APPLICATION OF RESEARCH TO MEAT JUDGING ACTIVITIES -- IDENTIFICATION OF QUALITY AND QUANTITY DIFFERENCES

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Before searching the literature on this subject, I questioned several of my colleagues on possible changes which might occur in judging contests. Their immediate response was that both lamb and pork carcasses would be ribbed in future contests, or that at least some cut surface of the muscle would be visible. Perhaps because of this, I have spent the bulk of my effort to resolving differences of opinion that might result therefrom, so we can be reasonably well informed in facing such new problems. Little effort was spent in reviewing subject matter areas where judges have apparently arrived at a concensus.

Lamb Carcass Evaluation

Cutability

Carcass conformation as currently evaluated is directly related to % fat trim and carcasses with a "more desirable" conformation have a lower % of retail trimmed cuts. Hoke (1961) when combining information on all grades found negative relationship (r = -.324**) between carcass conformation grade and % edible meat from the 4 major cuts. When considering this on a within grade basis, he found that conformation was related to % edible portion in the Good (r = 0.430**) and combined Utility and Cull groups (r = 0.676**) where finish contributed little to the visual impression of carcass shape. However, the correlation coefficient was 0.227 in Prime and 0.097 in the Choice group where finish determined a substantial part of the overall impression of carcass conformation.

Spurlock and Bradford (1963) used the California conformation score (25 grades) and found correlation coefficients of -.43* and -.26 n.s. to % trimmed cuts in 2 groups of carcasses and 0.38** to % fat. Melton and others (1968), using 72 lamb carcasses reported conformation score to have correlations of -.27* to trimmed 4 major cuts, 0.32** to % carcass fat trim and -.04 to % loin of carcass.

Field and Riley (1968) stated that questionable measures of muscle or retail yield such as conformation score or rib eye area seldom improve accuracy of equations for estimating composition. A critical look needs to be taken at conformation appraisal so as to improve it. Hines and Thornton (1962) summarized data from 1138 lambs and reported correlations of various factors to weights of trimmed leg, loin, rack and shoulder: body width 0.76**, leg circumference 0.54** body depth 0.46** and loin width 0.64**. However, this data was collected from carcasses with a wide range of weight. Since measured fat thickness also had a positive relationship of 0.42** to trimmed 4 major cuts, this casts doubt as to whether the cuts were actually trimmed.

Cunningham et al. (1967) reported correlation coefficients of various measurements to % retail leg-loin-rack-shoulder and to retail value, respectively, as follows: width of legs -.10 and 0.24, circumference of thighs 0.15 and 0.21*, and shoulder width -.26** and -.22**. Depth of thorax had a correlation coefficient of -.13 with retail value. Spurlock and Bradford (1965) reported that the relationship of leg width to carcass length ratio with % trimmed legs of carcass weight was -.38* and -.48* in two groups of carcasses and 0.29 to carcass fat composition.

It seems likely that carcass thickness and blockiness have been overemphasized, especially in carcass grading. Uniformity of thickness also has been overemphasized since musculature is not of uniform thickness through all areas of the carcass. Although there is no research to substantiate this statement, it would seem logical that uniform thickness indicates greater fat deposition over the loin and rack and nothing more.

The desirability of thickness in relation to length should be questioned as one convenient means of achieving this is to shorten the carcass. A limited amount of information is available on effect of carcass length and leg length. Cunningham et al. (1967) found length of body to have a low, but significant relationship to % retail trimmed leg-loin-rack-shoulder (r = 0.20*) and to retail value (r = 0.22*). They indirectly measured shortness of shank by measuring distance from crotch to tuber calcis and found a correlation of -.20* to retail value. Considerable effort is currently being spent on the relationship of leg conformation to carcass retail yield. It seems likely that this factor will be used in lamb carcass yield grading. Melton et al. (1968) give correlations of leg conformation score and measured length of leg to % trimmed leg-loin-rack-shoulder (r = 0.26* and 0.14), to % carcass fat trim (r = -.19 and -.15) and to % loin of carcass (r = 0.03 and -.27*). While length of leg shows poor correlations to retail yield or fat trim, an enlightened appraisal of leg conformation tends to be positively related to retail yield.

Many people have appraised rib eye area as a predictor of carcass retail yield. Carpenter et al. (1963) found correlations of 0.14, 0.13 and 0.15 between rib eye area and carcass value, % retail leg-loin-rack-shoulder, and % retail leg-loin. When this was converted to a rib eye area per cwt. carcass basis the correlations improved to 0.36, 0.35 and 0.40, respectively. Cunningham et al. (1967) calculated correlations of 0.04 and 0.33** between rib eye area and % retail leg-loin-rack-shoulder and retail value, respectively. Zinn (1961) found correlations of rib eye area to retail trimmed leg-loin-rack to be 0.08 for 21 rams, 0.28 for 50 wethers and 0.13 for 48 ewes. Melton et al. (1968) compared use of left and right *longissimus dorsi* area and determined correlation coefficients to be 0.05 and 0.01 to % trimmed 4 major cuts, -.09 and -.04 to % carcass fat trim and 0.09 and 0.13 to % loin of carcass. It seems that rib eye area is a poor predictor of carcass retail yield and only slightly better as a predictor of carcass value.

However, a major problem of the lamb industry is the high incidence of small rib eye muscles and improvement of this factor per se should be an important priority of the sheep industry.

