. (concl.).

Weight of car-casses	: Upper:		e:Low	Upper		e:Low	: Upper		e:Low	: Upper:	Commercial Middle:Low 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	0-1+	0-2	0-7	0-8	0-2	0-2	0-3			
730-733	1	2	4	2	7	8	2	2	3			
900 910	0-1	0-4	0-3	0-2	0-5	0-3	0-1	0-1	0-1			
800-849	1	4	3	2	5	3	1	1	1			
250 000		0-2	0-1			0-1						
850-899		2	1			1						
				0-1		0-1						
900-949				1		1						

The number of individuals in each cell are represented as follows: 2-3 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	1			
Classifi-	\$		2	1
cation	•			
Carcass	*	•	•	
weight	1			1
U. S.	\$		\$	1
Grade	1			
Length	:	;	8	:
of leg	:			
Circum-	3			:
ference	:	:	2	:
of round	1			
Width of	;	\$	8	:
round-p	1			
Width of	\$.		1
round-a				
Length of	\$		8	1
loin	1			
Length of	\$	8		:
body				
Total	\$		8	:
length	1			
Width of	*	8	8	:
shoulder	,		1	
Depth of	\$:		:
Body			*	
Plumpness	\$	1		1
of round				
Rib eye			8	
area				
width				:
length				
Width of	:		8	1
fat				:
Rib eye	•	•	i i	:
index			8	1
Color		:	:	1
Paddle	No. of the second second second			1

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

Military and the second		
	*	:
Carcass	1	: :
number		1
	:	: :
Comforma-	#	: :
tion 3		
C: 4		: :
Compact-		
ness		
Mart na		:
Thick-		:
ness		
Rib eye		
urp ala		
Loin	•.	:
110-1-11		*
Round		i
		1
Finish		i
		1
Thick-		: :
ness j		
		1
Distri-	1	: :
bution :		
Kidney		1
knob		1
		1
<u>Marbling</u>		
0		
Quality 1		
Grain of	•	
drain or		
lean		
Firmness		
L TY HWIG 22		
Color of		
lean		
rear _		
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	: Y : Measurements obtained from : original tracing Inches
1234567890	9.55 10.46 9.45 8.82 10.17 9.55 7.43 9.26 8.36 10.60	9.39 10.77 9.46 8.97 10.22 9.75 7.73 9.46 8.60 10.33
	S (X ²) 885.5425 Coefficient of correlation	s (Y ²) 903.5418 1 +0.982

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 obtain ed from projected negat iv e	: :	Y Measurements obtained from standard method
-		Square	Ir	nches
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		12.0 6
10		12.19		12.00

Error variance = .37 Coefficient of variability = 0.9% and 1.1%

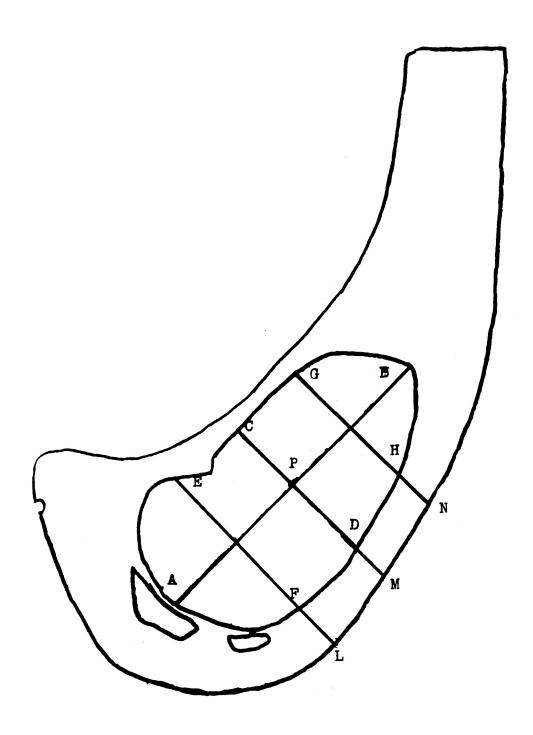
The carcass data were collected in the beef coolers of two packing companies. A three man crew collected the data at a rate of about fifteen carcasses per hour. One man recorded measurements; one man, using a sixfoot ladder, took measurements that could not be reached from the floor and one man assisted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

