A STUDY OF BEEF CARCASS GRADING CRITERIA

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Recently Dr. Briskey and I had the privilege of making a study of the present and proposed beef grade standards for the American National Cattlemen's Association.

The study was designed to answer the following questions:

1. Does the present grading system of grading beef carcasses adequately reflect dollar differences in the value of carcasses?

2. Are the proposed cutability grade standards based on sound research fact, and will they segment carcasses into groups, wherein the carcasses are similar in value?

3. Are the standards for quality used for estimating palatability based upon sound research information?

At the outset let me express our appreciation for the excellent cooperation we received from each of you in supplying data and reports of your research relating to these questions.

Part I. Quantitative Considerations

While many researches have been reported pertaining to the differences in value of carcasses, I must because of the time limitation for this presentation, refer only to typical research reports.

A. Cutability and traits associated with retail yield

Research data developed by Dr. Breidenstein (9), from 398 sides (including 1 side from 105 steers and both sides from 94 heifers) purchased from a midwest packer and representing primarily the Good and Choice grades clearly point up the variation in value of carcasses which is primarily attributable to differences in cutability or percent yield of retail cuts. Results were as follows for the 398 sides:

<table>
<thead>
<tr>
<th>Cutability results</th>
<th>Low</th>
<th>Ave.</th>
<th>High</th>
<th>Width of Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>% retail cuts of side weight</td>
<td>52.2%</td>
<td>62.8%</td>
<td>71.1%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Dollar value per cwt based on $45.00 market</td>
<td>$37.40</td>
<td>$45.00</td>
<td>$50.94</td>
<td>$13.54</td>
</tr>
</tbody>
</table>
Research at the University of Wisconsin performed on ninety-nine left sides of U. S. choice steer beef sides was selected at random within each of three weight groups (260-288 pounds), (300 to 325 pounds), (332-360 pounds) over a 6-month period.

<table>
<thead>
<tr>
<th>Weight groups</th>
<th>260-288 lbs</th>
<th>300-325 lbs</th>
<th>332-360 lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>% retail cuts from round, rib, loin, Chuck</td>
<td>50.8</td>
<td>49.7</td>
<td>48.5</td>
</tr>
<tr>
<td>% range in cuts*</td>
<td>47.0 - 54.6</td>
<td>46.4 - 53.0</td>
<td>45.5 - 51.5</td>
</tr>
<tr>
<td>Range in value per cwt (based on cut-out variation)</td>
<td>$6.56</td>
<td>$5.52</td>
<td>$5.25</td>
</tr>
</tbody>
</table>

* represents the range for 2/3 of the carcasses falling closest to the average cutout for the group.

These differences are not as large as those reported by the University of Illinois, since this study was done only on the four major whole cuts and one-third of the extremes in cutout were not included in the ranges reported; yet in this conservative analysis a range in value of close to $30.00 existed in 1000 lb. steers. If the Wisconsin data had been analyzed similarly to that of Illinois, it would appear that the results would be very similar. Studies made by the Livestock Division of the Agricultural Marketing Service (49) on 29 Prime, 83 Choice, 42 Good and 31 Standard grade carcasses provided similar results.

Obviously one must conclude from these data that extreme value differences exist in the carcasses falling within the same grade. There is also sufficient research data to define the magnitude of the variation in value of carcasses carrying the same grade. This research also substantiates opinions based upon experience of men in the retail and packing industries, that considerable variation in value based on cutability exists within and among grades and further that our present grades do not divide carcasses in line with their true value. Thus the answer to the question "Does the present U. S. system of grading beef carcasses adequately reflect dollars difference in values" can certainly be answered in the negative.

Several carcass characteristics, such as carcass weight, fat depots, conformation, muscle measurement and weight, bone size and carcass length have been given considerable study.

Cole et al. (21), Breidenstein (9), Murphy et al. (49), Brungardt and Bray (11) have reported the effects of weight on the retail yield.

All of the data reviewed indicates that groups of heavier weight carcasses will yield less than groups of light weight carcasses. This is not to say that on an individual carcass basis that every "heavy weight" carcass will cut out less than a "light weight" carcass. The inference
from these data supports present knowledge, that biological variation in all animal life is such that at any given weight, or age, irrespective of sex, the proportion of muscle, fat, and bone can differ widely among animals within the same species.

The amount of fat varies widely in carcasses. Data developed by Ramsey et al. (55) University of Tennessee, covering primarily Choice, Good, and Standard cattle indicate that the external fat thickness at the 12th rib varied from 1 to 27 millimeters, (about .1 to 1.1 inch) kidney fat from 1.8 to 8.9% and separable fat in the carcass from 14.3 to 42.8%. With good and choice grade cattle at Wisconsin (11) fat thicknesses varied from 0.35 to 1.60 inches, % kidney fat from 2.4 to 7.8 and calculated carcass fat (using separable fat from the 9-10-11 rib) from 28.5% to 40.5%. Since fat is not a factor considered in our present grades and since its quantity varies widely, it becomes obvious that it is one of the important factors contributing to the variation in value of carcasses.

Research relating the influence of fat on carcass cutability has been done at many institutions. Cole et al (19), Stringer et al. (58), Zinn (66), Brungardt and Bray (11), Murphy et al. (49), Brown et al. (10) and Breidenstein (9) report significantly higher negative correlations between external fat thickness and various measures of muscling.

In summarizing all of the research data one must conclude that the amount of fat on or in a carcass is a major factor in determining the quantity of saleable retail cuts that can be obtained from a carcass. This is borne out by the use of statistics which show that there is a highly significant negative relationship between the retail cut yields of carcasses and the quantity of fat - that is as fat content goes up, the quantity of retail cuts goes down.

