ESTIMATING YIELDS OF RETAIL CUTS FROM BEEF CARCASSES

BY

C.E. Murphey, D.K. Hallett, W.E. Tyler,

and J.C. Pierce

Livestock Division, Agricultural Marketing Service
Department of Agriculture

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At the 1956 meetings of the American Society of Animal Production, Pierce, Strong, Van Zandt, and Murphey reported on a study of 459 beef carcasses in which they presented information relative to factors influencing yields of wholesale and retail cuts.

Those studies indicated that there was a wide variation in yields of trimmed retail cuts both among all carcasses as well as among carcasses of the same grade. They also showed that variations in yields of cuts were due primarily to variations in conformation and finish. Conformation was positively associated with yield of cuts while finish had the opposite effect. Further analyses of these data indicated that when conformation and finish were expressed in terms of grades, finish was 4-1/2 times as important as conformation in predicting yields of closely trimmed, mostly bone-in retail cuts from the round, loin, rib, and chuck.

Since that time, in a further effort to develop additional factual information on this subject that might be useful in more precisely identifying differences in yields of cuts in grading, the Department has conducted other similar evaluation, measurement, and cutting studies.

One of these studies involved a series of seven separate tests conducted in cooperation with retail chain stores and included a total of 185 carcasses. The plan for these tests provided for selecting and cutting approximately fifteen right sides from carcasses within each of several weight and quality grade groups of both steers and heifers. Within each of the weight-sex-quality grade groups, it was further planned to include equal numbers of carcasses in each of three yield groups. One of these groups included carcasses which was expected to have a higher-than-normal "cutability" for their quality grade, a second group was expected to have a rather typical or normal "cutability", and the third group included

carcasses which were expected to have a lower-than-normal "cutability" for their quality grade. For added precision each of these three yield groups was again divided into three sub groups.

Selection of the carcasses for each of these groups was made by first evaluating each side for conformation grade and finish grade. Finish grade was a weighted average of separate evaluations for external finish, cod or udder fat, and kidney and pelvic fat in which external finish was assigned 50 percent of the evaluation and cod or udder fat and kidney fat were each assigned 25 percent. Then, by evaluating finish grade and conformation grade in the ratio of 4-1/2 to 1 and arbitrarily establishing two combinations of these factors for the upper and lower limits of the intermediate yield group, the carcasses were classified into the three groups. The two combinations for the upper and lower limits of the intermediate yield group in Choice quality carcasses, for example, were average Choice conformation and low Choice finish and average Choice conformation and high Choice finish, respectively.

Because of the limited variety of carcasses available in the particular packing plants at the time the selections were made, it was not always possible to include an equal number of carcasses in each of the yield groups.

Carcass measurements were taken substantially in accordance with the procedures outlined and adopted by the Reciprocal Meats Conference in 1952. The following measurement data were recorded: (1) length of body, (2) length of hind leg, (3) circumference of round, (4) depth of body, (5) length and width of the rib eye muscle between the 12th and 13th ribs, (6) area of rib eye, and (7) three thicknesses of fat over the rib eye.

After selection in a packing plant, the sides were shipped to the warehouse of the cooperating retailer. Here, each side was broken into standard wholesale cuts and then further defatted and otherwise trimmed to reflect a rather close, retail-style trim. Surface fat was trimmed to within 1/2 inch on the thick cuts and to within 1/4 inch on the thinner cuts such as the brisket. Some cuts were partially or completely boned. This resulted in removing about half the total bone. The flank portion on the short loin was nearly completely removed and the rib was trimmed to include only a narrow section of short ribs. This style of cutting is hereinafter referred to as producing "bone-in" retail cuts. All weights were recorded to the nearest one-tenth pound and all yields were computed as a percent of the total weight of the cuts from the side.

Some of the important results of these tests are included in Table I. Since value differences among carcasses of comparable quality are determined to a large extent by differences in the proportion of their weight that is located in the regions of the higher priced cuts, the column headed "Average difference in % trimmed major cuts between the high and low yielding groups" is of particular interest. Since there was no marked or regular differences in the yields of these cuts between weight or sex groups within any of the grades, data from all weight and sex groups for each grade have been combined.