Table 1

The Relationship of Various Lamb Carcass Fat Probes, Fat Measurements and Other Characteristics to Carcass Cut-Out from Four Trimmed Primals, % Fat Trim and % Trimmed Loin

Factor vs.	Simple Correlation Coefficients		
	% Trimmed LLRS	% Carcass fat trim	% Loin of Carcass
U.S.D.A. Conformation score	-.27*	0.32**	-.04
Leg Conformation Score	0.26*	-.19	0.03
Length of Leg, Inches	0.14	-.15	-.24*
U.S.D.A. Carcass Grade	-.34**	0.36**	-.10
Carcass Weight	-.30*	0.28*	-.16
L. dorsi Area, Left	0.05	-.09	0.09
L. dorsi Area, Right	0.01	-.04	0.13
Estimated % Kidney - Pelvic Fat	-.65**	0.56**	-.09
Carcass Fat Probes			
Body Wall, 12-13 rib, left	-.41**	0.49**	-.02
Body Wall, 12-13 rib, right	-.40**	0.46**	0.05
Over L. dorsi, 12-13 rib, left	-.30*	0.30	-.03
Over L. dorsi, 12-13 rib, right	-.19	0.23	0.02
5-6th rib probe, 5-6 in. from midline, left	-.66**	0.66**	-.16
5-6th rib probe, 5-6 in. from midline, right	-.66**	0.70**	-.18
Carcass Fat Measurements			
Body wall, left	-.73**	0.73**	-.25*
Body wall, right	-.77**	0.75**	-.24*
Over L. dorsi, left	-.61**	0.55**	-.14
Over L. dorsi, right	-.70**	0.63**	-.21
5-6th rib, left	-.52**	0.47**	-.16
5-6th rib, right	-.66**	0.57**	-.31*

Melton et al. (1968)

Amount of kidney and pelvic fat seems to be closely related to lamb cutability. Correlation coefficients of this factor to % retail trimmed cuts or edible portion from the 4 major cuts vary with -.54** reported by Carpenter et al. (1963), -.41** for ewes and -.48** for wethers reported by Judge and others (1966) and -.809** reported by Hoke (1961). This factor should definitely not be overlooked. Melton et al. (1968) reported a correlation coefficient of -.65** between estimated kidney and pelvic fat and % trimmed leg-loin-rack-shoulder.

King (1962) in the Safeway Stores Report stated that excessive fat was the major factor in reducing lamb consumer cut yields, and value return per cwt. carcass. Fat thickness was generally much more closely related to carcass cutability than was any indicator of muscle such as rib eye area. Zinn (1961) reported correlations of -.69** for rams, -.43** for wethers and -.53** for ewes. Hoke (1961) reported that visual finish grade had a correlation coefficient of -.653** to % edible portion from the 4 major cuts, whereas a single fat measurement over the middle of the eye had an r of -.816**. Carpenter et al. (1963) reported lower correlations with % retail leg-loin-rack-shoulder (fat-3 measures over rib eye, r = -.23), (fat, lower rib, r = -.05), (fat over eye plus lower rib, r = -.16). These measures were closely related to carcass value, however, with correlations of -.73, -.80 and -.79, respectively. Judge et al. (1966) reported correlations of fat thickness, 1 or 3 measurements, to % edible portion to range from -.60 to -.79.

Melton et al. (1968) used fat probes and related them to % trimmed leg-loin-rack-shoulder and % carcass fat trim (see table 1). The shoulder probe over the scapula, between the 5th and 6th rib, was most promising, that of the body wall intermediate in predictive value and that over the longissimus dorsi the least promising. Differences in relationships between left and right sides indicate that the probe over the rib eye was most difficult to achieve similar predictive values. Carcass fat measurements appeared to have a higher predictive value than the probes, except over the shoulder 5th-6th rib area. Fat measurements were calculated to be highly correlated with % trimmed 4 major cuts, with correlations ranging from -.52** to -.77**. It appears that external and internal fat should receive the most emphasis in determining carcass value.

Many prediction equations have been calculated for lamb cutability measurements, but they will not be discussed here. Lamb yield grading seems to be a logical step, with major emphasis given to finish and minor emphasis to muscle indicators such as rib eye and leg conformation.

If lamb carcasses are to be ribbed for future meat judging contests, an appraisal of rib eye area will have little value in predicting % edible portion, but the thickness of fat revealed by ribbing seems very important. However, rib eye area, per se, needs to be improved to increase saleability of lamb.

Lamb Quality

Perhaps we should critically evaluate each quality factor currently considered in U.S.D.A. lamb carcass grading. Maturity currently receives considerable emphasis since lamb carcasses are divided into young (A) or mature (B) lamb. In addition, ovine carcasses may be classed as yearlings or mutton. Criteria used are evidences of skeletal maturation and color of flesh, primarily that of primary and secondary flank muscles.

How closely is maturity related to such characteristics as flavor or tenderness? Weller et al. (1962) used 60 wether lambs (30 sets of twins) of Columbia breeding and randomly divided them into 6 groups. Three groups were slaughtered at constant individual pre-determined weights of

85, 110 and 135 pounds, whereas 3 other groups were slaughtered at ages of 150, 200 or 245 days. Leg roasts were prepared and sampled, but tenderness by subjective scores, chew count or shear value was not related to weight or age at slaughter. They reported roasts from animals over 6 months of age to be more mild in flavor than from younger lambs. Carpenter and King (1965) broiled rib chops from 259 ram, whether and ewe carcasses and found that as maturity score increased (more youthful indicated by a correlation of -.51 between age in days and maturity score), tenderness increased, as shown by a correlation coefficient of -.27 with shear force, and cooking loss decreased. Fresh muscle color score was not related to tenderness, but related to age in days, maturity score and cooking loss.

