No. 3

Fourth Annual Meeting of European Meat Research Workers,

Cambridge, September, 1958

THE YIELDS OF WHOLESALE CUTS FROM CARCASSES OF ABERDEEN-ANGUS CROSSES FATTENED ON GRASS AND IN YARDS

E.L. ref. 8.11.58

by

G. Harrington

(A.R.C. Statistics Group, School of Agriculture, University of Cambridge)

and

R. W. Pomeroy

(Agricultural Research Council & School of Agriculture, University of Cambridge)

The quality of beef carcasses is determined by their content of lean meat and bone, by the eating qualities of the lean, by the thickness, distribution, firmness and colour of the subcutaneous and intermuscular fat and by 'carcass conformation'. This last feature refers to the relative development of the various joints, which have different values according to whether they are suitable for grilling or roasting or only for stewing and boiling. As large a proportion of the total carcass weight as possible is required in the high-priced cuts lying in the hind leg and along the top of the back, and although conformation is often assessed purely subjectively, attempts have been made to use measurements of various kinds to describe the shape of the carcass. A direct objective measure of conformation is provided by cutting the carcass according to recognized commercial practice and weighing the joints, but for experimental work it is necessary to adopt a strictly standardized cutting technique; this can usually be done without serious financial loss. The idea of an "index of carcass value", such as the wholesale value of the carcass per lb. weight determined using standardized cutting techniques and average wholesale prices for the various cuts, is useful in investigational work, although the differences between carcasses tend to be exaggerated by such an index. This is because, in practice, some butchers may adjust their methods of cutting according to each particular carcass and to the prevailing demand and price differentials.

The object of the investigations described here was to study variations in the wholesale cut yield of beef carcasses of a type generally recognized in the meat trade as providing the highest quality beef available in the United Kingdom, and to examine the possibility of predicting the wholesale value index by simple cutting methods that do not require the complete breakdown of the whole carcass.

THE SAMPLE OF CATTLE

The cattle were specially purchased for this survey in Aberdeen market between July 1955 and May 1956 by a representative of a large firm of multiple butchers, who was asked to select typical animals of both sexes over as wide a weight range as possible. Apart from a few other breeds which have been discarded in the analysis, all cattle were Aberdeen-Angus crosses bred and reared in Scotland. The dominance of the black coat and polled condition of the Aberdeen-Angus is so complete that it is almost impossible to determine which other breed is involved in a cross, but in this case it is believed that the crosses were mainly Aberdeen-Angus x Shorthorn. The sex, liveweight and approximate age of the cattle were recorded. The sample fell into two parts - those purchased from July-October, 1955, having been fattened on grass, and those purchased from March-May, 1956, having been fattened in yards. The following list gives the numbers, weights, dressing percentages and ages of the cattle involved.

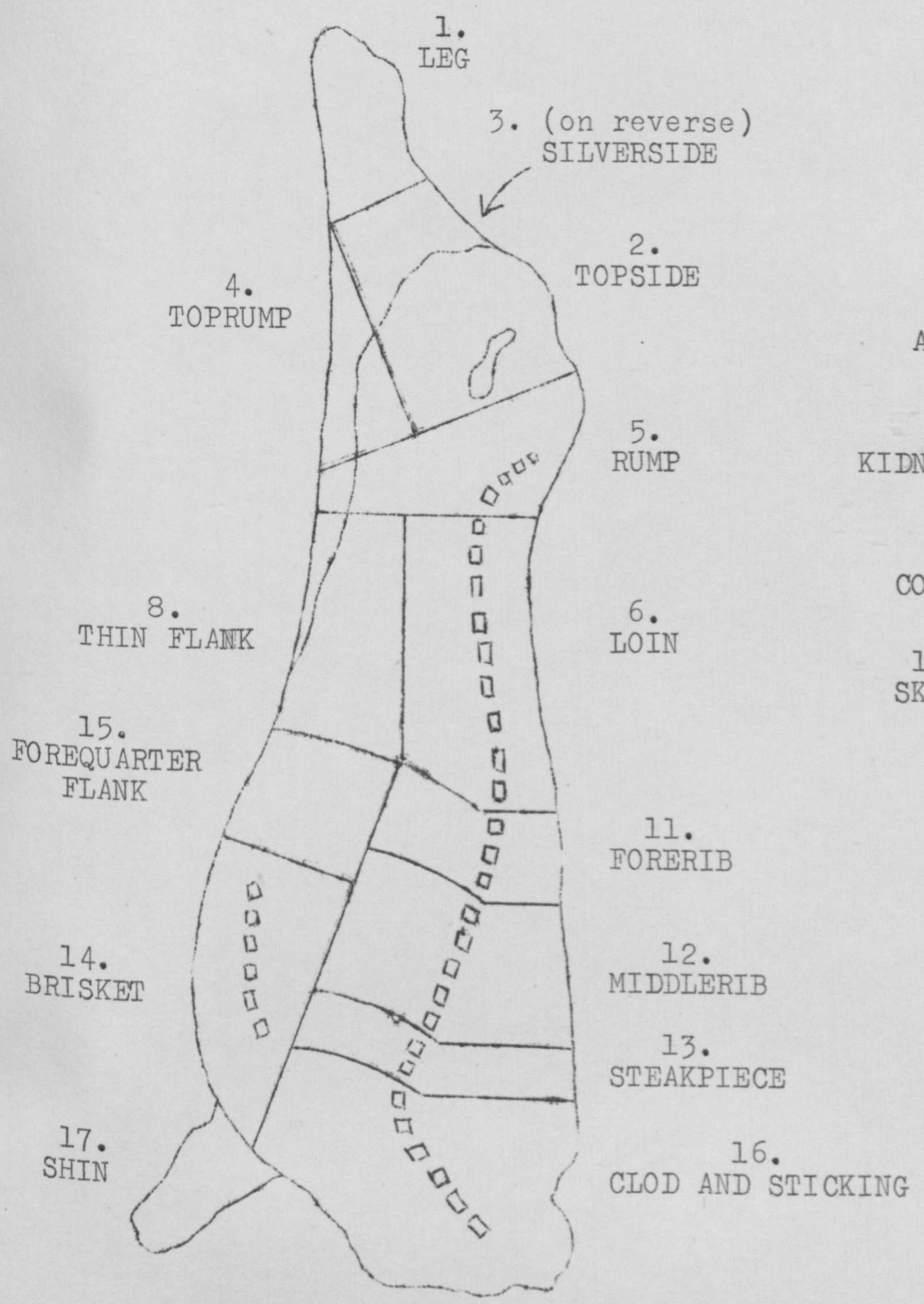
Group	Number	Average and Range of live weight(lb.)	Average and Range of dressing %age	Approximate ages
Heifers on grass	10	935 (728 - 1036)	57.8 (53.1 - 60.8)	4 at 2 yrs 6 at 2 - 3 yrs
Steers on grass	24	1149 (1036 - 1232)	59.0 (55.8 - 62.0)	5 at 2 - 2½yrs 19 at 2½- 3 yrs
Heifers in yards	12	999 (896 - 1204)	59.2 (56.7 - 61.5)	9 at 1½- 2 yrs 3 at 2 - 2½yrs
Steers in yards	22	1186 (1064 - 1344)	59.0 (56.3 - 63.5)	8 at 1½- 2 yrs 13 at 2 - 2½yrs 1 at 2½- 3 yrs