It	: N		l Values assigned the data	Col. No.
Number of ca	rcass	Actual	number	1,2,3,4
Sex				
Steer		1		5
Heifer		2		
Grade				6,7
Prime - High Aver Low		02 04 06		
Choice - Hig Ave Lov	rage	08 10 12		
Good - Hig Ave Lov	rage	14 16 18		
Commercial -	· High Average Low	20 22 24		
Utility -	High Average Low	26 28 30		
Weight		Actual	Weight	8,9,10
Length of le	e e	Actual	Measurement	11,12,13
Length of body		Actual	Measurement	14,15,16
Total length		Actual	Measurement	17,18,19
Length of lo	oin	Actual	Measurement	20,21,22
Width of sho	oulder	Actual	Measurement	23,24,25
Depth of boo	ly	Actual	Measurement	26,27,28

Width of round (posterior)	Actual Measurement	29,30,31
Width of round (anterior)	Actual Measurement	32,33,34
Circumference of round	Actual Measurement	35,36,37,38
Plumpness of round	Actual Measurement	39,40,41,42
Rib eye		
Area	Actual Measurement	43,44,45,46
<u>Width</u>	Actual Measurement	47,48
Length	Actual Measurement	49,50,51
Thickness of fat	Actual Measurement	52,53
Rib eye index	Calculation	54,55,56
Color reading		
Al	01	
A2	02	
A3	03	
A ¹ 4	04	
A5	05	
A6	06	
A7	07	
A8	08	
A9	09	
Alo	10	

Conformation

<u>Compactness</u>		5 9
Very Compact Compact Moderately Compact Modestly Compact Slightly Rangy Rangy Very Rangy	1 2 3 4 5 6 7	
Thickness of Carcass		60
Very Thick Thick Moderately Thick Modestly Thick Slightly Thin Thin Very Thin	1 2 3 4 5 6 7	
Rib eve (lean)		61
Very large Large Moderately large Modestly Large Slightly Small Small Very Small	1 2 3 4 5 6 7	
Loin		62
Very thick Thick Moderately Thick Modestly Thick Slightly Thin Thin Very Thin	1234567	
Round		63
Plump Full Moderately Full Modestly Full Slightly Deficient Deficient Very Deficient	12345067	

<u>Finish</u>

Thickness of Fat (extern	al)	64
Very Thick Thick Moderately Thick Modestly Thick Slightly Thin Thin Very Thin	1234567	
Distribution of Fat (ext	ernal	65
Very Uniform Uniform Moderately Uniform Modestly Uniform Slightly Uneven Uneven Very Uneven	12345767	
Kidney Knob		66
Very Large Amount Large Amount Moderately Large Amou Modestly Large Amount Slightly Deficient Deficient Very Deficient	1 2 3 5 7	
Marbling (Rib eye)		67,68
Very Abundant Abundant Moderately Abundant Slightly Abundant Moderate Modest Small Amount Slight Amount Traces Practically Devoid None	1 2 3 4 5 6 7 8 9 0 11	

Quality

Grain 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.

ments 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 -0.497
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 Coeffi- cients
Width of fat	Thickness of exter-	-0.155
Plumpness of round	Round plumpness	-0.626

Table 10. (concl.).

Carcass Measurement	Descriptive Carcass Evaluation	Correlation Coeffi- cients
Width of shoulder Width of round (anterior)	Thickness of carcass Thickness of carcass	-0.492 -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		n Coefficients	
:	Stalls	: Stull	
	0.1.0	^ 010	
Weight	-0.48 -0.15	-0.212	
otal body length	-0.49	-0.373 -0.497	
epth of body	-0.28	-0.413	
Width of round (posterior)	-0.17	-0.513	
width of round (anterior)	-0.56	-0.283	
lumpness of the round	-0.42	-0.621	
vidth of fat	-0.42	-0.314	

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

Carcass Evaluation	Correlation Stalls :	Coefficients Stull
		- 0-1
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 Carcass Evaluation	Correlation Constants	oefficients Stull
Width of fat	Thickness of ex- ternal fat	-0.33	-0.155
Plumpness of round	Round Plumpness	-0.42	-0.626
Width of shoulder	Thickness of car- cass	-0.20	-0.492
Width of round (an- terior)	Thickness of car- cass	-0.03	-0.304
Width of round (pos- terior)	Thickness of car- cass	-0.19	-0.512
Total length	Careass compact- ness	+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 my 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) Hirzel, R.