Table I. Certain Yield and Value Differences by Quality Grade and Yield Group

Quality Grade	Yield Group	No. of Carcasses	Difference in % Trimmed Major Cuts Between High and Low Yielding Groups 1/	Average Difference in Retail Sales Value per Cwt. of Carcass Between High and Low Yielding groups 2/	Overall Range Between Individual Carcasses in % Trimmed Major Cuts 1/	Overall Difference in Retail Sales Value Between Individual Carcasses per Cwt. of Carcass 2/
Prime	High	9	7.6	$6.29	10.71	$9.09
	Intermediate	17				
	Low	3				
Choice	High	29	5.4	5.07	12.33	10.66
	Intermediate	36				
	Low	18				
Good	High	11	5.1	4.25	12.24	10.27
	Intermediate	19				
	Low	12				
Standard	High	7	4.6	4.49	7.03	5.79
	Intermediate	17				
	Low	7				

1/ Percent of side weight in combined trimmed "bone-in" retail cuts from round, loin, rib, and chuck.

2/ Based on retail prices furnished by the cooperating retail store at time test was conducted.

Because differences in yields of cuts are difficult to evaluate economically, a retail sales value, based on prices furnished by the cooperating store at the time of the test, also was calculated for each side cut. The average difference in retail sales value between the groups of high and low yielding carcasses in each grade are likewise indicated. Thus, with an average difference of $5.07 per cwt. between high and low yielding Choice quality carcasses, a 600 pound high yielding carcass would be worth $30.42 more than a low yielding 600 pound carcass. Differences between high and low yielding individuals within each grade were much greater than between high and low yielding groups. As seen in the table, this was as high as $10.66 per cwt. Between two 600 pound carcasses this difference would be $63.96.

The coefficient of correlation between the yield group and the actual combined yield of retail cuts from the round, loin, rib, and chuck ranged from .71 to .90. Most of these were about .80.

Another study also was conducted that involved the evaluation and cutting of one side each of 162 steer, heifer, and cow carcasses of Prime through Canner grades and of most of the conventional weights. This study was conducted in Chicago in cooperation with a large boning establishment and a major packer. Data collected in this study included all the measurements and evaluations made in the previous study plus an actual estimate of the yield of closely trimmed "bone-in" retail cuts previously mentioned. Since the evaluation and cutting work with the chain stores had indicated that measures of fatness, alone, were quite closely related to yields of "bone-in" retail cuts, this estimate of yields of "bone-in" in retail cuts was based solely on an evaluation of the external finish and the estimated percent of kidney and pelvic fat. The "percent kidney fat" when referred to herein means the percent of kidney and pelvic fat, including the kidney, which was removed from the entire loin in making the "bone-in" retail trimmed cuts. However, in addition to making wholesale cuts and the previously mentioned "bone-in" retail cuts, in this study all of the cuts also were completely boned and yields of entirely boneless cuts from the round, loin, rib, and chuck were determined.

The outline of this project provided for selecting carcasses within 10 different yield groups each of which included a range of 3.0 percent in "bone-in" retail cuts from the round, loin, rib, and chuck. In actually selecting the carcasses, an attempt was made to select three carcasses in each of as many of these yield groups as were available within various weight-sex-quality grade groups. In most cases, of the three carcasses included in each yield group, one had a conformation grade that corresponded to its quality, one had a conformation grade which was at least in the next higher grade than its quality and the third had a conformation grade which was at least in the next lower grade than its quality. The distribution of carcasses used in this study is shown in Table II.