METHODS

The 68 cattle were slaughtered in Aberdeen, and split into the left and right sides, referred to throughout the following by their trade names, the 'Close' and the 'Rising' sides respectively. The sides were quartered between the 10th and 11th ribs by a cut following the line of the ribs and sent to London. There, the quarters were weighed to the nearest half-pound and broken down into wholesale joints by the same experienced butcher, the individual joints being weighed to the nearest ounce. The style of cutting used was that known as the London & Home Counties method (Gerrard, 1951, Tayler, 1958) with some slight modifications and this is shown diagramatically in Figure 1 (p.3). The 'crop' (forequarter less the brisket, flank, shin and neck cuts) was divided into a 3 bone forerib, a 5 bone middlerib and a 2 bone steakpiece, instead of the more usual 4 bone forerib and 4 bone middlerib. The clod and sticking cuts from the neck were not separated. The 'round' was divided into topside, silverside and top rump (or thick flank) cuts, the femur being included in the silverside. No 'aitchbone' joint was cut from the round, and 'cod fat' included the udder fat in heifers. The difference between the total weights of the forequarter and hindquarter cuts and the actual forequarter and hindquarter weights are referred to as forequarter and hindquarter losses, being due to slight trimming waste and evaporation during jointing. The cutting procedure was 'standardized' in so far as the butcher was attempting to conform to the same pattern throughout and was not influenced by the prevailing price differentials between cuts. No attempt was made to standardize the cutting rigourously by using a revised method based on anatomically distinguishable points of reference.

The measurements of A and B, the diameters of the 'eye' muscle, were also recorded.

The index of wholesale side or carcass value (referred to below either as the 'index', or the 'side' or 'carcass value') was defined as the total wholesale value of the side or carcass based on the cutting yields and the following prices, divided by the total weight of the side or carcass.



Also:-

7.
KIDNEY KNOB

9.
COD FAT

10.
SKIRT

Figure 1

Diagram showing the modified 'London & Home Counties' style of cutting used in this investigation.

Hindquarter			Forequarter		
1. Leg	9	pence/lb.	11. Forerib	18	pence/lb.
2. Topside	28	"	12. Middlerib	16	"
3. Silverside	28	"	13. Steakpiece	16	"
4. Top Rump	26	"	14. Brisket	7	"
5. Rump	38	"	15. Forequarter Flank	7	"
6. Loin	34	"	16. Clod & Sticking	10	"
7. Kidney Knob	6	"	17. Shin	9	"
8. Flank	6	"			
9. Cod Fat	2	"			
10. Skirt	6	"			

These prices were suggested by Mr.F.H.Gerrard of the National College of Food Technology, as representing as accurately as possible the wholesale price differentials between cuts during the period of the investigation.

BIOMETRICAL METHODS

Variation in the weight of a particular cut through the sample has been studied using analyses of variance. Within each group of carcasses, a 2-way classification into 'sides' and 'carcasses' was possible and these were then pooled over groups giving the following analysis.

	d.f.
Between groups of carcasses	3
Between carcasses within groups	64
Between sides	1
Sides x groups	3
Sides x carcasses within groups	64
Total	135

The sides x carcasses within groups mean square gave a measure of cutting variations, and the significance of the between sides mean square indicated whether there were systematic differences between sides in the weight of the cut in question.