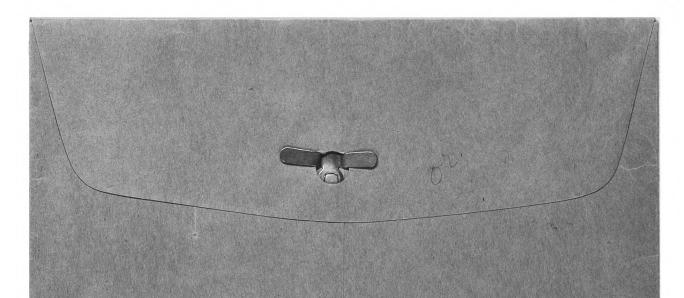
 Factors affecting quality in mutton and beef with special reference to the production of muscle, fat, and bone. In conference on cooperative meat investigation. Report of the Review Committee. National Livestock and Meat Board, Vol. IV, Grades and Measurements, Ref. No. 25. Chicago, 1942.

- (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



Tabular form of the carcass data

KAROLTON KLASP-6½ x 9½

MADE BY

THE AMERICAN ENVELOPE CO.

WEST CARROLLTON, OHIO

```
3456789012345678901234
123456769012345678901234567890123456789012.
                                                                     557894418
                                                                   of fatturion
                                                                         4 222
                                                                         44,94,44
44,44,44
                                                  Wid
                                                               Le Le
                                                              Ø
                       Width of Shoulder
                                                               Thioknes Rib eye Round Thick C
                                                      Thicknes of fat Rib eye
                                                             ding
pacti
ckne
                                                                         0000
                  ength
  umber
                             Width
                                                                        Grain
Color
Color
                               ound
                                                            olor
eadi
ompa
     Grade
                 ota1
             eng!
                           ody
                                             Area
                     Loin
               ody
                          Dept
            63
O
                                                   Rib
                 8459538037038544008401230
20521053870011518532040037539048008811258
20621053673511518861538037535545008561164
20721248868011218059538538036544008751286
20820853774511518761038039534045008531176
80921050871011418561038539038044008501197
21021053873011518851039038039044008631182
31121257875812219764537038035546508651142
21221047469311318259537537034045008001154
81381851970511818862040040034544009101890
21420645271011416561057038035042508751232
                                             5547491281084000355444
21521240567511418166036037035041508701289
 21620839467011117860035538033542008551272
21720853071011919063038039039045009551345
21820846667011318059039037537043000001
                 7951038038036543005401350
                                             70755913000x33002x35
                 8963089039035045509851303
                                             733367188841880028
 22120852970011818863041038034543509151307
                  882838539838542989881341
22520847270511418560537037037043008701234
22621247571011216361033039033044508601211
                                             60175512526227003
22720852371011618762037038037043509051275
                                             712761132242160023533225052142
                                             655376121301
83920856873512119564038539038545009801333
                                             5314501818484000283888
 23021244967011217960035036035041508501269
23121049069511618662038037038042508851233
                                             93725412022233002333
23220656272011718962541540040045009151271
                                             046963120191710022838
 23320862274012319764042539039047509651304
 3421051070011518663040038035544008801257
23521049769011518461041038035043509151326
                                             55535411721216002233
 23620655872011618561041539536545008901238
23721055472011919163038539037544509001350
 23421056574512019465038541037045509751308
 23921253773011919257059536536043508951226
 24110464480012920966049042043052510301287
 24311075281013021167044546044651010201265
     106827201351976504104303904700950131
 24511070675012319863046540043550009851313
 24710462073511519160042041043547502051231
 2481086297551221976604304204U04700920121<sub>2</sub>
 24910470876512119765044543044050510001307
                                             52025818617242031
 <u>8501125797251161886284254054104750[301283</u>
251106738795127206660465410425510:0001258
                                             726961137262240411211214
 2541086367701191966254254104154750,951292
35510266772511618860046040639047505601324
                                             634359127888150811
25711062073511919261043040038048009751327
                               54700 00119
                                             640756132312550522234223032232
 26011063075512319964042540038047009551265
30810064378011719564045042538047009751250
                                             7301601341988804333338888082848
 2031006087501181936164204153964600960
36710481779012220164050043043553010701354
                                             074650134888310411111814088848
26510479481012620756047045041550510501296
                                             667552136272610422223112022242
269106794800122202650475420435505±0801350
                                             704351146442860411111212038348
                                             797260147318770412122213012242
27010283281512720867051043043051010601301
27110485479012720667048043545053010701354
                                             5353471243926004222231222022342
 7811874182513021248043545039049010251
                                              63763145222500533435
37311857677518520246046544037048070851400
                                             760761144162360823342333063271
27411071279012920845043044047052520201291
                                             721165141152170543333344063858
27511273782012821048044543039047010201243
                                             0637561321623504443433333662242
27611066678612820645046045039548510001282