Table II

DISTRIBUTION OF CARCASSES BY GRADE, WEIGHT, CLASS, AND ESTIMATED "BONE-IN" YIELD GROUPS

				Estimated Bone-In Yield Group									
Quality Grade	Weight lbs.	Class	No.	1	2	3	4	5	6	7	8	9	10
Prime	6-700	Steers	7				3	2	1	1			
"	6-700	Heifers	4				1	1	1	1			
"	8-900	Steers	12				2	2	3	2	2	1	
Choice	5-600	Steers	5			1	3	1					
"	5-600	Heifers	11				2	4	3	2			
"	7-800	Steers	14			4	3	3	3	1			
"	6-700	Heifers	12			1	2	3	3	2	1		
Good	4-500	Steers	9		1	4	3	1					
"	4-500	Heifers	13			1	3	4	4	1			
"	6-700	Steers	14			3	4	2	3	1	1		
Standard	4-500	Steers	7		1	5		1					
"	4-500	Heifers	4			3			1				
"	6-700	Steers	7			3	3	1					
Commercial	5-600	Cows	10			1	3	3	3				
"	7-800	Cows	10				2	4	2	1	1		
Utility	4-500	Steers	4	1	3								
"	5-600	Cows	11		3	4	3	1					
"	5-600	Steers	4	1	3								
Cutter	350-450	Cows	2		2								
Canner	350-450	Cows	2	2									
	Total		162	4	13	30	37	33	27	12	5	1	

Table III. OVERALL AND WITHIN QUALITY GRADE VARIATION OF YIELDS OF BONE-IN AND BONELESS RETAIL CUTS FROM ROUND, LOIN, RIB, AND CHUCK

		Bone-In			Boneless		
Quality	Number	High	Low	Range	High	Low	Range
		%	%	%	%	%	%
Prime	23	60.2	43.6	16.6	51.1	37.0	14.1
Choice	43	64.2	48.2	16.0	55.0	40.6	14.4
Good	35	62.6	50.5	11.9	53.4	44.6	8.8
Standard	18	65.2	57.1	8.1	58.3	48.4	9.9
Commercial	21	62.8	50.5	12.3	51.2	42.0	9.2
Utility 1/	8	66.7	62.5	4.2	56.4	51.5	4.9
Utility 2/	9	65.1	55.5	9.6	55.0	45.7	9.3
Cutter	3	67.6	67.3	.3	57.3	54.9	2.4
Canner	2	66.2	62.0	4.2	55.0	47.5	7.5
Overall	162	67.6	43.6	24.0	58.3	37.0	21.3

1/ Steers and Heifers
2/ Cows

Table III gives the overall and within-quality grade variations in yields of "bone-in" and boneless retail cuts from the round, loin, rib, and chuck for the 162 sides included in the study. This shows that among all the carcasses included in the study there was a total range of 24.0 percent in "bone-in" and 21.3 percent in boneless retail cuts from the round, loin, rib, and chuck. Furthermore, there was about 2/3 this variation among carcasses within each of the Prime and Choice grades and about 1/2 this variation among carcasses of the Good and Commercial grades and among Utility grade cow carcasses.

Simple and multiple regressions and correlations for the entire 162 carcasses were calculated between the various measurements, evaluations, and yields of cuts. Similar calculations were not made for smaller groupings such as the carcasses in each quality grade or in each quality-sex-weight group. The results of some of the more interesting and significant of these relationships are presented in Tables IV and V. Since the carcasses were so variable in weight it is obvious that simple correlation coefficients among many of the carcass measurements or between most of the carcass measurements and the various yields of cuts would have little meaning. Therefore, in this report, carcass measurements were generally included only in the summary of the multiple regression analyses.

Table IV. SIMPLE CORRELATION COEFFICIENTS BETWEEN VARIOUS CARCASS MEASUREMENTS AND EVALUATIONS AND YIELDS OF MAJOR 1/ WHOLESALE, "BONE-IN" RETAIL, AND BONELESS RETAIL CUTS

	Level of Trim		
Variable	Wholesale	Bone-In Retail	Boneless Retail
Av. thickness of fat over rib eye	-.68	-.85	-.81
Single thickness of fat over rib eye 2/	-.69	-.83	-.79
Subjective evaluation of external finish 3/	-.72	-.90	-.85
Percent kidney fat	-.42	-.66	-.63
Percent total fat trim	-.78	-.98	-.94
Percent total bone	-.68	.77	.62
Yield of major wholesale cuts		.84	.79
Yield of major bone-in retail cuts			.98

1/ Round, loin, rib and chuck.