Cunningham et al. (1967) accumulated data from 99 lambs, including 20 rams, 34 wethers and 45 ewes of 7 diverse breed and crossbred groups. They found that slaughter age had a correlation coefficient of 0.68** to shear force value and 0.38** to % total cooking loss. Batcher et al. (1962) had previously stated that meat from rib-loin cuts became less tender as maturity increased when lambs ranging from 4 to 14 months of age were sampled.

Oliver and others (1967) used data from 90 wether, 112 ram and 135 ewe carcasses ranging in age from 119 to 304 days and in live weight from 35.4 to 56.2 kg. Rib chops were broiled and shear force value was correlated to other factors. Age in days in wethers, rams and ewes, respectively, showed correlations of 0.24*, -.04, and 0.16 to shear force value while U.S.D.A. maturity grade showed correlations of -.41**, -.22** and -.29**. This means that youthful lambs, as determined by maturity score tended to have more tender meat, but relationships were not high. Also color score for wethers, rams and ewes showed correlations of -.03, 0.01 and 0.23** to shear force value and use of color to predict tenderness seems to have no value. Kropf, et al. (1968) reported very low relationships of color of flank muscles and of the rib eye cross section to such end product quality evaluations as shear value, number of chews, tenderness score or juiciness score (see table 2).

However, it should be recognized that flesh color would affect saleability of product to the consumer and so possesses an intrinsic value of its own.

Quality factors such as feathering, flank fat streaking and carcass firmness have been used since they were believed to be associated with marbling. Results reported by Carpenter and King (1964b) would support this as feathering, flank fat streaking firmness, and rib eye marbling score showed correlation coefficients of 0.39, 0.47, 0.38 and 0.65 to % fat in the Longissimus dorsi. This study involved 259 lamb carcasses. However, Riley and Field (1967) report the following correlations of various carcass characteristics to marbling as follows: Maturity 0.15, thickness and firmness of flanks 0.18, flank fat streaking 0.23, feathering 0.26, conformation grade 0.20, final grade 0.35 and color of lean -.14. Their study involved 299 carcasses covering the full range of the Choice and Prime grades.

Kropf et al (1968) found that feathering score showed correlations of 0.23** and 0.22**, overflow fat 0.11 and 0.10, flank streaking in primary flank 0.20** and 0.19**, and flank streakings in the secondary flank 0.23** and 0.19**, with marbling score and % fat in the rib eye muscle. Marbling score was highly significantly correlated to % fat in the rib eye

(r = -.55). This study included 379 lamb carcasses. However, Kropf et al. (1968) found that these quality indicators per se were not strongly related to cooked characteristics of loin roasts such as shear value, tenderness score, number of chews or juiciness score (see table 2).

Carpenter et al (1964) reported correlation coefficients of Warner-Bratzler shear value of broiled rib chops to the following factors: fat trim without kidney and pelvic fat -.18*, % kidney and pelvic fat -.05, feathering score -.24**, flank fat streaking score -.15, flank firmness score -.10 and loin eye area -.29**. This data was collected from 169 wether carcasses of 4 different breed groups. Riley and Field (1967), using 299 lambs ranging from low Choice to high Prime reported the following correlations of various quality indicators to Warner Bratzler shear force value of broiled chops: maturity -.22, thickness and firmness of flanks -.08, flank fat streaking -.09, feathering -.15, conformation grade -.12, final grade -.06, and lean color 0.08. One can conclude that the subjective quality factors had very little effect on shear value. The authors stated that selection for trim, muscular carcasses did not adversely affect tenderness.

The current use of thickness and firmness of flanks should be critically reviewed as increases in firmness are often due to increasing quantities of fat. Melton et al. (1968) found that flank firmness had the strongest negative relationship to % trimmed leg, loin, rack and shoulder (r = -.57) and positive relationship to % fat trim (r = 0.51) of any quality

Table 2

Correlation Coefficients of Certain Subjective and Objective Measures with Cooked Lamb Loin Roast Characteristics, Marbling Score and Rib Eye Fat Content

	Shear Force Value	No. of Chews	Tenderness Score	Juiciness Score	Marbling Score	% Fat L. dorsi
Feathering Score	0.02	-.04	0.02	0.10	0.23**	0.22**
% Fat, Intercostal Muscle	0.03	0.02	0.24	0.08	0.22n.s.	0.32**
Fat Streaking Score, Primary flank	0.11*	-.01	-.04	0.15*	0.20**	0.19**
Fat Streak Score, Other flank muscles	0.04	0.04	0.00	0.08	0.23**	0.19**
Marbling Score, Rib-Eye	-.14*	0.21**	0.24**	0.20**	---	0.55**
% Fat, L. dorsi	-.14*	-.23**	0.22**	0.28**	0.55**	---
U.S.D.A. Carcass grade	0.03	0.10	0.05	0.18**	0.26**	0.29**
Color Score, Flank Muscles	0.06	-.04	0.10	0.00	0.08	0.03
Color Score, L. dorsi	-.12*	-.10	0.06	0.06	0.11	-.07

Kropf. et al. (1968)

indicator. Hankins (1947) reported that % fat in the breast had a correlation coefficient of 0.94 with % fat in the whole lamb carcass. Perhaps, we could also look at beef carcass information. Hankins and Howe (1946) found that fatness of flank was more highly related (r = -0.95) to fatness of the entire carcass than that of the often used 9-10-11 rib cut. Hedrick et al (1963) found that % fat in the beef flank was significantly and negatively associated with % trimmed wholesale cuts (r = -.86) and % 4 trimmed primals (r = -.80). Miller et al (1965) also reported % retail yield of the flank was significantly related to % boneless retail cuts (r = 0.78) or partially boneless retail cuts (r = 0.81).