                                             8830671511322505444555
27711074181012820947045043536550019102558 796163147182330633433333062262
 37811264879012320244045541037048<del>50970</del>1887
                                             72096114018889054333433305
27911671181012520646043546037548010401283
                                             840873143141090644345553063562
28011269678012220044043544536549010301320
                                             731455139182580622423332053261
28111477181513021147045544039051010151240
                                            688258135148380544544445063252
28211274461012921646045043037549009601209
                                             706355145812630643534334062262
38411077180012720745044543040048009401178
                                            077362133202140644344333055468
28511863679512420345043543538046505901
                                             78376015318855063343342
28611063677512620345043542037048009801264
                                                             654343434072262
287114736810131212470430420393480 TB001230
                                             054063153858480544344333053652
28611065679512420346544542038548510101270
                                            71856313718209053333333323052251
28910876180012720746046045033547529001250
                                             554365154812360428382388043342
29011078879018780647046045037548010351338
                                             765668133191970618381388058361
29310675680512920948047045042048010951360
                                             7153521408946904233333328022241
29411276783013321646042547038549010251234
                                             783760150182810622332433053261
                                             751475150082080543434544063552
29511670482013021246047043540549519851
29611272880012520544045544039053010151268
                                             843767151178830488838433058541
29711075680012520544048045042049010651331
                                             059859130282200633323223052261
29811263179012119943041042036547009751234
                                            778564130188030533438433068351
39910876779012620544048042037548510751360
30010678480012420443047043038549010501318
                                             7802591413023804333333233032242
                                             711460140312310533322333053352
30111076178012820645045541040550510701371
30211277181512921046045545039050509951220
                                             866955136812470533433333062452
30310476478018680445541048543543510151300
                                             0575731462620004333332223022141
30411076481012320444045543038549010451290
                                            763758134382310533443323053352
                                            0853611353922206333333223062361
30511280679513020946046045538050010201383
30611276781012620745640545039043509201135
                                            636354136163510544534433053258
30711275683018821146042043037044509301180 677352133192550543433433052252
30811058676012520168540042036044008851164
                                                             533434434084574
30811082282313021246043545537049510001212
                                            623152141148710533444423058258
30911861680512520567538543037044509101130
                                                             555455554084674
30911876480012820846042046537042509201150
                                            048961138192260544344432062251
31011878481013221347040544035543509201135
31111270778012720547041542038046509801179 993973160338190544334433052352
31211884183013321648045045038047509701168 823069145192100644344532063362
31311675689013423349043541039048510301157
                                            757964141183200543444523062251
31411671880518920946041845038849010001248 696056131172410733232523074371
31510679179013080946046544035051010401317
                                             850669141832040588881388043<u>1</u>51
31611291661013321448049047041550010601333
                                            920271145322040823522211053301
51811287183013421750047045543552510401253
                                            69095013624378053333333322052452
32010881680013021048044543039049810301287
                                             8868561503126705323333222053252
32111088281018880947043546041051310701320
                                             739862135352170532483212052451
32210481280012880646046046041049510701337
                                             656654135292500622322312043261
  310686281013021147048047041882010301271
                                             904971141271960433332322040241
32410685281013021148047044041533010101246
                                             650556139262390533232322042350
32510690684013321747050045042054010901297
                                             8540701471920905333333322052350
38621053673011510941038039038045509401287
                                             565756120133130534345334062251
32720851571011418540538039034044009801295
                                             64315712017210043323333333042241
32811064677012119843042041038046010001298
                                             63275913212227052233232323052251
32920651772011316540040539037545509201877
                                             547657116158030533883384038851
33011271678012520545044542037546009901269
                                             717959134192270533332324072351
33120646170011018041037040034041508951278
                                             528951115112250433333324022141
33811259675011919441038042038546510001333
                                             58955013016577063333333323062362
33321249670011518542038037036543508951278
                                             6231671151517105332333334062251
33421445171011818941035040032543008801239
                                             0656621301 4 8 0 9 0 6 3 4 3 4 3 3 2 4 0 7 8 2 6 1