The between groups of carcasses term was split up into between sexes, between treatments (yard v grass fattening) and an interaction (sexes x treatments) using the weighting method described by Yates (1934) to allow for the disproportionate numbers of carcasses in the four groups. The influence of variations in side weight on the weight of the cut were allowed for by means of analyses of covariance using the between carcasses within groups term as the error. This was justified since the regression of weight of cut on weight of side did not vary significantly between the four groups for any of the cuts. The mean weights of the cuts for the four groups were adjusted to a side weight of 300 lb.

Correlations and regressions were used in relating wholesale carcass values to various cut-out yields etc.

RESULTS

Variations between groups of carcasses.

The average weight of the 136 sides of beef cut during the test was 325 lb., the average weights for the individual cuts overall and within each of the 4 groups being shown in Table 1. Sides of steer carcasses were heavier by 50-60 lb. than those of heifers both in winter and summer, and sides from animals of both sexes tended to be heavier when fattened in yards than when fattened

Yo

on grass, the mean difference between treatments being significant at the 5% level. These differences in side weights make the comparison of individual cut weights between the 4 groups difficult and for this reason they have been adjusted to a constant side weight of 300 lb. using the regression coefficients given in Table 2; these give the average effect of an increase in side weight of 10 lb. on the weight of each cut, and although they were first calculated within each group of carcasses, pooled values are given since no significant differences between the 4 groups were found. These regression coefficients thus supply no evidence that the 4 groups of animals were in markedly different stages of development. When considered in relation to the mean weights of the cuts (Table 1), it is seen that the cuts along the underline of the animals (brisket and flanks) were increasing at proportionally the greatest rate and the shin and hind-leg cuts at about half this rate with those along the top of the back intermediate.

The weights of the individual cuts in the 4 groups adjusted to side weights of 300 lb., and the significance of the differences between sexes and treatments are given in Table 2. Sex differences and treatment differences may be considered separately, since the interaction between these was not generally an important factor; this was significant at the 5% level only in 4 of the 19 analyses. The differences between the mean weights of corresponding cuts from steer and heifer carcass sides weighing 300 lb. (averaged over treatments) are shown in the right hand diagram of Figure 2. Heifers showed a greater weight of the internal fats (cod fat and kidney knob), suggesting that at this weight of carcass, they are at a more advanced stage of development than steers. According to Hammond's theory of growth and development, waves of growth progress along the animal's back from the head backwards and from the hind parts forward, meeting at the loin, after which the animal deepens. On the basis of this theory, it is to be expected that the heifers, being at a later stage of development, would show relatively greater development of loin and flank cuts than the steers in carcasses of the same weight, and these trends were well demonstrated in this investigation. Steers showed a greater weight of the neck cuts and others along the top of the back but the effect progressively decreased along the back until heifers were heavier in the loin and rump. Steers were also heavier in the round (topside, silverside and top rump) and in the bony leg and shin cuts, but heifers were heavier in both flank cuts.

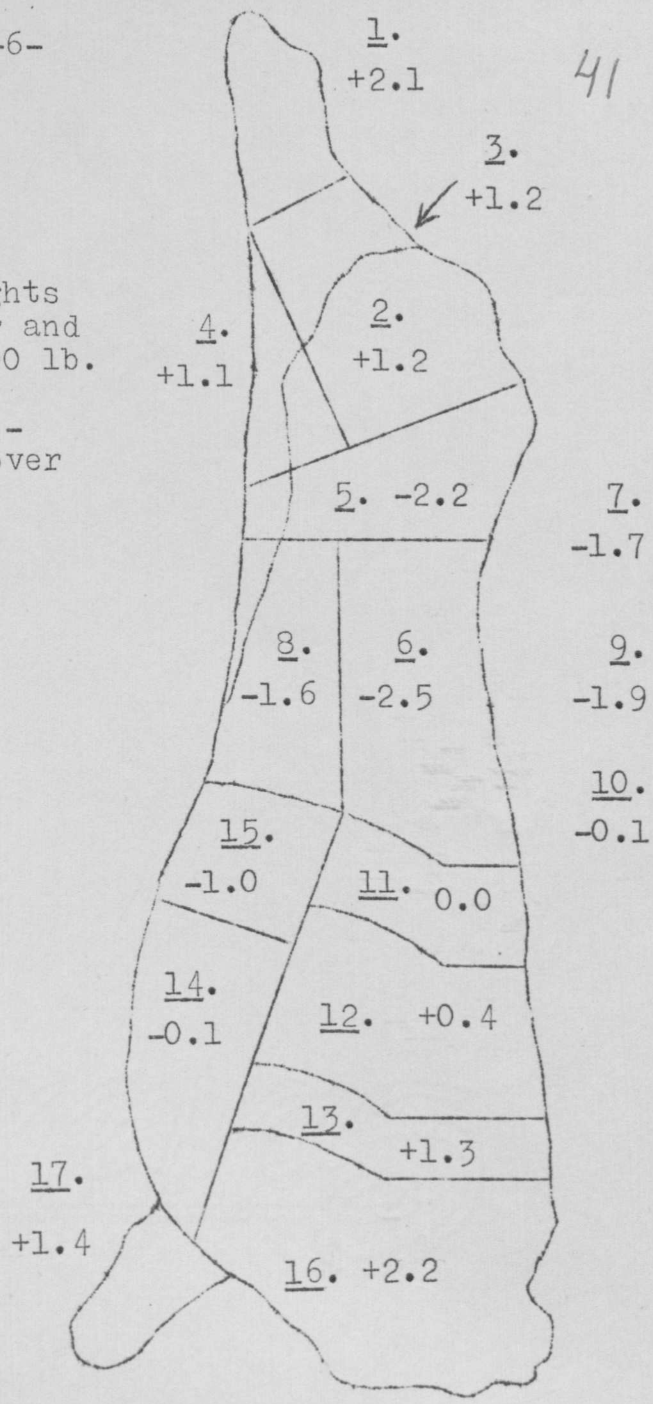
The differences between the mean weights of corresponding cuts from sides of yard-fattened and grass-fattened animals weighing 300 lb. (averaged over sexes) are shown in the left hand diagram of Figure 2. These differences were generally smaller and of less significance than the above sex differences. The trend of weight differences along the back from neck to loin, the greater weight of brisket and flanks in the grass-fattened animals and of the round in the yard-fattened ones, the slight non-significant differences in internal fatness, all suggest that the grass-fattened animals were in a slightly more advanced state of development, and they were, in fact, some 6 months older on average (see p.2). However, the rump, leg and shin cuts did not conform to this pattern. Rump was associated with round rather than loin in showing greater weight in the yard-fattened animals than the grass-fattened, whereas neither leg nor shin showed this trend as expected. In view of these divergences from the developmental pattern, it must be considered whether the method of cutting was, in fact, sufficiently standardized to detect differences between animals cut up at 2 different times of the year. There was a 5 month gap between the summer and winter series and slight changes of method, which could have developed during this period, may unconsciously have been incorporated into the 'standardized' experimental cutting technique, although it is difficult to envisage