Since outside fat can be objectively measured, it is then reasonable to expect that its measurement could serve as a guide in predicting retail yield. The percentage of kidney and pelvic fat if obtained by an objective means (cutting and weighing) can likewise aid in estimating retail yield. Estimates of these percentages are less accurate, and probably will be only as precise as an individual can train himself in making relatively accurate estimates.

Conformation has long been a factor in our present grade standards. Its inclusion has been based upon the opinion that it is related to the retail yield of a carcass, especially in the preferred cuts. This trait has been measured subjectively and relates primarily to the shape and fullness of the round, loin, rib and chuck. Conformation is dependent upon muscle thickness, depth, and length, but likewise by fat depots both on the outside of the cuts and between the muscles. Even though the conformation grade is supposedly only an estimate of muscle shape and thickness, it is especially difficult to ascertain this trait in heavily fatted carcasses - thus one immediately recognizes the likely possibility of scoring conformation higher in fat carcasses and lower in carcasses which are less fat.

Relatively few research reports are available which establish the degree of relationship between carcass conformation and retail yield, yet
enough evidence is available to indicate that its effect is far less than that for fat thickness or fat deposits inside the carcass.

Breidenstein (9) found no association between conformation and yield of retail cuts in steers grading primarily Good and Choice, but established that an increase of one-third of a grade in conformation in heifers resulted in an increase of 0.54% retail yield in heifers. However, it should be pointed out that the range of conformation studied was rather narrow.

Butler (13), Texas A. & M. College, reported from a four-year study involving carcasses varying widely in conformation that wholesale cutout data was surprisingly similar. The longer carcasses had slightly higher percentages of hindquarter and round. He concluded that the animal breeder has considerable latitude in selecting animals of different shapes without encountering great changes in the percentages of wholesale cuts. The limitation was brought out in other Texas studies and studies at Wisconsin (11) which indicate that the variation in wholesale cut yield is small, but with trimmed wholesale cuts (defatted to 3/8 inch), the differences in yield are highly different and highly associated with retail cut yields.

Murphey et al. (49) report in their studies that finish was $4\frac{1}{2}$ times as important as conformation scores in predicting yields of closely trimmed, mostly bone – in retail cuts from the four major wholesale cuts.

Researches by Coll and associates (30), Branaman et al. (7), Zinn et al. (64), Cole et al. (23), and others indicates that conformation as measured subjectively today is not a significant factor in the cutability of carcasses. However, the conclusion that conformation does not have any effect on the retail cut yield of a carcass is not justified at this time. Conformation measured objectively and excluding fat deposits might give different results from those obtained through visual appraisals. In order to ascertain the influence of conformation or shape and thickness of cuts, one must objectively measure muscles and study these measurements in relation to cutability. A number of research efforts have been directed toward this possibility.

Loin eye area has been studied perhaps more than any other single muscle measurement, primarily because it is practical and causes no extra cutting of the carcass than is usually done in commercial operation.

Tennessee (20), Wisconsin (11), Texas (14), Missouri (58), Kansas (32), Ohio (15), and Illinois researchers (9) report significant, yet not especially high (approximately 0.4 to 0.5) correlation coefficients between loin eye area and retail yields. If carcass weight and carcass fatness are held constant, this relationship is decidedly reduced. This is expected since muscle size is a function of weight - thus heavier weight carcasses usually possess larger loin eyes; however, Wyoming workers (29) show this relationship to be non-linear.

The researches reviewed indicate that although this measurement is positively associated with retail yield, its influence is small in magnitude, especially when compared to that of fat. However, some additional emphasis on loin eye size may be justified in view of the fact that it represents the
second most tender muscle in the carcass, represents 10% of the weight of muscle in the carcass and is the major muscle in high priced cuts. (T-bone, porterhouse, rib roasts).

The part to whole relationships (example - weight of round to weight of carcass), between certain weights or percentages of wholesale cuts or major muscles and separable muscle or retail cut yield has produced some very high correlators. Cole et al. (20) found the separable muscle in the round to be associated with 90% of the variation in total separable muscle in the carcass. Orme et al. (51) in studies relating to the prediction of total carcass muscle from the weight of entire muscles, found that they could account for 64% to 92% of the variation in total separable lean by this means.

From these studies one can conclude that weights of the large muscles can be used in predicting total carcass muscle weights. A significant research report by Thornton and Hiner (in 1963) (50) suggests that measurements of the round can be used in predicting the volume of the round. Brungardt and Bray (11) established a correlation of 0.83 between percentage of trimmed round and retail cut yield and a correlation of 0.75 between percentage of untrimmed round and retail cut yield. The percentage of round may provide some indication of size of muscle, but it should be remembered that the percentage of round decreases with increasing amounts of fat in the carcass - thus % round also can be used as an indication of carcass fatness.

In summary muscle weight or volume measurement which can be converted to weight or percentages suggest the possibility of developing more precise methods for estimating the percent or weight of muscle or saleable meat in the beef carcass.

Tennessee researchers (21) report that length of carcass is negatively associated with external fat thickness and positively associated with pounds of separable lean, but negatively correlated with loin eye area. Cole et al. (22) working with 75 steers and 68 heifers representing 5 grades and 4 weight groups found that carcass length was not consistently greater in either sex. As carcass grades increased from Utility to Prime grade, fat thickness increased and carcass length decreased. A greater number of steaks was associated with greater length, but when the carcasses were adjusted for carcass weight, length was not associated with the numbers of steaks.