33521050478011418641538038035544509501319
                                             003749145882950423323323052141
33621040770011018039535037031038507901128
                                             488947113118400343344333058831
53731449672011418640049039033042008701208 608257123172150533343344073351
33810681183012520845547542040551010301240 9095671523022604333333323043141
33911276478012620445042546038049010301380 7065691343419507333333333553171
34010688680012820845546543042550511001375
                                                             422222233042141
34111483081012720847042046042048571001358 779864135202091033333432052290
34211082680013321347046045039547510501312 723761136162220522333323053251
                                             005664148418210528333883053851
34410880180018720744547543539551010601325 - 600551130192540433432313051141
54511281682012821046043046038049010501280
                                             750169141192040933333312052172
34611201801013221347045546040548510701320
                                             710857134192330843343433042273
34711084477013820947047843041051510401350
                                             883029163262620522332323052252
34811688888013481649543046048053011101353
                                             054058131182250833433443062272
34911080682013121347046045040550010301256
                                             783067133261980534333323051152
35011274182012620847045543040050510401268
                                             7379711351919205433333332062358
35111273180012720747043045035047510301287
                                             055356124192210533433343052252
35 8110 7478 001 89 80 9 4 50 4 50 4 50 3 9 0 4 8 5 1 0 3 0 1 8 8 7
                                             6133651401281503332883333051138
 35311860678012880647041546050550010201307
                                             668960130042160643343533062663
35411680879012520446043046040051011001392
                                             630856132312550632422313052361
35511467878013020847044044538549010201320
35612268481013421558043547037850516301871
                                             589559125192110633444323072362
3561226848101342155804354703785051<del>630</del>1871
35711275479012820947542546837550010301303
                                             74186213519217053333333333062251
35811078781012820947044545039550510301271
                                             620266140178210522332333053252
 35911476180012820845041545037548510701337
                                             7617651431688010333338333058878
36011275661013221349043544041046010201259
                                             596055129262340544443333062252
36111460176012319945042045037548510401368
                                             722957140212430522323322052152
30210668178012119943045042035046009801256
                                             737268128271880322332223022151
36311069679012420345043541037549510101276
                                             728859140188370533322323062351
36411271178012320144044042036546010201307
                                             039264124301920433435232061242
36511071780012520546044045037048510101268
                                             6676611313021405333333333042251
366106711810183204435455436390480:0301271
                                             747660134352230433322323052241
36720453167011618362038538036045507801164
                                             83916514513883083883838385088888
36820449266011117758036037539544508201242
                                             999974162092180112222434021212
36920249861011017157041035036543008051319
                                                             111283323011111
37010648865011217755537537036045508001230
                                                             888488388048381
 37110453671011518660539038536047008401183
37210856074011819261038541037045508401135
                                                             223233433032222
 37311254073011819163039038536545508751198
                                                             333443534042303
37411252074011618962039039035545008401150
                                             861166149062230433332433054403
 37521050371511418665537538034542508001118
                                             8578751411118803333443230333302
37621051270511218362039537035044008701234
                                             772764141002180333332423041302
 37710852871011718860537038534546508501197
                                             989468166828670428382423033202
37811252071011518660540538835043008401225
                                             8398661381420903333333344052208
 37921049768011318158538536533543507901161
                                             890673142081940423233324052342
38011453172011618863040036036545508301152
                                             738757147142570543333435053458
 38110851169011218159539037535543508151181
                                             929475141111830322332324032232
38811050369010917858039037036544008501831
                                             9681691542122302222223325051322
 38311049671011318458037037535544008451190
                                             38421645370011818863535539033543008251178
                                             798763139082200244334445062223
 38520847869511018058035537033048508101173
                                             790562146092550222242323032223
38621245367011017759035537533042508401253
                                             938078153058180383383335053838
 38721450870011618659536039032542507851123
                                                             433433323054243
38921446472011316559637537538641008101185
                                             608862144152380833323334052388
 39021051872011518761036038535543504201208
                                                             834344444032222
 59110450478011418665049539536 04850,401305