Figure 2a (right)

SEX DIFFERENCES

Differences between average weights of corresponding cuts from steer and heifer carcass sides weighing 300 lb.

(Each difference = Steer weight - Heifer weight in lb. averaged over treatments).



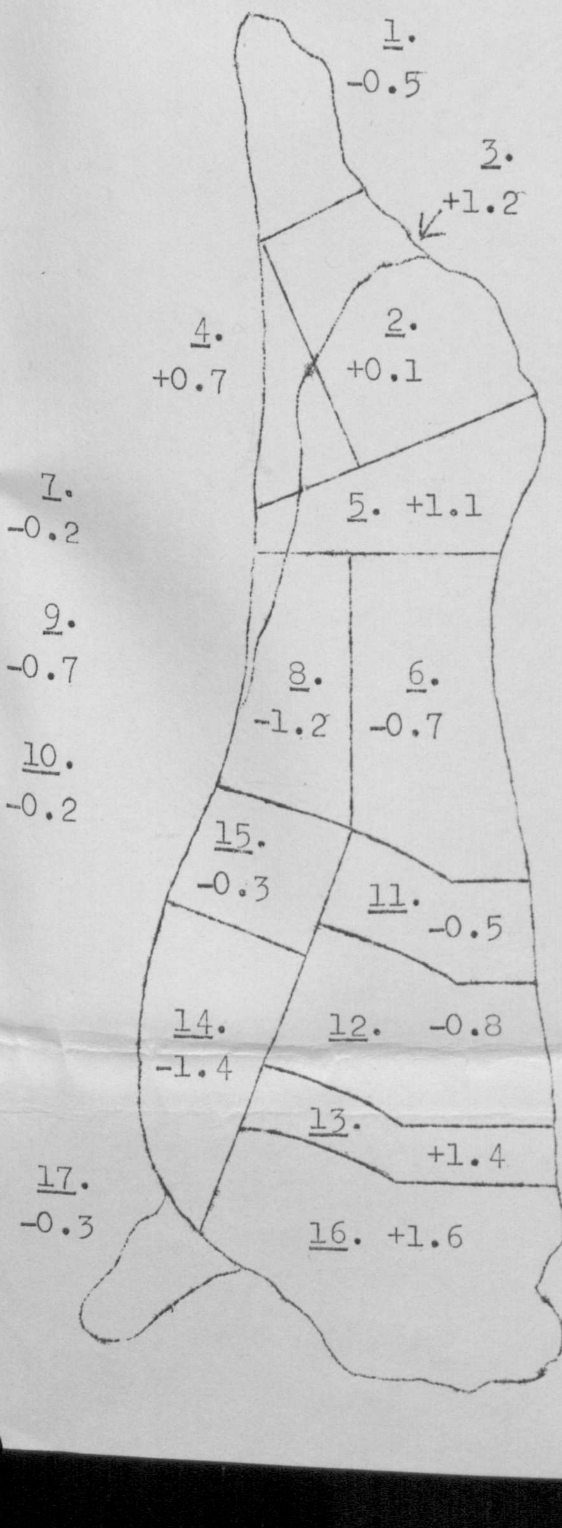


Figure 2b (left)

TREATMENT DIFFERENCES

Differences between average weights of corresponding cuts from carcasses of cattle finished in yards and on grass, the sides weighing 300 lb. in both cases.

(Each difference = Yards weight - Grass weight in lb. averaged over sexes).

(See Figure 1)

(Refer to Figure 1 for the names of the cuts)

42

what the changes could have been to affect the leg and shin cuts so markedly. An alternative explanation for the greater development of these 2 cuts in the grass-fattened animals may be that this method of feeding represents a relatively low plane of nutrition compared with yard-fattening. Animals kept on a low plane of nutrition have been shown to have proportionally greater bone development at a given weight than similar animals on a high plane of nutrition (McMeekan, 1940), and the leg and shin cuts contain a high percentage of bone. Table 2 indicates that the weight loss due to trimming and evaporation in the forequarter was more marked in winter than in summer but there is no simple explanation for this.