2/ Made at a point 3/4 the length of the rib eye measured from the edge nearest the backbone.

3/ This was the measure of external finish used in conjunction with estimated percent kidney fat in estimating the yield of "bone-in" retail cuts from the round, loin, rib, and chuck.

Data in this table indicate that the various measures of external fatness were all rather highly correlated with yields of cuts — particularly major "bone-in" and boneless retail cuts. They also indicate that the single thickness of fat over the rib eye was nearly as highly correlated with yields of cuts as was the average of three measurements. Neither of these was as highly correlated with yields of these cuts, though, as the subjective evaluation of external finish. This latter evaluation was essentially an "adjusted" thickness of fat over the rib eye which takes into account the actual thickness of fat over the rib eye and also variations in deposition of fat on other parts of the carcass when these are not typical of the fatness over the rib eye.

In this same connection, it is interesting to note the extremely high correlation coefficients between percent total fat trim and yields of major "bone-in" and boneless retail cuts. These would indicate that the yields of these cuts could be predicted very accurately if a means were available to predict the percent of fat trim. The total percent of bone in the carcass was not nearly as highly correlated with yields of cuts as was the percent of fat trim.

The extremely high correlation coefficient between yields of major "bone-in" and boneless retail cuts indicates that the percent of bone left in the "bone-in" cuts is either extremely constant or that variations in the bone content of the "bone-in" cuts are very closely related to variations in the yields of those cuts. The simple correlation coefficient between average thickness of fat over the rib eye and percent kidney fat was only .42.

Since the primary purpose of this study was to study the relationships between carcass characteristics and the yields of trimmed retail cuts, multiple regression analyses included only yields of major "bone-in" and boneless retail cuts as dependent variations. These are shown in Table V.

Since the relationship between thickness of fat over the rib eye and percent kidney fat was not particularly close, it is not surprising that the multiple correlation coefficients involving average thickness of fat over the rib eye plus percent of kidney fat with yields of both "bone-in" and boneless retail cuts were considerably higher than the simple correlation coefficients between the average thickness of fat over the rib eye and these same two dependent variables. With respect to yields of "bone-in" retail cuts, only one of the measurements or evaluations — length of rib eye muscle — substantially increased the multiple correlation coefficient beyond that obtained with the average thickness of fat over the rib eye, percent kidney fat, and side weight. Considering increased length of eye muscle as a desirable attribute in carcass evaluation, however, would seem to be of doubtful wisdom since length of eye muscle would likely be associated with an increase in the length of bones in the rib and loin and also with the weight of external fat over the outside of these cuts. These multiple correlation coefficients again indicated that the yields of "bone-in" retail cuts were very closely related to fatness and that little added precision in estimating such cuts was attained by adding the other skeletal or muscular characteristics studied. On the other hand, when the yield of boneless major retail cuts was used as the dependent variable, the area of the rib eye made a distinct improvement in the multiple correlation coefficient when added to the average thickness of fat over the rib eye, the percent kidney fat, and weight. None of the other measurements or evaluations showed any similar improvement. The fact that the area of the rib eye was relatively more important in estimating the yield of boneless retail cuts than it was in estimating yield of "bone-in" retail cuts indicated that the area of the rib eye, when used in conjunction with measures of fatness and weight, was probably measuring the relationship between muscle and bone.

It was noted in cutting the sides that frequently there was quite a wide variation in the amount of intermuscular fat among carcasses of the same degree of external fatness. Since it appeared that this variation might be related to quality grade, marbling was used also as an independent variable. Its use, however, did not increase the size of the multiple correlation coefficient when added to average thickness of fat over the rib eye, percent kidney fat and side weight.