B. Regression Equations Measuring Quantitative Differences

The review of the research pertaining to the influence of carcass weight, outside fat, kidney and pelvic fat, muscle size, muscle area or weight and carcass length lead to the following conclusions:

1. That these traits are measurable and effect the percentage retail cut yield of a carcass.
2. That wide variations exist in the quantitative measurements of each of these traits.
3. That the wide variations in the quantity of these traits also represent wide variations in value among carcasses now being graded the same.
4. That these traits can be measured or estimated rather easily.

5. That these traits vary in their total influence upon retail yield; for example variations in quantity or thickness of external fat usually has a greater influence on retail cut yields than carcass weight.

With this knowledge we have seen the development of a number of regression equations (scoring systems) by researchers in attempts to develop simple, applicable procedures for measuring value differences in carcasses.

Hankins and Howe (34) developed an equation for predicting the separable lean in a carcass using the quantity of either muscle or fat separated from a cut referred to as the 9-10-11th rib cut.

Cole and associates (20) (21) (51) developed several regression equations which they report provide good estimates of carcass cutability. Equations involving the use of the weight of individual muscle or muscles, accounted for 77 to 94% of the variation in total carcass lean.

Using fat thickness at the 12th rib and carcass weight these same workers developed a prediction equation for retail yield. This equation involves easily obtained measurements and considerable accuracy since these workers found a correlation of 0.88 between actual and predicted pounds of lean with an average difference between the two values of 5.8 pounds.

Wisconsin researchers (11) have developed an equation for retail yield using % trimmed round and fat thickness at the 12th rib. The standard error of the estimate and actual yield was 1.4% for retail cut yield and the equation accounted for 81% of the variation in percentage of retail cuts. Two major breed associations are using this equation in their carcass improvement programs.

Breidenstein (9) in studies involving 398 sides found heifers and steers to vary significantly in cutability and thus developed equations for the two sexes. This appears to be justified, although the factors in the equations are not widely different. The equation which included a factor for conformation grade accounted for 72% of the variation in retail yield and the standard error of the estimate was 2.42%. The equation for heifer carcasses was slightly less accurate.

A regression equation was developed by the U.S.D.A. (40) to predict the estimated percentage of boneless retail cuts from the round, rib, loin, and chuck, and equals 51.34 - (5.78 x a single measurement of thickness of fat over the rib eye) - (.462 x estimated percent kidney fat) - (.0093 x carcass wt.) + (0.740 x area of the rib eye). The correlation between predicted and actual cutout was 0.906 with a standard error of the estimate of 1.9% - thus accounting for 80% of the variation.

Palmer et al. (33) at the University of Florida reported on a study involving 138 cattle varying in slaughter weight, breeding and quality grade. The relationship between carcass retail yield estimates made through the use of the U.S.D.A. yield equation and actual yields was 0.76, indicating that slightly under 60% of the variation in retail cut yield was
accomplished. Correlation coefficients between predicted yield grades and actual yield grades were highly significant.

Ramsey and associates (55) studied the relation between the present beef carcass grades and the proposed U.S.D.A. yield grades to fat thickness and separable lean, fat and bone in the carcass. Present carcass grades and yield grades which ranged from one to five showed a highly significant positive association (0.49) which indicates that the higher grades in our present federal grading system yielded lower percentages of retail cuts.

An evaluation of dual graded beef carcasses by the U.S. Army Subsistence Center, Chicago, provided the following results:

<table>
<thead>
<tr>
<th>Yield grade</th>
<th>Lbs of carcass beef possessed</th>
<th>yield of usable beef</th>
<th>% raw fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>35,027</td>
<td>70.2</td>
<td>11.0</td>
</tr>
<tr>
<td>3</td>
<td>56,532</td>
<td>67.6</td>
<td>13.9</td>
</tr>
<tr>
<td>4</td>
<td>29,664</td>
<td>65.7</td>
<td>16.0</td>
</tr>
<tr>
<td>5</td>
<td>27,399</td>
<td>61.7</td>
<td>20.7</td>
</tr>
<tr>
<td>6</td>
<td>15,588</td>
<td>59.4</td>
<td>23.1</td>
</tr>
</tbody>
</table>

Workers carrying out this study concluded that the dual grading system developed by the U.S.D.A. is accurate in determining yields of usable meat. It should be noted, however, that these figures represent averages. No indication of the range of values within the averages was given.

Brungardt (11) in studies with 99 choice grade carcasses using the same four variables as used in the U.S.D.A. equations could account for 67% of the variation in retail yield.

Breidenstein (personal communication) U. of Ill., has made a study relating the accuracy of computed yield groups to corresponding retail yields.

<table>
<thead>
<tr>
<th>Yield group</th>
<th>No. of Carcasses</th>
<th>Ave. % total Retail Yield</th>
<th>Std. Deviation</th>
<th>Computed Ave. Yield Grade</th>
<th>Std. deviation for computed values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>67.91</td>
<td>3.85</td>
<td>1.7</td>
<td>.23</td>
</tr>
<tr>
<td>2</td>
<td>189</td>
<td>65.90</td>
<td>3.95</td>
<td>2.52</td>
<td>.25</td>
</tr>
<tr>
<td>3</td>
<td>443</td>
<td>62.43</td>
<td>3.33</td>
<td>3.47</td>
<td>.28</td>
</tr>
<tr>
<td>4</td>
<td>302</td>
<td>60.28</td>
<td>2.50</td>
<td>4.39</td>
<td>.28</td>
</tr>
<tr>
<td>5</td>
<td>131</td>
<td>57.31</td>
<td>2.76</td>
<td>5.51</td>
<td>.27</td>
</tr>
</tbody>
</table>
Attention is directed to the fact that the standard deviations overlap the midpoint between the yields for adjacent yield groups.