Because of the high probability that current emphasis on increasing levels of flank firmness actually upgrade carcasses with poorer cutability without any real improvement of eating quality, it is suggested that a common minimum level of flank firmness be required for the Choice and Prime grade and then no further emphasis be given to this factor. Perhaps the "slightly full and firm" degree of firmness would serve as this minimum level.

Considerable work has been devoted to the effect of lamb carcass marbling on tenderness (or shear value) and other sensory attributes. Cover et al. (1944) reported no relationship between lamb fatness and tenderness. Correlation coefficients between marbling score and shear value were -.252 non significant (Stouffer et al. 1958), -.03 (Carpenter et al. 1964), -.196, -.189 and -.221 when cooked by oven broiling, microwave oven and deep fat frying (Carpenter and King, 1964a); 0.06 for wethers, -.03 for rams and -.14 for ewes (Oliver et al. 1967) 0.07 (Cunningham et al., 1967) and -.14** (Kropf et al., 1968). Relationships between longissimus dorsi fat and shear value were -.16 for wethers, -.07 for rams and -.07 for ewes (Oliver et al., 1967); -.282 and -.235 for microwave oven preparation and deep fat frying (Carpenter and King, 1965a) -.09 (Carpenter and King, 1965b) and -.14* (Kropf et al., 1968). Additional relationships are presented in Table 2. Although some studies found significant relationships, none are high enough to conclude that marbling has an important effect on lamb tenderness. Marbling appears to have a slight effect on sensory appraisal of juiciness and also on chew count and tenderness score.

Batcher and others (1962) used a total of 102 lamb carcasses and stated that intramuscular fat did not affect tenderness, juiciness or flavor. However, cooked loin chops with a cooked fat content of 2 to 3.9% tended to have a lower taste panel score and a higher Kramer shear force value than those with a higher fat content. Kropf et al. (1968) also grouped results by sex and by visual marbling score of the rib eye muscle. Tenderness was evaluated as mean taste panel score (based on 7 point scale) and Warner Bratzler shear force value of 1/2 inch cooked cores (see tables 3 & 4). Marbling score appeared to have little effect on either sensory tenderness or on shear force value.

If lamb carcasses should be ribbed for carcass judging in future meat contests, it would seem desirable that our minimum marbling requirements not be set too high. Research data suggest that "traces" to "slight" degrees of rib eye marbling be set as our minimum quality level. The color requirement should be to avoid extremes which might detract from show case appearance of lamb cuts. For both lamb carcass judging and grading, a common minimum level of flank firmness for Prime and Choice Grades should be set at "slightly full and firm" and then no further emphasis should be given to this factor in improving the quality grade.

Table 3
Subjective Tenderness Scores* for
Lamb Longissimus Marbling Score Groups
(No. of Carcasses and Mean Score)

Marbling Score	Ram	Wether	Ewe
Prac. Devoid	1 - 5.4	0	0
Traces	12 - 5.3	4 - 5.6	5 - 5.5
Slight	18 - 5.4	10 - 5.5	8 - 5.5
Small	17 - 4.9	13 - 5.4	28 - 5.5
Modest	9 - 4.9	13 - 5.5	47 - 5.6
Moderate	1 - 3.5	6 - 5.4	19 - 5.8
Sl. Abundant	0	1 - 5.3	3 - 5.8
Mod. Abundant	0	0	1 - 5.7

*7 = Very tender, 1 = extremely tough

Kropf et al. (1968)

Table 4

Warner-Bratzler Shear Force Values* for
Lamb Marbling Score Groups
(No. of Carcasses and Mean Shear Force)

Marbling Score	Ram	Wether	Ewe
Prac. Devoid	1 - 8.7	0	0
Traces	12 - 8.5	4 - 6.9	5 - 7.4
Slight	18 - 8.0	10 - 7.6	8 - 7.4
Small	17 - 9.0	13 - 8.0	30 - 8.1
Modest	9 - 8.4	13 - 7.1	47 - 7.7
Moderate	1 -14.6	6 - 8.1	19 - 6.2
Sl. Abundant	0	1 - 7.8	3 - 8.0
Mod. Abundant	0	0	1 - 7.4

* lbs. for 1/2 inch L. dorsi core, Roasted Loin.

Kropf et al. (1968)

Pork Carcass Evaluation

Carcass Composition

No purpose can be served by spending much time on the pork carcass length controversy. Length appears to have a very weak relationship with carcass value and the reasons for consideration of a minimum length requirement are its possible relationship to reproductive performance and secondly, a wish to avoid any tendency toward extremely short carcasses, which might later be difficult to reverse.

Again, backfat or finish seems most important in its effect on carcass cut-out. However, certain muscling factors have been studied to determine their predictive value of carcass cut-out.