Variations between carcasses of the same group

Table 1 gives the pooled standard deviations measuring the variation in the weight of a particular cut within a given group of carcasses. These are based on the mean weight of the 2 examples of each cut from the 2 sides of the carcasses. They show, for example, that the average of the 2 loins from about one carcass in 20 from, say, heifers fattened on grass, deviated from the overall average for grass-fattened heifers by some 6.6 lb. (twice the standard deviation). There was some evidence that the carcasses of animals fattened on grass, particularly the steers, were more variable than the other groups studied in their yield of certain cuts, notably leg, topside, forerib, middlerib and cod fat. Some of the variation in the weight of a particular cut was, of course, due to gross variations in the weight of the side, which the pooled standard deviation of 26.2 lb. shows to have been considerable. To take account of this, the standard deviations and coefficients of variation measuring the variability in the weight of a particular cut among sides of the same weight from animals of the same type have been calculated and are shown in Table 2. The cuts trimmed from the body cavity, the kidney knob, cod fat and skirt, tended to vary in weight among carcasses of the same sex and weight to a greater extent than did the main meat cuts. A sample of 10 carcasses from a given group of the same weight would show, on average, a range between the heaviest and lightest kidney knob weights (averaged over sides) of some 6 lb., compared with a range in mean rump weights of some 3 lb.

Variations within carcasses

The rising sides were, on average, some 2.7 lb. heavier than the close sides, this difference being of similar size in all 4 groups of carcasses.

	Rising side	Close side	Overall average
Heifers on grass	271.6 (lb.)	269.2	270.4
Steers on grass	340.4	338.2	339.3
Heifers in yards	297.8	294.3	296.0
Steers in yards	351.4	348.5	350.0

Table 3 shows the difference between sides in the average weights of individual cuts. Only in one case, that of the kidney knob, did the difference between sides differ between groups and for this cut the averages for steers and heifers are given separately in the table. The largest differences between sides occurred in cuts along the top of the back, the loin and the middle rib. This suggests that the carcasses were unequally divided into 2 halves when chopped down the back; the curving away of the chopper during the separation of the sides could also explain the opposite effect on the weight of the neck cuts. The rising side is generally expected to yield a heavier kidney knob than the close for anatomical reasons, but it is surprising that this was observed only in heifer carcasses. The only other significant difference between sides concerned the silverside which is not adjacent to the plane of division of the 2 sides of the carcasses. This may therefore represent a slight but genuine developmental difference between the left and right sides of the animals.

'Cutting error' variances are given in Table 3, these being calculated as the interaction mean squares ('sides x carcasses') in the analyses of variance. It is not possible to estimate the natural variation in the difference between sides which is included in this measure of cutting variations; it is assumed small compared with the variations due to cutting and of equal importance for all cuts. The variances show, for example, that the difference in weight between the loin cuts from the 2 sides of the same carcass deviated from its average by more than 3.6 lb. for about one carcass in 20, (this value being equal to twice the standard deviation of the difference, which is $\sqrt{2 \times 1.623}$). That is, for about one carcass in 20, the difference in weight of loin between rising and close sides was greater than + 4.7 lb. or less than - 2.5 lb., since the mean difference for this cut was 1.1 lb.

Relative cutting errors may be compared using the coefficients of variation in Table 3, which are equal to the ratios of the square roots of the cutting error variances and the mean weights multiplied by 100. It is to be expected that cutting errors for adjacent cuts may be correlated. The kidney knob, cod fat, skirt and both flanks showed comparatively high cutting variation, confirming that they are difficult cuts to remove in a standardized manner. Apart from the fairly high values for the back cuts, the steakpiece, middlerib and forerib, where the occasional miscounting of number of ribs may have inflated the standard errors, the remaining coefficients ranged from 2.4 to 5.6%.

Variations in the index of wholesale carcass value

The wholesale value index among the 136 sides averaged 18.583 pence/lb., the mean side values in the 4 groups being shown in Table 4. The difference between the sexes was highly significant, heifers giving sides worth some 0.22 pence/lb. more than steers. The treatment difference was significant at the 5% level, the yard-fattened cattle yielding sides more valuable by about 0.13 pence/lb. than the grass-fattened. These differences must be considered in relation to carcass weight, however, because there was a small but significant negative correlation between carcass value and weight within the 4 groups ($r = - 0.283$, pooled within groups, and - 0.419 overall); that is, among carcasses of the same type, the heavier ones tended to be worth less per pound weight than the lighter, the decrease in the index being 0.024 pence for a 10 lb. increase in weight (cf. the regressions for individual cuts in Table 2). The mean values of the groups adjusted to side weights of 300 lb. are therefore also given in Table 4; the sex differences, when weight was allowed for, was reduced to 0.07 pence/lb. and became non-significant, that is the apparently greater value of the heifer carcasses was largely due to their being marketed at a lower weight. The slightly greater value of the yard-fattened animals occurred despite the fact that these animals were marketed at a somewhat higher weight than the animals fattened on grass, so at a constant weight, the treatment difference became more marked, increasing to about 0.17 pence/lb.