The data regarding the four factors used in establishing yield grade are of considerable interest.

<table>
<thead>
<tr>
<th>Yield group</th>
<th>No. of carcasses</th>
<th>Hot carcass weight</th>
<th>Fat thickness 12th rib</th>
<th>% kidney, pelvic &amp; heart fat</th>
<th>Loin eye area sq. in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>549.4</td>
<td>.19</td>
<td>2.60</td>
<td>13.10</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>67.62</td>
<td>.10</td>
<td>1.12</td>
<td>1.91</td>
</tr>
<tr>
<td>2</td>
<td>189</td>
<td>573.1</td>
<td>.28</td>
<td>2.92</td>
<td>11.70</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>88.27</td>
<td>.15</td>
<td>1.72</td>
<td>1.72</td>
</tr>
<tr>
<td>3</td>
<td>443</td>
<td>628.0</td>
<td>.38</td>
<td>3.72</td>
<td>11.15</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>92.67</td>
<td>.14</td>
<td>1.11</td>
<td>1.38</td>
</tr>
<tr>
<td>4</td>
<td>302</td>
<td>650.7</td>
<td>.65</td>
<td>3.96</td>
<td>10.35</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>81.91</td>
<td>.15</td>
<td>1.00</td>
<td>1.22</td>
</tr>
<tr>
<td>5</td>
<td>131</td>
<td>722.4</td>
<td>.92</td>
<td>4.59</td>
<td>10.20</td>
</tr>
<tr>
<td></td>
<td>Std. Dev.</td>
<td>94.6</td>
<td>.19</td>
<td>1.13</td>
<td>1.41</td>
</tr>
</tbody>
</table>

In additional studies at Illinois involving 12 separate lots, simple correlations between the U.S.D.A. yield grade and % total saleable product ranged from -0.37 to -0.84 with most values between -0.6 and -0.8.

Correlations from -0.6 to -0.9 indicate that 35 to 80 percent of the major variations in retail yield can be accounted for by this equation. However, most data fall within the range of 50 to 70%.

From the research reviewed it can be concluded that the U.S.D.A. regression equation does predict the retail cut yield of carcasses with reasonable accuracy when applied to steers and heifers varying in weight and grade. The choice of the word reasonable is based upon the knowledge that there is wide biological variation in beef cattle; that is to say that wide variations exist in not only quantity but distribution of muscle, not only quantity but distribution of fat and similarly for bone. Various combinations of distribution patterns for muscle, fat depots and bone result in a certain number of animals or carcasses that are generally the same, but also some that are far from the average in these respects. When one works with biological material, in this case beef, one should recognize that there will always be a number of "odd" carcasses that will fail to conform to any equation for predicting retail yield.

Further, it can be observed that significant dollar value differences exist for the average retail values for carcasses placed in the proposed yield groups. It is also obvious from the research data that this method of evaluating carcasses or dividing them on the basis of value is far superior to the present U.S.D.A. grading system.
The number of grade categories to use will be dependent almost entirely upon the precision required. Some deviation from the mean will always occur. Too great a number of grades may divide carcasses into groups where the value difference between adjacent grades is not economically significant; likewise too few grades will fail to separate carcasses that vary significantly in value in the commercial trading of carcasses. It is our considered judgment, based upon a practical range of 10% to 12% variation in retail yield that three to five yield grades will provide sufficient means for reasonable standardization of the product. As greater precision is built into such a system, it may then become feasible and practical to increase the number of yield groups.

The preceding statements are not intended to convey the impression that the U.S.D.A. yield grade standards have been perfected to their optimum, even though they currently represent a significant guideline for establishing carcass value for the producer, processor, retailer, and consumer. Greater precision in predicting yield grades is desired yet it is unlikely that any objective approach using carcass measurements will ever account for more than 80% of the variation in cutability. It should be remembered, too, that the U.S.D.A. yield grade equation was developed to cover steers and heifers, involving several grades and weight ranges. It is expected that greater precision could be developed if separate formulas had been developed for each of the sexes, for the different weight ranges and for high vs. low grading carcasses. It may not be practical to suggest this approach at this time when there is so much misunderstanding as to how yield grades are determined. However, if these yield grades become a part of grade specifications, efforts should be put forth to study the precision that may be brought about by including these traits in yield prediction equations.

Additionally, continued efforts must be devoted toward the possible use of other objective measures which might be added to this procedure for greater definition of carcass values. For example, considerable interest among cattlemen has been expressed relative to the inclusion of conformation in the prediction of retail yield. From the limited data available, it would appear that subjective measurements of conformation have only minor effects on cutability - yet this is hardly enough evidence to say that objective conformation measurements of the high priced cuts would not be more closely associated with the retail yield. It would appear that research is urgently needed for the critical evaluation of this trait in relation to cutability.

Part II. Quality Considerations

Quality of an item is generally defined either in terms of degree of superiority in a specific property or characteristic or in terms of overall excellence. Historically beef has had to be fat to be of high quality. In fact from biblical times to the present time there has existed a belief that fattening the animal improved the quality of its meat.

Today we know that "eating" quality of beef is extremely variable. Of this variability we can, in general, say that beef from old animals is less palatable than beef from young animals. We can also feel somewhat confident in saying that beef which is devoid of marbling or inferiorly marbled
is less palatable than beef with some marbling. It has also been established that the eating qualities of tenderness, juiciness and flavor vary from animal to animal, sire to sire and breed to breed. In addition to eating quality, itself being highly variable, the range in and incidence of certain muscle characteristics thought to advance eating quality are also highly variable. Grade standards for quality, therefore, have been established in an attempt to categorize these variable properties into uniform groups.