Lumbar lean depth and area, as well as chine bone depth have been studied. Kauffman et al. (1959) used 304 pork carcasses and after adjusting for carcass weight differences, calculated correlations of 0.361 and 0.474 between lumbar lean depth and area versus loin eye area and of 0.544 between lumbar lean depth and lean cut yield Pearson and others (1959) used 142 carcasses and tested the relationship between several lumbar lean measurements and either % lean cuts or loin eye area. The following correlations were calculated with the above 2 factors: area of outer lumbar muscle 0.18 and 0.21, depth of outer lumbar muscle -.02 and 0.02, depth of inner lumbar muscle 0.44 and 0.53 and depth of both muscles combined 0.42 and 0.59. Pearson and co-worker (1959) also tested the predictive value of total lumbar lean depth within more narrowly defined carcass weight groups of 120-139, 140-159, and 160-179 pounds; and reported correlations of 0.57, 0.57 and 0.26 with % lean cuts and of 0.57, 0.52 and 0.31 with loin eye area. Kropf (1962) compared vertebral chine bone measurements at the 1st, 7th and last rib locations and lumbar lean depth at the last lumbar vertebra and found that the two most anterior of these measurements were very poor predictors of loin eye area, % lean cuts or carcass specific gravity. The last rib and last lumbar depths had correlations of 0.28** and 0.40** to loin eye area, 0.39** and 0.35** to % lean cuts and 0.18 n.s. and 0.38** to carcass specific gravity. A combination of all 4 depth measurements showed correlations of 0.24*, 0.40**, and 0.32** to loin eye area, % lean cuts and carcass specific gravity.

Pearson et al. (1959) also tested the predictive value of lumbar lean plus fat to lumbar lean ratio within the above stated carcass weight groups and calculated correlations of -.68, -.76 and -.59 to % lean cuts and of -.60, -.57 and -.37 to loin eye area. They conclude that use of lumbar lean measurements had little advantage over use of backfat alone.

No literature was found regarding the predictive value of lumbar lean depth or other measures of muscling with the effects of carcass backfat statistically removed. The above reports indicate that lumbar lean and more posterior chine bone depth measurements have a positive but somewhat limited predictive value of carcass muscling.

Recent information does not seem to be available on what linear ham measurements may be related to carcass cut-out. Kropf (1962) reports that length of hind leg had correlations of 0.17, 0.53** and 0.28** to loin

eye area, % lean cuts and carcass specific gravity. This would tend to support the view that length through the center section of the ham is related to carcass value, but a direct and repeatable measurement of this center length is difficult.

Many research reports deal with the effect of pork loin eye area to carcass composition. Kline and Hazel (1955) report correlations of 0.65 to 0.67 when relating loin eye area at the 10th and last ribs with % lean cuts and of 0.69 to 0.74 when related these area measurements to % loin. Bowman et al. found loin eye area correlations of 0.43 to % carcass lean and of 0.36 to % carcass protein. Kropf (1962) calculated correlations of 0.227* and 0.298** between loin eye area at the 10th and 13th thoracic vertebral locations and carcass specific gravity. Multiplying these area measurements by carcass length improved these correlations slightly to 0.313** and 0.366**. Kline and Goll (1964) report loin eye area to be related (r = 0.71**) to % ham plus loin. Topel et al. (1965) calculated correlations of 0.54** and 0.64** between % lean cuts and longissimus dorsi area at the 10th and last rib locations, respectively, Christian et al. reported loin eye area at the 10th rib to be correlated to % skinned ham (r = 0.66), % lean cuts (r = 0.69), % separable lean in ham (r = 0.70), carcass composite moisture or protein (r in both cases = 0.64) and carcass fat content (r = -.64). The above results are generally encouraging and it seems that exposing the pork loin eye muscle should lead to more accurate carcass appraisal in meat judging contests.

The total appraisal of fat and lean in a pork loin cross section should be used if pork carcasses were "ribbed". Pearson et al. (1956), found that fat to lean ratio of the loin - fatback at a location posterior to the last rib had correlations of -.60 to % lean cuts and of -.59 to carcass specific gravity. Bowman et al (1962) found that the proportion of muscle in the loin-fatback cross section posterior to the 10th and last ribs had correlation coefficients of 0.85 and 0.77 to % lean in carcass or of 0.78 and 0.74 to % protein in the carcass.

Pork Quality

Relationships between loin eye marbling score and sensory tenderness are shown by correlations of -.07 (Judge et al., 1960), 0.86** (Batcher and Dawson, 1960) and 0.37 (Henry et al., 1963). Percent fat in the longissimus dorsi showed correlations of 0.58** in 29 gilt carcasses and 0.25 in 25 barrow carcasses by Kauffman (1960) and 0.44** (Kauffman 1964). Kauffman (1960) reported a fairly high relationship of % fat to number of chews (r = -.62** and -.41*). Relationships of % fat to shear force value were shown by correlations of -.58** and -.41* by Kauffman (1960) and -.35** in a later study by Kauffman. Marbling score or % fat had a varying relationship with flavor (r = 0.13, Judge et al., 1960) (0.48** and 0.17, Kauffman, 1960) (r = 0.23, Henry et al., 1963) (r = 0.38**, Kauffman et al., 1964). The relationship to juiciness was more pronounced (r - 40**, Judge et al. 1960) (r = 0.91**, Batcher and Dawson, 1960) (r = 0.82** and 0.54**, Kauffman 1960), (r = 0.70** Kauffman, 1964), except for the report of Henry et al. (1963) who observed a non significant relationship.

Batcher and Dawson (1960) indicated that marbling was less closely related to cooked characteristics in hams than in loin chops. Carpenter

(1961) related that increased % fat in fresh pork ham to about 26% (MFB) improved composite palatability score (total of scores for tenderness, juiciness and flavor), but marbling had much less effect on score of cured hams. Carpenter set up an arbitrary acceptance-rejection level at a composite palatability score of 10.5 and found that loin eye fat levels of about 22% (MFB) resulted in acceptable scores. This level of fat was slightly above that in the marbling score of 3, as defined by Wisconsin Special Bulletin #9. Later Bray (1966) concluded that marbling effects palatability of fresh more than cured pork. Marbling in pork chops is more highly associated with juiciness than with tenderness, and "eatability" of chops is affected more by marbling than is "eatability" of roasts. With baked chops, panel scores generally increased with each increase in marbling score but a score of three seemed to be acceptable for tenderness, juiciness and flavor and the score of two seemed to be a borderline acceptable case. Cuts with marbling scores of one were inferior in quality.