At first sight, it is surprising that the sex differences found for the individual cuts at 300 lb. should cancel out to leave a small non-significant sex difference in the index of wholesale side value, whereas the less evident treatment differences found for the individual cuts should combine to give a most marked preference in favour of the yard-fattened animals. In the treatment comparison, however, the rump cut difference combined with the round difference, so that the majority of the high-valued parts were better developed in the yard-fattened animals at 300 lb. side weight. On the other hand, in making the sex comparison, the superiority of steers over heifers at 300 lb. in the weight of the valuable leg cuts tended to counterbalance the superiority of heifers in rump weight. Since the possibility exists that a slight change of cutting procedure may have arisen during the test, it is not clear whether the greater wholesale value per pound of the yard-fattened animals was a genuine effect of the mode of fattening.

The range in the index of wholesale value of the 136 sides was from 17.806 to 19.568 pence/lb. using the particular wholesale prices quoted above, or 1.762 pence/lb. (9.5% of the mean) which is equivalent to a price differential of £4/8/0 on carcasses of 600 lb. weight. For the weights of individual cuts, when no allowance was made for side weight differences, there was some evidence that the 4 groups of carcasses were not equally variable and this trend was confirmed from the analysis of the indices of wholesale carcass value. The components of variance in Table 4 indicate that the sample of carcasses fattened in yards varied in wholesale side value much less than did the samples of grass-fattened cattle. In fact, the indices for the 12 heifers fattened in yards did not differ significantly. This non-homogeneity of the within-group variations means that the pooled analysis of variance for carcass value must be interpreted with caution.

The largest difference between the indices of wholesale value of the 2 sides from the same carcass was 0.753 pence/lb., but the mean difference (0.047 pence/lb.) was not significant. The standard error measuring cutting variation (the square root of the cutting error variance) was 0.164 pence/lb., or about 1% of the mean. As might be expected, this variation in the index (which is a sort of 'weighted average' of the individual wholesale prices) due to cutting errors was relatively smaller than the corresponding variations for the individual cuts, since the errors tend to cancel out each other.

From the data presented here on the variations in the index of wholesale carcass value both between and within carcasses, it is possible to make an estimate of the number of animals needed in controlled experiments to detect differences in carcass value between animals on 2 given treatments. The following list shows the differences between the treatment means of carcass value (in pence/lb.) required for significance at the 5% and 1% levels for various numbers of animals per treatment. The figures refer to steers only and separate values are given based on the grass-fattened and yard-fattened animals, since these differed markedly in variability. The loss in accuracy due to cutting only one side of each carcass is also shown.

	Number of animals per treatment	Carcass values based on cutting data from both sides		cutting data from one side only	
		5% level	1% level	5% level	1% level
Steers	5	0.42	0.61	0.46	0.67
	10	0.28	0.38	0.30	0.41
fattened on	15	0.22	0.26	0.24	0.33
	20	0.19	0.25	0.21	0.28
grass	25	0.17	0.22	0.18	0.25
Steers	5	0.18	0.26	0.22	0.32
	10	0.12	0.16	0.14	0.20
fattened in	15	0.10	0.13	0.12	0.16
	20	0.08	0.11	0.10	0.13
yards	25	0.07	0.10	0.09	0.12

 45

In interpreting this table, it should be borne in mind that the wholesale meat trade works on very small margins. A treatment difference of, say 0.25 pence/lb., which requires from 10-20 steers per treatment to detect it depending on conditions, is equivalent to a price differential of 12/6d on 600 lb. carcasses.

Estimating the index of wholesale carcass value

It is often not possible in practice to obtain full cut-out data on a series of experimental carcasses and it would be useful to have a simple means of estimating the index of wholesale carcass value. To obtain information on this problem, overall carcass values (calculated on the basis of combined weights of cuts from rising and close sides) have been correlated to various measurements, the results being given in Table 5. The product of the two diameters of the eye muscle cross-section (A x B), the ratio of weights of hindquarter and forequarter, and carcass weight were all significantly correlated to the index but the residual standard errors indicated that they are of little predictive value. This applied also to the weights of loin, rump and round (separately expressed as percentages of carcass weight) which all had low correlations with carcass value. The percentage of combined loin and rump had a lower correlation with carcass value than did rump alone, but the percentage of combined loin, rump and round had a high correlation, 0.926, when the grouping of the carcasses was ignored and the sample of 68 considered as a whole. The standard errors of prediction for this combination of cuts were 0.098 pence/lb. when a single overall prediction equation was used, and 0.096 pence/lb. when separate prediction equations were used for each group, compared with the overall standard deviation of 0.258 pence/lb. for carcass value. When the forerib cut was included, the correlations and standard errors were only slightly changed compared with the values for the (loin + rump + round) percentage, but the inclusion of the leg cut in both cases reduced the correlation and increased the errors of prediction by some 25%. The correlations calculated from the percentage yields of combinations of cuts from one side only were naturally somewhat less than those for the combined yields from both sides, four examples being given in the table. The standard errors of prediction of carcass value from the percentage of (loin + rump + round) from the rising and close sides were 0.126 and 0.133 respectively, and from the percentage of (loin + rump + round + leg) from the 2 sides were 0.137 and 0.153 pence/lb.