In retrospect, and in all due respect to the early report of Slater (U. S. D. A.) in 1927, the quality standards were originally developed without sufficient research evidence. However, it should be remembered that these standards were developed for practical use. To be of practical use they had to be in conformity or compatibility with prevailing customs or practices. Therefore experience and practice substituted for research as they attempted to group, with specific terminology, the criteria or factors which were used by the trade at that time. Special emphasis should be given to the fact that the original purpose of the quality standards was to group or make more uniform, not guarantee, a consistently significant advance in superiority on a carcass-by-carcass basis.

A brief review of the development and amendments of the present quality aspects of grade are:

1. **1926.** Much of the terminology used to describe beef quality characteristics in the present day specification takes its origin with the original development of the grading standards with quality standards defined very subjectively. A description of these standards is listed in Table I.

   **Table I**
   **Original (1926) Description of Beef Quality**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Texture</th>
<th>Color</th>
<th>Marbling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime</td>
<td>Firm</td>
<td>Light</td>
<td>Abundance</td>
</tr>
<tr>
<td></td>
<td>Velvety</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>Firm</td>
<td>Light</td>
<td>Always</td>
</tr>
<tr>
<td></td>
<td>Velvety</td>
<td></td>
<td>present</td>
</tr>
<tr>
<td>Good</td>
<td>Moderately</td>
<td>Light to</td>
<td>Some</td>
</tr>
<tr>
<td></td>
<td>firm</td>
<td>slightly dark</td>
<td></td>
</tr>
</tbody>
</table>

2. **1936.** Amendments to these specifications in 1936 left quality descriptions unaltered.

3. **1949.** In 1949 the descriptions of the fat were altered to omit reference to fat color.
4. 1950. In 1950 the quality specifications were subjected to major revision. Prime and Choice grades were combined. The Good grade was renamed Choice and the Commercial grade was divided into two grades by designating the beef produced from young animals included in the top half of the grade as Good.

In this amendment the descriptions were similar but the marbling requirement was spelled out for Prime, Choice, Good and Commercial grades of carcasses with soft, red chine bones terminating in soft pearly-white cartilages. Progressively more marbling was required in carcasses with evidences of more advanced maturity. Prime required slightly abundant; Choice, small; Good, traces.

1956. In 1956 the quality standards were as described in 1950 except that they were amended by dividing the Commercial grade into two grades strictly on the basis of maturity with beef produced from young animals being designated Standard while Commercial was retained as the grade name for beef produced from mature animals. As an aid in the correct interpretation of the standards, the department, for the first time used colored photographs of marbling scores. (Developed by G. Wellington, Cornell).

A--DERIVATION OF QUALITY GRADE

It would seem important to review the degrees of excellence in marbling, maturity, color, firmness and texture as they are used in the specific derivation of a quality grade. Assuming acceptable color, firmness and texture, the marbling and maturity become dominating factors.

There are 12 marbling scores varying from an extremely abundant to a devoid amount of intramuscular fat. The terms applied to the specific degrees of marbling are given in the following table.

<table>
<thead>
<tr>
<th>Table II</th>
<th>Degrees of Marbling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extremely abundant</td>
</tr>
<tr>
<td></td>
<td>Very abundant</td>
</tr>
<tr>
<td></td>
<td>Abundant</td>
</tr>
<tr>
<td></td>
<td>Moderately abundant</td>
</tr>
<tr>
<td></td>
<td>Slightly abundant</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modest</td>
</tr>
<tr>
<td></td>
<td>Small</td>
</tr>
<tr>
<td></td>
<td>Slight</td>
</tr>
<tr>
<td></td>
<td>Traces</td>
</tr>
<tr>
<td></td>
<td>Practically devoid</td>
</tr>
<tr>
<td></td>
<td>Devoid</td>
</tr>
</tbody>
</table>
Table III
Carcass Maturity vs. Chronological Age

<table>
<thead>
<tr>
<th>Grade</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime</td>
<td>9-18</td>
<td>19-27</td>
<td>28-36</td>
</tr>
<tr>
<td>Choice</td>
<td>9-20</td>
<td>21-31</td>
<td>32-42</td>
</tr>
<tr>
<td>Good &amp; Standard</td>
<td>9-22</td>
<td>23-35</td>
<td>36-48</td>
</tr>
</tbody>
</table>

The maturity scores were termed A, B, C, D, E and F. Since the bottom part of D and all of E and F are for older cattle only qualified for Utility and Commercial, we will confine our discussion to Groups A through C. Note in Table III that as one goes from Good to Prime the range for each maturity score narrows markedly. In addition to the difficulty that one encounters in estimating maturity within these narrow ranges from A to C, the problems are made more difficult by the fact that "A" maturity in a "Good" grade carcass may not be "A" maturity in a Choice grade carcass.

The next Table (IV) shows the specific minimum degrees of marbling required for a particular grade when the carcasses have at least the minimum conformation score for the grade in question.

Table IV
Minimum Marbling Requirements in Relation to Maturity

<table>
<thead>
<tr>
<th>Grade</th>
<th>Conformation Equivalent</th>
<th>Maturity Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Prime</td>
<td>Min. Prime or better</td>
<td>Slightly abundant</td>
</tr>
<tr>
<td>Choice</td>
<td>Min. Choice or better</td>
<td>Small</td>
</tr>
<tr>
<td>Good</td>
<td>Midpoint Good or better</td>
<td>Traces</td>
</tr>
</tbody>
</table>

As maturity increases there is a stepwise increase in marbling requirement. These relative changes in marbling requirements with maturity can be worked out rather easily. One degree advance in marbling is required for each degree advance in maturity as long as all other factors remain the same.