Kauffman (1960) found that consumers failed to select marbled chops over lean chops in a test involving actual purchase of meat. Only 29% purchased marbled chops and if the price of marbled chops in relation to lean chops was lowered by 4¢, 8¢ and 12¢, this percentage increased to about 51, 53 and 73. In home taste tests, 62% preferred cooked marbled chops and 18% preferred cooked lean chops.

Kropf (1962) scored pork longissimus dorsi marbling at eight anatomical locations within the loin and found that marbling score at the 10th and 13th thoracic vertebral locations had correlation coefficients of 0.929** and 0.933** to the total score at all 8 locations. Thus a marbling evaluation at these locations was a good predictor of marbling in the entire longissimus muscle.

Eisenhut et al. (1965) hinted that bovine marbling may be coarser where more severe muscle contraction has occurred, due to formation of larger fat globules. Bray (1966) also suggested that the kind or rate of post mortem change in muscle influences visibility of marbling. If Eisenhuts findings also carry significance in pork, we should be critical of coarse marbling.

Judge et al. (1960) found that color score (3 point scale) had a low relationship with tenderness ($r = -.30^*$) but non significant relationships with juiciness and flavor. Carpenter (1961) compared 8 light colored loins with 8 dark colored loins and found no effect on tenderness, although the dark group was higher in juiciness. He also reported color to have correlations of 0.51** and 0.23 to juiciness in light and heavy weight carcasses.

It seems that a certain minimal marbling level is important in pork quality, although it also seems possible that pork muscle can have too much marbling.

Some research has been directed toward the goal of predicting marbling in pork muscle. Kauffman, (1950) reported correlations between feathering - overflow score and loin marbling ($r = 0.26^{**}$ in 508 carcasses) and ham marbling ($r = 0.32^{**}$ in 114 carcasses). Allen and Bray (1964) used 24 barrows and 24 gilts, all Yorkshires and concluded that feathering -

overflow score is of little value in predicting loin eye marbling score (r = 0.17 and 0.44*) or % fat (r = 0.03 and 0.17) on a moisture free basis. Marbling score of the diaphragm (r = 0.71**, 0.60**, 0.62** and 0.75**) and lumbar muscles (r = 0.46*, 0.52**, 0.42* and 0.67**) provided the most valid estimates of loin eye marbling score or % fat and the brisket muscle fat content proved of little value in predicting marbling score. Kauffman (1960) reported encouragingly high correlations between lumbar lean marbling score and % fat in the loin eye muscle (r = 0.86** in gilts, 0.52** in barrows, 0.71** in combined gilts and barrows, and 0.18 n.s. in a group of 32 carcasses with a narrow range in fat %). Quality in selected muscle areas in the intact side of pork can give indications of muscle quality. However, if possible, a loin eye cross section should be exposed both for the purpose of determining the quality level and the lean to fat ratio.

Beef Carcass and Wholesale Cut Evaluation

Beef Composition

Many research reports have dealt with the relationship of conformation grade to carcass cut-out. Pierce (1957) found that when carcass weight and finish grade were held constant, conformation grade showed a correlation coefficient of -.1202** with closely trimmed retail cuts from the 4 major cuts. Murphey et al. (1960) concluded that finish was 4 1/2 times as important as conformation score in predicting yield of closely trimmed, mostly bone-in retail cuts from the 4 primal cuts. Goll et al. (1961) also stated "Some of the analyses involving yields in this study indicate that finish exerts more influence on yields of wholesale cuts than conformation." Zinn et al. (1961) reported correlation coefficients of -.50 and 0.69, respectively between carcass cut-out and carcass % fat trim and conformation score. Breidenstein reported no significant relationship between conformation and retail cut yield in steer carcasses ranging from 500-700 lbs. and grading Good and Choice. In heifer carcasses ranging from 500-650 lbs. an increase of 1/3 conformation grade increased cutability by 0.34%. The Bray-Briskey report (1964) concluded that conformation effects on trimmed retail yield are less than those of external fat thickness or of internal fat deposits. Hedrick et al. (1963) concluded that it is difficult for superior muscling development to compensate for excess fat deposition. However, Tyler et al. (1964) state that "at the same fat thickness, thickly muscled, high conformation cattle will have higher cutability than thinly muscled cattle". Stringer and fellow workers (1965) compared effect of Average Good and Average Choice conformation when finish and weight were equal within these conformation groups. They report no significant difference in yield of boneless, closely trimmed retail cuts from the round, loin, rib and chuck. Pearson (1966) concluded from previously reported research that beef and dairy cattle finished with the same type of ration, under similar environments with the same length of feeding period had similar cut-outs.

Allen (1966) attempted to appraise beef carcass conformation in such a way as to eliminate fat effects and appraise true muscling effects. However, his carcass conformation scores showed correlations of -.12 and -.23 to pounds and & boneless trimmed cuts from the round, loin, rib and chuck. Similar appraisals of hindquarter conformation showed correlations of -.07 and -.17 to the same factors and similar values for round conformation were r = -.09 and -.14.