Figure 3 shows the indices of wholesale carcass value plotted against the percentage yields of combined loin, rump and round from both sides, the variable which had the highest overall correlation with carcass value. The differences in regression equation between the 4 groups of carcasses were slight for this particular variable, indicating that little accuracy of prediction is lost if a single overall regression equation is used. This is important if the method of predicting the index is to be of value for general application. The regression coefficients for both combinations involving the leg cut did differ between groups, being similar for the 2 sexes but significantly different between the treatments. This may be a further manifestation of a slight difference in cutting method between the 2 periods of the investigation.

DISCUSSION

Comparison of carcass conformation studies by different workers even within the same country will always be suspect when based on commercial cutting tests until a detailed systematic method of jointing has been devised. The formulation of such a plan for beef carcasses, and for pork and lamb as well, making use wherever possible of anatomical points of reference is one of the most

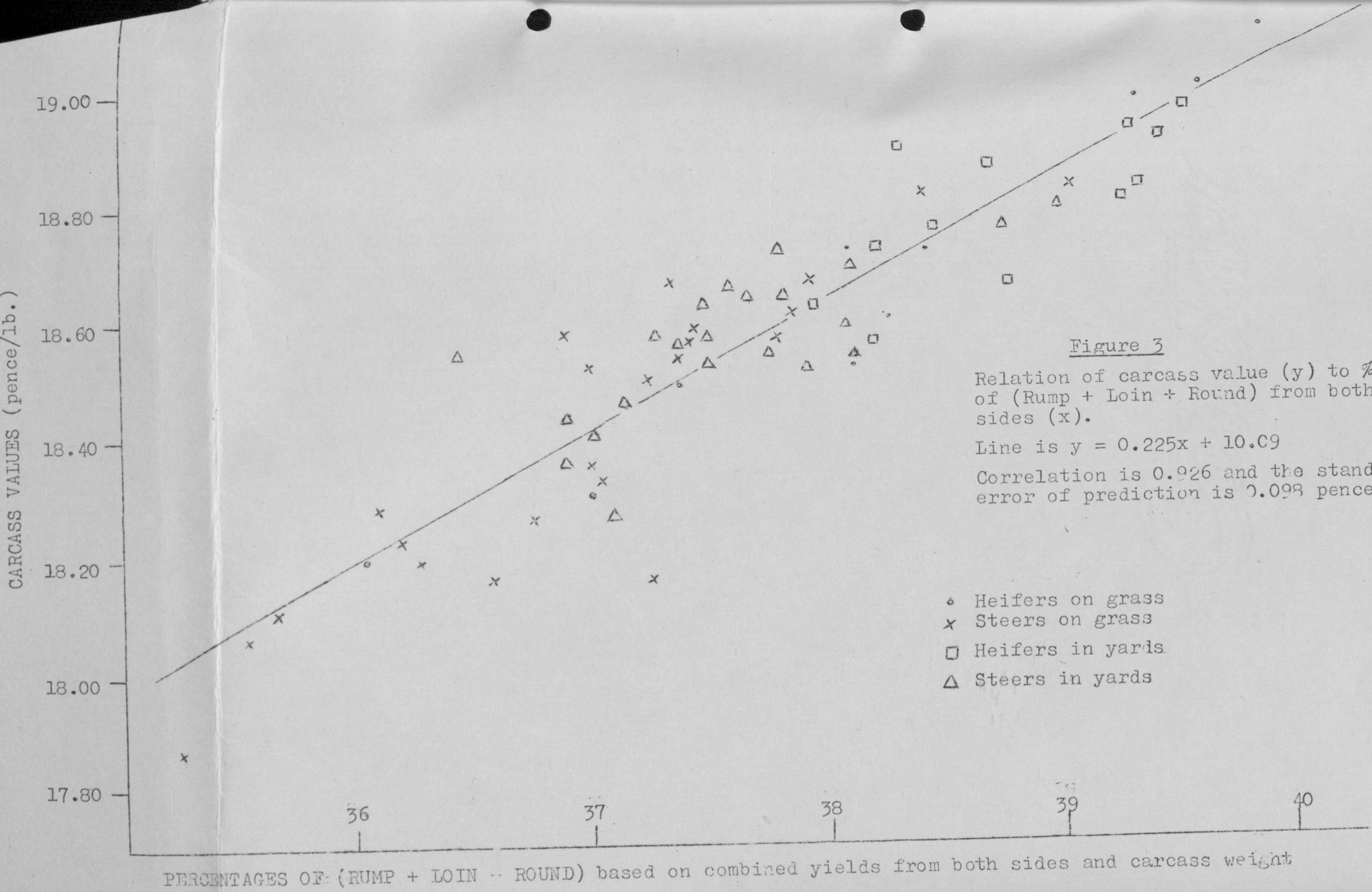


Figure 3

Relation of carcass value (y) to %age of (Rump + Loin + Round) from both sides (x).

Line is y = 0.225x + 10.09

Correlation is 0.926 and the standard error of prediction is 0.098 pence/lb.

46

important requirements for the advancement of carcass quality studies at the present time. The need is emphasized by comparing our results with those of Tayler (1958) who presented cutting data for twin steers of various breeds and for Hereford crossbred steers on four treatments. The method of cutting employed, although broadly the same as that used here on the Aberdeen-Angus crosses, involved a more detailed breakdown of some of the joints, but the results suggest that there were other differences of procedure. For example, the average weight of thin flank for steers on grass adjusted to 300 lb. side weight in this study was 13.0 lb. The average thin flank weight for 20 right sides (averaging 307.8 lb. in weight) for Tayler's Hereford crossbred steers was 9.7 lb. This difference is too much to attribute entirely to a breed or treatment effect and suggests the line of demarcation of thin flank from rump and loin was based on different points of reference in the 2 studies. Similarly the cod fat weighed 9.1 lb. in our sample of Aberdeen-Angus steers fattened on grass, compared with 5.6 lb. for the combined cod fat and goose skirt from the right sides of the 20 Hereford crossbred steers. This might indicate a markedly different level of fattening or a different method of trimming.