It becomes extremely more perplexing, however, to compute or balance marbling and maturity for a particular grade when the conformation is inferior. In Table V, we can see that for practical purposes we increase the marbling requirement one degree for each one-third reduction in conformation grade. It is important to point out, that Low Choice carcasses of one maturity score could vary five degrees
in marbling because of inferior conformation scores. Now if one compares an adequately formed Low Choice carcass of A maturity with a carcass of inferior conformation and C maturity we find a spread of 7 out of the 12 possible degrees of marbling and in both cases the carcasses qualify for Low Choice.

Table V
Marbling Requirement by Specified Degrees of Conformation and Maturity

<table>
<thead>
<tr>
<th>Grade</th>
<th>Conformation</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. Choice</td>
<td>Small</td>
<td>Modest</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Low Choice</td>
<td>Midpoint Good</td>
<td>Moderate</td>
<td>Sl. abundant</td>
<td>Mod. abundant</td>
</tr>
<tr>
<td>Midpoint</td>
<td>Standard</td>
<td>Mod. abundant</td>
<td>Abundant</td>
<td>Very abundant</td>
</tr>
</tbody>
</table>

In practice, both marbling scores and maturity classifications are grouped into high, average or low. This further subdivision provides the practical meat grader with 34 possible marbling scores and nine maturity classifications. In just A through C maturity groups we can therefore see 336 different grade combinations for marbling and maturity when conformation is not inferior. Now if conformation were also considered one could see the likelihood of many more combinations depending upon the specific lack of conformation.

I wish to emphasize that this is generally a matter of practice and the five subdivisions of marbling scores and maturity scores into high, average and low are not defined in the specifications. The reason these many combinations are pointed out here is not to be critical but rather to underline an important difficulty in determining the association of this narrowly defined characteristic to eating quality. It further illustrates the difficulties encountered in interpreting studies on grades when they may have been derived from so many different combinations of quality factors.

B--DIFFICULTIES IN DERIVATION OF MEANINGFUL QUALITY GRADE

Before proceeding further I wish to emphasize that quality standards are highly desirable. Nevertheless it is difficult to interpret and apply extremely specific specifications for quality factors to varying biological material. In addition to the mechanical difficulties of deriving a quality score I wish to further point out other reasons why it is difficult to derive a quality which may be specific for the entire carcass when this quality grade is based on narrow limits of marbling and maturity. They are as follows:

1. Variation in type of marbling

The amount of marbling which is visible at the 12th-13th rib as pointed out in 1959 by Wellington and Stouffer (63) may vary widely in character.
2. **Relation of Amount and Distribution of Marbling to Quantities at Other Areas**

Blumer, et al. (4) and Blumer (3) in 1963 have noted that at one-fourth inch away from the cut surface the marbling score may have changed markedly. Cook (24) has also shown a major change in marbling by vertebrae and it was noted that there is the greatest difference in marbling between the 12th and 13th rib and the extremities.

3. **Relation Between Marbling and Ether Extract (Chemical Fat) -- Not Perfect**

Thirdly, in addition to nature and distribution of marbling the correlation or relation between score and ether extract although relatively high (approx. .6 - .8) still only explains about 50% to 65% of the variation. Wellington and Stouffer (63) point out that the relationship between marbling score and ether extract values are more poorly aligned in the higher scoring brackets.

4. **Difficulties in Maturity Evaluation -- Relation to Chronological Age, Not Perfect**

Fourthly, it should be realized by both the government grading service and the packing industry that specific maturity evaluations are at best only estimates of the actual age in young cattle. From A to C maturity, bones and cartilages are described as ranging from soft, pearly-boned cartilages with red porous bones to chine bones tinged with white and the cartilages on the end of the chine bones are soft to moderately ossified. The major difficulty quite obviously appears in distinguishing between A and B maturities. C maturity which has hard and/or slightly to moderately ossified cartilage tips and fused sacral vertebrae as well as chine bones tinged with white can be distinguished readily from A and B. Kaufman (Illinois personal communication) has noted a correlation of + .67 between maturity score and actual chronological age in 32 cattle. Lewis et al. (Unpublished data, University of Wisconsin) have noted a low but highly significant correlation of over .30 between carcass maturity and chronological age in 113 cattle varying in maturity from A through B. Alsmeyer (1) has also noted low but positive correlations. Gregory et al. (University of Nebraska) have also noted a very low correlation between maturity and age. It is very obvious that more basic work needs to be done to improve estimations of carcass maturity and to further understand the relationships and significance of the relationships between chronological and physiological age vs. maturity score.

**C--Relationship of Carcass Quality Factors to Palatability of Meat**

1. **Interpretation of research data:** Before briefly discussing the relationship of presently used carcass quality factors with palatability it would be well to emphasize the difficulties which one encounters in making a fair appraisal of reported work. To begin with, there are a tremendous number of variables which may be involved and which may influence the ultimate results: Breeding (2, 16, 17, 18, 38, 44, 56), age (1, 3, 60), feeding (57), feeding period (65), daily gain (65), weight (1, 6), activity before
slaughter (41, 12, 9a), and stress (13) of the live animal as well as cooking method (26), internal temperature, sample location, sample size, panel size (numerous reports), panel training (numerous reports showing various amounts of training), aging period (3, 37), cooling rate (9a), fiber size (5, 33, 39, 60), connective tissue composition (2, 31, 48, 38), color (9a, 12), carcass maturity (1), marbling quantity (3, 43, 50) and marbling distribution (24, 3) are only a few of the variables which may influence ultimate results of studies on these problems.

2. Influence of grade on eating quality: Since major changes in grades were made in 1950, it is difficult to interpret the results of studies conducted by grade prior to that date. Results of specific differences between grades and the magnitude of these differences have been extremely varied.