Brackelsberg and Willham (1968) found that carcass conformation had correlations of -.11 with % muscle in the carcass and 0.19 with % fat trim. Abraham et al (1968) used 835 steers of diverse breed groups with a wide variation in slaughter weight and reported that conformation had correlation coefficients of 0.46 to weight and -.44 to % boneless cuts from boneless cuts of the 4 primals.

Martin et al. (1966) used 10 carcasses of low Choice conformation and 10 with Average Standard Conformation which were paired on basis of similar carcass weight, longissimus dorsi area and fat thickness. Muscle cuts were classified as thick or thin. Thick muscles of the hindquarter were those at least 5.1 c.m. thick and included strip loin, tenderloin, top sirloin, knuckle, top round, bottom round and eye of round. Rib and chuck muscles were classed as thick if they were at least 7.6 cm. thick. All cuts were uniformly trimmed. Choice conformation carcasses had 0.93%* more yield of thick muscles, 0.82%* less yield of thin muscles and no difference in total muscle yield. Choice had 2.60%* more fat and 2.72%* less bone. On a fat adjusted basis, the Choice conformation carcasses had 1.71%* more muscle. Choice had more top sirloin* and bottom round**, whereas Standard had longer, wider thinner muscles. The interesting part of Martins results is that it deals not only with total quantity of muscle, but with how useful the muscle is for more expensive cuts.

Dikeman (1968) also attempted to evaluate beef carcass conformation in such a way as to subtract fat effects. When he combined two weight groups and calculated correlations of conformation score to pounds and % retail yield of the round-loin-rib-chuck and also pounds and % of total fat trim, values were 0.19, 0.11, 0.08 and 0.01, respectively. Hindquarter conformation score gave correlations of 0.21, 0.14, 0.05 and -.03 and round conformation values of 0.21, 0.17, 0.02 and -.06, when correlated with the same factors. The fact that most of his correlations were positive, even if low, means that a more accurate appraisal of muscling can be made.

To accurately appraise muscling, fat effects should be carefully substracted and such out-moded concepts as blockiness, shortness, straightness of side and depth of side should be discarded.

Several studies have evaluated effects of carcass length. Cole et al. (1960b) used 99 carcasses from cattle with a wide variation in type and considerable variation in carcass weight. Carcass length had a highly significant correlation (r = .39**) with carcass separable lean, which was a closer association with separable lean than shown by round width, chuck width or body depth. Linear measurements were more closely related to carcass weight than to % of physically separable components. When they multiplied average rib eye area of measurements at the 5th rib, 12th rib and last lumbar vertebrae times carcass length, this value had a correlation of 0.75 to weight of separable carcass lean. Hedrick et al. (1963) report correlations of -.10 to % retail yield from the round-loin-rib-chuck and of 0.60** to the weight of this retail yield. Du Bose et al. (1967) reported a correlation of carcass length of 0.88** to weight of retail yield from the 4 primal cuts. This was reduced to 0.35 with carcass weight held constant. Abraham reported values of 0.82 and -.23 when correlating carcass length to weight and % of boneless cuts from the 4 primals. Dikeman (1968) gave correlations of 0.88 and 0.10 to weight and % of retail yield of the 4

primals when combining 2 weight groups. When calculations were made within weight groups of 500-550 pounds and 700-750 pounds, correlations were 0.64 and 0.58 to weight and 0.54 and 0.58 to % of retail yield. It appears that length of carcass should be considered as desirable characteristic, especially if this length is in the muscular and high priced parts of the round as well as in the loin and rib.

Abraham et al (1968) state that body length, round width and round length were highly correlated with most traits affected by carcass weight, but when carcass weight was held constant, only round width was significantly related to the yield of boneless steak and roast meat. They suggested that different factors may need to be considered in predicting cutability for different breed groups.

Birkett (1963) took various carcass measurements and related them to % and pounds of trimmed 4 primals, trimmed loin and trimmed round. Results are presented in Table 5. Carcass rump length and loin length were associated with yield of trimmed 4 primals and trimmed loin. Round circumference at 40% of the distance from the shank end, round length and forearm circumference were related to yield of trimmed 4 primals and trimmed round, whereas the round circumference measurement at the 50% location was related only to the round yield. Perhaps fat collar was being measured in the 50% measurement, thereby reducing its predictive value. Rib eye area was not related to the yields considered here.

Ahlschwede (1965) found a slight tendency for round circumference and length to be related to carcass cut-out at earlier stages of development, prior to deposition of much exterior finish. Carcass length or a series of round circumference measurements at 40, 50, 55, 60, 70, 75% of round length were not consistently related to yield of any section of the round, except some circumference measurements tended to be related to pounds of top round yield. Allen (1966) when combining weight groups found round length to have correlations of 0.83 and 0.02 to weight and % of boned retail cuts from the round-loin-rib-chuck whereas round circumference had correlations to these two factors, of 0.56 and -.40. Evidently his round circumference measurement also included some of the round fat collar. Dikeman (1968) found highly encouraging relationships between round length and lbs. ($r = 0.68$ and 0.57) and % ($r = 0.64$ and 0.52) of retail cuts from the four primals. Round circumference measurements were not as encouraging with correlations of 0.07, -.04, -.03 and -.12, to the same factors. Considerable variation exists in results, but length measurements and round measurements (providing fat effects are subtracted) have some predictive value of carcass cut-out.

However, as considerable earlier research indicates, external finish and amount of kidney and pelvic fat have a greater effect on carcass edible portion than any currently used indicators of muscling.

With the encouraging accuracy and commercial potential of U.S.D.A. yield grades, it seems that yield grading of beef carcasses in meat judging contests is long overdue!!