It was also quite interesting that by using a total of 17 independent variables — all those listed in Table V — very high multiple correlation coefficients were obtained with both styles of retail cuts. In this same connection, though, it is likewise interesting that when the two direct measures of fatness — average thickness of fat over the rib eye and percent of kidney fat — were not considered, the multiple correlation coefficient between the other fifteen variables and percent of boneless retail cuts was .907. Since all these variables — except marbling — are measures of muscling or skeletal structure this might indicate that fatness, as such, is not necessarily the only factor that is closely related to the yields of trimmed retail cuts. There is a more likely explanation, though, of the apparently contradictory data which indicates that measures of muscling and skeletal structure add little to the accuracy of estimating yield of retail cuts over and beyond measures of fatness and which indicates that measures of muscling and skeletal structure add little to the accuracy of estimating yield of retail cuts over and beyond measures of fatness and which, at the same time, also indicate that measures of muscling and skeletal structure, without considering measures of fat, are also highly correlated with these same yields of cuts. This explanation revolves around the fact that a carcass is composed only of muscle, bone, and fat and that any measures which are closely related to two of these components will automatically be closely related to the third. Thus, if measures of muscles and skeletal structure were closely related to the actual development of muscle and bone in the carcass, these would also be closely related to the fat and to yields of boneless retail cuts.

It is also obvious that, if two of these components are combined, then measures closely related to the third component will likewise be closely related to the two that are combined. This is apparently why measures of fatness are so closely related to yields of "bone-in" retail cuts and why measures of muscling and/or skeletal structure do not make a further significant contribution to the accuracy of estimating these yields. As pointed out previously though, when considering yields of boneless retail cuts, the inclusion of a measure of muscling — area of rib eye — did substantially increase the size of the multiple correlation coefficient beyond that obtained with measures of fatness only.

In this same connection, it is also interesting to note that the multiple correlation coefficient between the yield of major boneless retail cuts and area of the rib eye, round index of plumpness, length of body and weight was .807. This, again, illustrated the close interrelationships that existed among the various measures of fat, muscle, and bone.

Two other relationships — numbers 20 and 21 — again indicated that a subjective evaluation of external finish was a better measure of yield of cuts than either of the two objective measures of fatness over the rib eye. It is entirely possible, however, that an average of a number of measurements of thickness of external fat made at various points on the carcass might well be a better measure of the external fatness of the carcass than the subjective evaluation used in the study.

There was little to choose between the single thickness of fat over the rib eye and the average of three such measures when used in conjunction with percent kidney fat, weight, and area of rib eye to predict yields of major boneless retail cuts.

The following are three of the regression equations developed from these data:

> Percent "bone-in" retail cuts from round, loin, rib, and chuck = 65.49 - 7.24 (av. thickness of fat over rib eye, in.) - 1.24 (percent kidney fat) + .35 (area of rib eye, sq. inches) -.0038 (carcass wt., lbs.)
>
> Percent boneless retail cuts from round, loin, rib and chuck = 52.66 - 5.33 (av. thickness of fat over rib eye, in.) -.979 (percent kidney fat) + .665 (area of rib eye, sq. inches) -.0065 (carcass weight, lbs.)
>
> Percent boneless retail cuts from round, loin, rib, and chuck = 52.56 - 4.95 (single thickness of fat over rib eye, in.) -1.06 (percent kidney fat) + .682 (area of rib eye, sq. in.) - .008 (carcass weight, lbs.)

Initially it had been assumed that kidney fat was just "so much excess baggage" that would affect the yields of cuts solely through its effect on carcass weight. However, it will be noted in each of these equations that the regression coefficient for kidney fat varied from .979 to 1.24. This indicated that each one percent variation in kidney fat affected the yield of retail cuts from the round, loin, rib, and chuck by from about one to one and one-fourth percent. This is, of course, a much greater effect than can be ascribed to it simply as "excess baggage." Obviously, therefore, the percent kidney fat must have been rather closely interrelated to some other factor that also affected yields of cuts — possibly intermuscular fat. It is recognized, of course, that in commercial practice the quantity of kidney fat could be altered very considerably by trimming. Therefore, in developing a system of possible yield grades designed to reflect differences in yields of major boneless retail cuts, it was felt advisable to develop a regression equation that considered the percent kidney fat as an added weight of fat that would be trimmed in making retail cuts. Such an equation which also included a single thickness of fat over the rib eye, area of rib eye, and carcass weight was developed by (1) subtracting the weight of kidney fat from the original side weight, (2) recalculating the yield of major boneless retail cuts as a percent of the kidney-fat-out side weight, (3) developing a regression equation between the above yield of major boneless retail cuts and thickness of fat over the rib eye, area of rib eye, and side weight, and then (4) arbitrarily assigning a regression coefficient to the percent kidney fat that would make its effect on yields of boneless major cuts be substantially that of increased weight only. Using the above procedure, the following regression equation was developed:

> Percent boneless retail cuts from round, loin, rib, and chuck = 51.34 - 5.78 (single fat thickness over rib eye, in.) -.462 (percent kidney fat) + .740 (area of rib eye, sq. in.) -.0093 (carcass wt., lbs.)

This equation was applied to the 162 carcasses included in the study and an estimated yield of major boneless retail cuts calculated. The simple correlation coefficient between this estimated yield of cuts and the corresponding actual yield of cuts was .906. While this regression equation sacrifices some of the accuracy of others developed in this study, it is considered a much more reliable one to use as the basis for a grading system.

A system of yield grades has been developed and studied but has been used only for demonstrating the possible application of a so-called dual grading system. In this dual grading study each carcass was given two grades — one for its quality of lean and another for its yield of major boneless retail cuts. The quality grade was determined by considering the factors presently considered in evaluating quality — the color, texture, firmness, and marbling of the lean in relation to maturity — and the grades identified by using the present grade names. The yield grades were determined essentially by the above equation and included ten grades — numbered from 1 to 10. Each yield grade included a range of 2.3% in yield of major boneless retail cuts and the junction of yield grades 1 and 2 was at 53.1 percent of such boneless retail cuts. The junction of each successively lower grade (higher number) reflected a 2.3% lower yield of these cuts. Thus, the junction of yield grades 9 and 10 would be at 34.7 percent of boneless retail cuts from the round, loin, rib, and chuck.

Table V

Multiple Correlation Coefficients Between Various Combinations of Carcass Measurements and Evaluations and Yields of Major "Bone-In" and Boneless Retail Cuts

No.	Variables	Level of Trim: Bone-In Retail	Level of Trim: Boneless Retail
1	Average fat thickness over rib eye + percent kidney fat	.909	.871
2	" " " " " " " " " " + weight	.909	.873
3	" " " " " " " " " " " + conformation grade	.910	.881
4	" " " " " " " " " " " " area of rib eye	.917	.916
5	" " " " " " " " " " " " length of body	.915	.873
6	" " " " " " " " " " " " length of hind leg	.910	.875
7	" " " " " " " " " " " " depth of body	.913	.873
8	" " " " " " " " " " " "circ. of round	.910	.877
9	" " " " " " " " " " " " round index of plumpness	.911	.877
10	" " " " " " " " " " " " average width of rib eye	.910	.892
11	" " " " " " " " " " " " length of rib eye	.928	.902
12	" " " " " " " " " " " " marbling	.912	.877
13	" " " " " " " " " " " " ratio meat to bone	.909	.875
14	" " " " " " " " " " " " maturity	.918	.873
15	" " " " " " " " " " " " ratio area of rib eye to length of rib eye	.911	.900
16	" " " " " " " " " " " " ratio major to minor retail cuts (bone in)	.916	
17	" " " " " " " " " " " " ratio major to minor retail cuts (boneless)		.855
18	Single thickness of fat over rib eye + percent kidney fat + weight + area of rib eye		.912
19	Subjective evaluation of external finish + percent kidney fat + weight + area of rib eye		.935
20	All 17 above variables	.965	.957
21	All 17 above variables + subjective evaluation of external finish	.974	
22	15 of above variables (avg. thickness of fat over rib eye and % kidney fat excluded)		.908
23	Area of rib eye + round index of plumpness + length of body + weight		.807