Palmer et al. (52) of Florida State University, in a large study (535 animals) found that grade accounted for only 8% of the variation in tenderness and palatability. In comparing Prime and Good grades Doty (American Meat Institute Foundation) and Pierce (U. S. D. A.) (27) in 1960 in a study of 153 cattle found the Prime grade to be superior to the Good grade in tenderness. In a limited study Husaini et al. (42) (Ohio State University) found a significant correlation of a rather large magnitude between carcass grade and tenderness, although the grades varied widely by breeds. Cole and Badenhop (19), (University of Tennessee) Kiehl (45), (University of Missouri) and Harrison et al. (35) found preference for higher grades but in general there was no difference in eating characteristics of "Good" and "Choice". Kropf and Graf (46) (U. S. Army, Quartermaster Food and Container Institute) found higher but non-significant differences in tenderness in higher grades. Cover (25) (Texas A & M) found only a slight trend in favor of the higher grades, while Lowe and Kastelic (Iowa State University) (47) noted such extreme variation between animals of the same grade that it became apparent that further, more extensive and more basic studies were required.

In an extensive study of loins varying by a third of a grade from Low Good to High Choice, Naumann (50) (University of Missouri) found no natural breaks in acceptance. While a positive relationship existed between grade and consumer acceptance, it was obvious that the relationship was slight. The adjacent grade segments (High Good - Low Choice) had a large overlapping distribution.

Most Choice and Good carcasses have similar eating qualities, but a few Good carcasses were inferior to Choice, therefore some studies find no difference, while others find a small difference. It was therefore pointed out by Kiehl (45) (University of Missouri) that it is the occasional "odd ball" or "counterfeit" in palatability which causes merchandising difficulties.

Collectively these data indicate that although the mean value may not be greatly different, the risk of having an "odd ball" in the higher grades is markedly reduced in comparison with the lower grades.

3. Influence of marbling on eating quality: Since marbling plays a predominant role in establishing grade it is logical to consider it as the next variable.
Wellington and Stouffer (63) (Cornell University) in a study of 121 cattle found that although the tenderness and juiciness of steaks with marbling ranging from slightly abundant to very abundant (regardless of A, B or C maturity) were generally grouped at higher values; there was a very low correlation (.26) between marbling and tenderness. These workers also pointed out, on the basis of ether extractable material that marbling quantities are more difficult to discern to specific degrees at the higher levels. Although studies comparing Prime and Choice have not been extensive it is entirely feasible that any attainable virtue of marbling levels off at about the 8% fat level (moderate to slightly abundant). In the large study at the University of Missouri involving loins varying from Low Good to High Choice, marbling and consumer acceptance were positively correlated although at only the .21 level. Alsmeyer et al. (1) (University of Florida) in a large study with cattle ranging from devoid to modest marbling derived a correlation of .23 between tenderness and marbling.

Lewis et al. (Unpublished data) with over 130 cattle and an 18-member trained panel, noted highly significant correlations between marbling and tenderness, however at only the .40 level.

Blumer (3) considering extensive evidence noted that marbling and juiciness were significantly correlated although at only about .36 which would account for only approximately 15% of the variation. Hiner (40) found the quality of juice to be related to marbling and to be highly heritable. Doty and Pierce (27) although indicating a specific relation between marbling and juiciness observed that this was not apparent above 7 or 8% fat (moderate to slightly abundant).

Considering these points and the low correlations between marbling and tenderness, it may be inferred that because some marbling may be desirable (numerous papers) moderately abundant to extremely abundant amounts may not necessarily make the product superior. Perhaps a more realistic evaluation of marbling within youthful animals and over the marbling range which seems advantageous, as long as beef can be guaranteed a quality item would be to the betterment of the entire industry. Research in this area should be emphasized.

Additionally, Blumer (3) in a review of studies involving 2,600 cattle found a range from 1 to 36% of the variations in the tenderness attributable to marbling. These relationships are not as high as would be desired considering the emphasis given marbling in determining grade.

In favor of marbling: There are several points in favor of marbling.

1. Marbling is visible to the consumer's eye, she can use it as a guide to reduce the risk of obtaining an undesirable product.

2. It is the only feature of muscle which can on the basis of existing research data, be subjectively evaluated on a scale form.

3. Although correlations between marbling and palatability are not high, they are positive almost without exception.
4. Considering (a) the difficulties in subjectively scoring for a particular degree of marbling and (b) the fact that marbling varies throughout the area being tested, and (c) the difficulties in obtaining acceptable palatability evaluations, perhaps positive correlations of .2 - .4 between marbling and palatability are not extremely low after all.

It should be re-emphasized as stated by Doty (28) that meat quality probably depends on too many factors to be highly correlated with any one single measure. In other words, when thought is given to all the variables that influence palatability and its estimation, perhaps we are not being realistic to even expect a high correlation between marbling and palatability.