Table 5

Partial Correlation Coefficients
(Weight Held Constant) of Various Bovine
Carcass Measurements to Various
Carcass Yields

	Trimmed 4 Primals		Trimmed Loin		Trimmed Round	
	%	lbs.	%	lbs.	%	lbs.
Carcass Rump Length	0.36*	0.37*	0.44*	0.44*	0.10	0.09
Carcass Loin Length	0.46**	0.49**	0.55**	0.54**	0.14	0.12
Carc. Round Circumference						
40%	0.43*	0.40*	0.00	0.01	0.72**	0.70**
50%	0.19	0.14	-.15	-.15	0.49**	0.46**
Forearm Circumference	0.45*	0.41*	0.16	0.14	0.52**	0.51**
Rib Eye Area	0.31	0.25	0.14	0.12	0.33	0.34
Round Length	0.48**	0.51**	0.33	0.33	0.43*	0.41*

Taken from Birkett (1963)

Beef Quality

Alsmeyer et al. (1959) in a study including wide ranges in maturity and marbling and a total of 16 sires within Brahman, Shorthorn, and Crossbred groups; found variability in taste panel tenderness to be associated with variability of the following factors: Breed of sire 13.6%, Sires within breed 14.3%, Carcass grade 11.5%, Age at slaughter 8.1% and Marbling Score 6.9%. The same figures for variability of these factors accounting for variability in shear tenderness are 5.4%, 12.2%, 20.2%, 6.3% and 12.4%.

In carcass or wholesale cut judging, grade can be evaluated and within grade, marbling effects and indirectly through carcass maturity age in days can be estimated.

Blumer (1963) summarized marbling effects until that time and found that 0.01 to 36% of variation in tenderness can be accounted for by marbling. He calculated a mean figure of 5%, pro-rated according to numbers of carcasses in each study represented. He also found that about 16% of the variation in juiciness score could be accounted for by Marbling variation. Walter et al. (1965) and Goll et al. (1965) compared rib steak samples of longissimus dorsi representing moderately abundant, slightly abundant, modest, slight, traces and devoid degrees of marbling and found no difference in

shear value, or in tenderness, flavor or juiciness scores. Romans et al. (1965) compared slight and moderate degrees of marbling and found no significant difference between marbling levels in shear force value, tenderness or flavor in rib steaks, but moderate degree of marbling resulted in more juicy steaks. Field et al. (1966) compared longissimus dorsi roasts of traces to moderate marbling level and of various ages at slaughter. In 84 steer and heifer carcasses, cuts with Moderate and Modest marbling were more tender than the small marbling group and were rated higher in flavor than all other marbling groups. In 134 bull carcasses, marbling did not affect shear force value, but roasts from the Moderate and Modest groups were rated higher on panel tenderness flavor and juiciness. Covington (1968) found steaks with a Moderate degree of marbling to have a lower shear force value than those with Small marbling. McBee and Wiles (1968) used 8 degrees of marbling ranging from Devoid to Slightly Abundant and state that shear value, tenderness score, juiciness score and flavor score improved with additional degrees of marbling in a direct, linear relationship.

Effects of beef maturity have been studied. Walter et al. (1965) and Goll et al. (1965) compared the then existing A, B and F maturity groups and found the F group to have higher average shear force values, lower tenderness scores and lower flavor intensity scores. Tenderness was compared with Warner-Bratzler shear values on broiled and deep-fat fried steaks and Kramer shear values on raw and broiled steaks. The A group tended to be more tender, but only the Kramer shear results on broiled steak were significant between the A and B groups. Romans et al. (1965) used 80 beef ribs representing the then existing A, B, C and D maturity groups and found no significant effect on Warner Bratzler shear force value of rib steaks, although the D maturity steaks tended to have higher shear values. The taste panel found steaks from the D group to be less tender than A or B and have more flavor than B.

Field et al. (1966) divided cattle into groups representing 300 to 399, 400 to 499, 500 to 599 and 600 to 699 days of age. In data representing 31 steers plus 53 heifers, age in days had no significant effect on Warner-Bratzler shear force value, or tenderness, juiciness or flavor score. In 134 bull carcasses, longissimus dorsi roasts from the bulls representing 300 to 399 days of age had lower shear values and higher tenderness scores, although no effect was noted on flavor and juiciness. Most block beef currently comes from steers and heifers and the fact that no differences were noted from 300 to 699 days of age might mean that todays A & B maturity groups are similar to product eating quality. McBee and Wiles (1968) found no difference between the old A & B maturity groups in tenderness, although steaks from the B maturity carcasses were more juicy ($P < .01$) and more flavorful ($P < .10$). The old A & B maturity groups were combined into one group in the beef grade standards dated April 7, 1965.

Covington (1968) studied rib steaks from carcasses of the A-A, A+B- and BB+ maturity groups (new grade standards) and found no differences in shear force value. His data supports that of Field et al (1966) and of Romans et al. (1965). Perhaps the current A & B maturity groups could be further combined if differences in eating quality are not found between them. At least this suggestion deserves more study.

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R. F. KELLY: Thank you, Don. The next topic that we will discuss is the one that presents every member of the judging team every time he looks at a class, and it also presents the coach with a problem when he selects the class, and that is How Should Quality and Quantity Characteristics Be Weighted? How should we put these two together in a complex situation that we might have, how much emphasis should we put on quality, how much emphasis should be put to conformation, how much should be put to the cutability score, and the like. To discuss this for you, we have Bob Kauffman of the University of Wisconsin. Bob.

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