                                             673370146232100212821213022121
 39210246669510817757038537035041008401217
                                             752162139122240211221313022121
3931134 = 167011017759034036033043008301238
                                             770567130062050133322445052313
 39410257572011218458040537037543509401305
                                                             111221224011111
39520847367011318061034036032544007801164
                                                             122323313022112
 39610454372011518764039536536043509101263
                                             999175150112000882221324021221
39711464681012820969038543533545508601061
                                                             844545443074274
40011860183013181470040045035045008801060
                                                             055045444074474
40111660780013021071042541536048009201150
                                                             444544434074573
40211460678012520468540545038548005601128
                                                             433443334063463
40311867681013021168543044035050009101183
                                                             433334444093673
 40411862680012520566040544035045008751093
40511850480012520568038542035543508551068
                                                             755544535084373
40611859879012520468038544035542508801113
40711668680018680670038044538048508401050
                                                             644445444084474
40512060680012820869038044035045509201150
                                                             654444544104774
40911663176012420067039543037046009101197
                                                             93333333083574
4111164163018921868837548838547009001084
                                                             544655544085653
41212467681013021169042543539047509201135
                                                            1044444554117774
41311662680018980968540044537048008851106
                                                             <del>5445444340846</del>53
41411879177012420166039042037046508201064
                                                             634543545074464
41511667182018720970040045038546508601048
                                                             834444343074373
41611457678012220066037541035543509151173
                                                             534444333063253
41711859181012620769539042536046508301024
                                                             <del>744445544074474</del>
41511659680018720768041543034047508901112
                                                             744444434084574
41911463682012821069039544536045508801073
                                                             534444433063453
42011057176012620267538042035546508151072
                                                             544544544074354
421222461730119192670300440275395066000
                                                             565665654085554
42212245678012720570530546029540507200983
                                                             555656454084554
42312448680012220269032546533542507600050
                                                             766666755105774
42412070188013519374537549038030509701108
                                                             654455444074664
42512456784013221673536044034044007800928
                                                             667766555085664
42612248180012520569033042032041007600950
                                                             655555644074564
42718449660012220268033546534042007600950
                                                             865565754080675
42812445179012120067533043029040507300924
                                                             666766655095665
48912645184513021471531546530044006900816
                                                             877767655095674
43012244474012019465032042530543007501013
                                                             755655545105773
43112450683012821171033545029541007550909
                                                             666666645084564
43213049481013421571037045035544508201012
                                                             655555544074564
43312451581012620770533545029543507700950
                                                             766566655095474
43412246181012520874533545031042007600938
                                                             755655645095674
43512449181012520568535544531041008101000
                                                             866666655106775
43612444477512520268032543532042507450961
                                                             766766666095774
43712250680012220271034545531045007600450
                                                            10556555545105554
43812452678012920769533047530045507801000
                                                             766656655106674
43912046776013119767532042033040507000981
                                                             645555444074363
44012257179013121072537542032046007550955
                                                             854555545084674
44112261682013421674037046032548507850957
                                                             644555444074464
44212448176012720568031544531044007250929
                                                             666666765094664
44311247570011318359039036038545509251324 7978641402421804334333333052151
44410853272011515863541538035547009301291 722461137192240333323322051151
44511059778011919163040541038548009051360
                                                             533483383068168
44611054271011718862040039538545009501338
                                                             533433323062262
```

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

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 accurate 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.