4. Influence of maturity on eating quality: It is quite obvious (Bray, 8) that before proper evaluations of carcass maturity can be made, objective techniques must be developed. This is especially evident in view of the work of Lewis et al. (Unpublished, University of Wisconsin) who shows carcass maturity estimations to be more highly correlated with chronological age in some breeds than in others. If this difference is reproducible it may mean (1) that some cattle breeds are unknowingly being discriminated against or (2) that carcasses of certain breeds do actually mature faster or reach a more advanced stage of physiological maturity than others. However, in all cases the carcasses were definitely considered youthful. Walter et al. (62) found no significant difference in tenderness between A and B maturity ribs within many marbling classifications. Tuma (1963 unpublished data, South Dakota State) noted no significant difference in tenderness between the youthful maturity classifications although B maturity was most flavorful. Chronological age was positively correlated with tenderness (.23) (older more tender) in a large study by Alsmeyer (1) indicating that within the range of 5 to 30 months of age tenderness actually increased with advancing maturity. Lewis et al. (Unpublished data, University of Wisconsin), in a study of essentially A and B maturity cattle ranging in age from 13 to 26 months noted that tenderness increased with advancing age (.45 ). At older ages including cattle 3 1/2 to 4 years of age, it has been shown by numerous workers Blumer (3); Tuma et al., (60); Henrickson, (36, 37) and Hiner et al., (38) that tenderness decreases with advancing age. Henrickson et al. (36, 37) and Tuma et al. (60) showed that 42-month old cattle were less tender than 18-month old cattle.

D=SUMMARY

In summary, one can realistically state that the beef industry must maintain its image by producing a quality product. For the betterment of the beef industry, this image must be maintained at all costs. When beef quality is evaluated, marbling and maturity are the two properties which vary most widely and discernibly. The relationship of marbling score to ether extractable material (chemical fat) is lower at the higher marbling levels. Likewise the relationship between carcass maturity and chronological age and the importance of this maturity over the A and B range is rather limited. Marbling when considered by a specific degree is, as a single measure, poorly correlated with palatability even though, over broad limits, it can provide some assurance of satisfaction. This does not mean that Choice has to be better than Good (they may both be superior) it merely means that the risk of obtaining an undesirable product is lower in the Choice grade.
In further elaboration let us state that if the livestock producer is to continue improvement, it seems imperative that he should gear his production toward an acceptable degree of quality. This was not initially done in the pork industry when they changed type, and it has now reached devastating proportions. Pork muscle quality is being questioned by the processor, retailer and consumer and consequently reflects a direct merchandising disadvantage to the producer.

Consideration should be given to the need for continued revision and updating of standards as research results become available. This would promote the efforts to make the standards even more effective. While one should take note of the point made by Pierce (54) in 1959, that little could be gained by rejuggling the boundaries, the data which have emerged since 1959, make it imperative that the emphasis given marbling and maturity in the establishment of these boundaries be re-evaluated.

Marbling, at best, has by itself only a low correlation with palatability, and the correlations within and the differences between average to top Good and average Choice are especially low. Additionally, no differences have been reported in the palatability of muscle from A and B maturity carcasses of similar grade. Consequently, in view of these facts which are becoming more completely established each year, it would seem that a few alterations in the use of marbling and maturity in establishing grade standards might be suggested for study and consideration. These alterations might serve an interim period while a massive highly organized program would be developed to more thoroughly study basic beef muscle properties.

The following two areas are suggested for consideration: (1) Marbling classification be regrouped into more general categories. (2) Today's A and B maturity be combined into an A (9-27 mo.) maturity classification, the present C maturity renamed B (27-36).

This would provide for a more workable and readily definable system based on principles established from research data.

While other possibilities such as general reduction in marbling requirement may be considered, justification is not as simple as with the above mentioned suggestion. Differentiation between A and B maturities is extremely difficult and there is no evidence to clearly support the fact that they should be separated. Likewise there is no evidence to support maturities in Prime covering different ranges than in Good or Choice. Therefore it is recommended that consideration be given to combining A and B maturities into a new A and converting C to a new B. This modification would reduce the risk of penalizing the young cattle which may have been classified B or B- and therefore failed to make the Choice grade. This would hold the requirement for the Choice grade to a "small" amount of marbling. This point should receive extensive immediate research. It would also appear that improvements could be made in reducing the number of marbling classifications. This would be a logical move since the correlations between the various narrow degrees of marbling and palatability are not high and since broader ranges would provide general areas of
acceptability and make the standards more realistic, more effective, and more workable.

These suggested alterations, even if favored, would not serve the final answer. In fact, it should be reiterated and stressed that this may not be the answer at all. It instead would only offer hope for utilizing existing research information more effectively to bring about a more realistic use of quality standards based on present quality knowledge. The final answer should and will come from research as it develops and the standards should be continually molded until the day when research and research alone has provided indisputable criteria to use in the objective evaluation of beef quality.
<table>
<thead>
<tr>
<th>Grade</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Choice</td>
<td>9 - 20</td>
<td>20 - 31</td>
<td>31 - 42</td>
</tr>
<tr>
<td>Good</td>
<td>9 - 22</td>
<td>22 - 35</td>
<td>35 - 48</td>
</tr>
<tr>
<td>Standard &amp; Good</td>
<td>9 - 18</td>
<td>18 - 27</td>
<td>27 - 36</td>
</tr>
<tr>
<td>Grade</td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 - 27</td>
<td>27 - 36</td>
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</tr>
<tr>
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<td>9 - 27</td>
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</tr>
<tr>
<td>Good</td>
<td>9 - 27</td>
<td>27 - 36</td>
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</tr>
<tr>
<td>Standard</td>
<td>9 - 27</td>
<td>27 - 36</td>
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</tbody>
</table>
REFERENCES


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DR. KING: Thank you, Bob, for a very fine, comprehensive presentation, and if you haven't seen this report I assure you it is very comprehensive and very complete. Our next topic, The Effects of Sex Differences in Beef Carcasses Relative to Cutability and Palatability, was originally scheduled for one of the minor league boys to make this presentation and due to a conflict in scheduling my friend Frank Orts was unable to attend this conference but did ask to be remembered to his friends. We called upon an old pro that we knew we could depend upon at the last minute to make this presentation for us. At this time I would like to present to you Dr. Vern Cahill of Ohio State University.

# # # # # # # # # # # #