The information presented above on the cutting variations encountered in this survey will enable the improvement achieved by the adoption of a more strictly standardized technique of jointing to be measured. There have been 2 previous attempts to measure the accuracy of carcass cutting tests, both in the United States. Lasley & Kline (1957) gave results for 222 pigs expressed in the same manner as in this paper. The coefficients of variation for individual cuts ranged from 2.3 for ham to 6.4 for Boston butt, values which are comparable with those found here for the major meat cuts. Butler, Garber & Smith (1956) expressed the results of a study of both sides of some 80 beef carcasses in terms of correlations, but it is possible to compute coefficients of variation from other data given in the paper. These values included 9.5% for 'kidney and fat' weight, 4.7% for 'rib' weight, 6.3% for brisket, 7.4% for flank, 3.2% for 'full loin' and 6.2% for rump. In all cases where a comparison may reasonably be made between the joints produced by two greatly differing cutting systems, the agreement was remarkably good. It is not intended to discuss here in detail how the method of cutting may be improved but it is clear from these results and from the American work that the trimming of internal fat and the removal of the flank cuts are the most important sources of variation at the moment.

The cuts showing the greatest relative rate of development at the mean carcass weights found in this study were the cheap brisket and flank joints. This suggests that from the point of view of desirable conformation the optimum carcass weight had been passed, and that this sample of cattle had reached the desired level of finish and were marketed at somewhat too high a weight. In the analysis, the effects of sex and treatment on conformation were examined using covariance techniques to adjust the individual cut weights to a basis of 300 lb. side weight. This procedure was preferable to the use of mean percentage weights to compare the relative development of the different groups of carcasses, as the 4 groups were of similar mean dressing percentage and as the chosen weight was well within the ranges of weights found in the 4 groups. The method of comparing conformation would not be applicable to groups differing widely in mean carcass weight or degree of finish (estimated by dressing percentage); this might occur in a beef cattle experiment in which the end-point was determined by age rather than live weight or estimated dressing percentage.

After adjustments had been made for variations in side weight, the remaining variability in cutting yields in this sample of beef-type cattle was quite large, although markedly less in the yard-fattened cattle than in the grass-fattened groups. This latter difference is no doubt a reflection of the more uniform plane of nutrition provided by yard fattening. It is likely that cattle by beef bulls out of dairy or dual-purpose cows, which provide the bulk of our home-produced beef, would be even more variable in cut-out yield and conformation than this sample, although Brookes & Latham (1957) considered that the proportions of joints in a very small sample of dairy-bred steers were strikingly similar. Useful comparative cutting data for other breeds and crosses may eventually become available in this country from trials being carried out by National Agricultural Advisory Service Experimental Husbandry farms (Jones & Rennie, 1956).

The application of a detailed cutting test to experimental animals provides a large amount of information to be analysed and interpreted. Often it is difficult to obtain a clear indication of the overall importance of the treatment effects or breed differences, as some cuts may show significant differences whereas others appear unaffected. It is suggested that some index of wholesale carcass value, similar to that used in this investigation, provides a useful means of summarizing the results and of measuring the overall effects of treatments. The use of such an index in scientific investigations has been criticized because prices fluctuate so much from day to day and from place to place. However, the adoption of an average price structure is no more of an abstraction than is the use of a standardized cutting method, for in practice some butchers may adjust their cutting techniques to existing prices and differentials. A more realistic objection to the method is that cuts of the same type are considered of equal value per lb. whatever their weight. It may be possible for weight differences in a particular wholesale cut, say loin, to be due to variations in fat cover or the proportion of bone. Again, a long narrow loin or rib will be of intrinsically higher value than a short wide one of the same weight because of the greater difficulty of cutting retail joints from the latter. From these points of view, it may be preferable to extend the cutting test to retail rather than wholesale cuts but the boning out and the trimming of excess fat would introduce further problems of standardization.

The use of an index of wholesale carcass value in the present study has provided some information relevant to the development of new methods of carcass evaluation. Hammond (1956) suggested that conformation in beef carcasses might be measured using a particular type of cut employed on the Paris meat market. This method, called the "pan traité" (Charlet & Février, 1952; Leroy & Charlet, 1953), effectively separates the high and low priced parts by a single cut through the m.tensor fascia lata to the point of the ileum and then approximately parallel to the line of, and 12 inches from, the backbone to the 5th rib, division of the backbone being between the 5th and 6th ribs (Pomeroy, 1958). This cut is occasionally used with Scotch beef where the high priced part (or 'gun-bit') is sent to London, while the low priced part is retained in Scotland. Apart from this limited trade with high quality carcasses, the cut is almost unknown in this country. Its introduction as a means of evaluating experimental carcasses, many of which would be of inferior quality, might meet with some opposition from wholesalers who might prefer the conventional straight quartering between the 10th and 11th ribs.

In this investigation, the yield of the "French" cut has been estimated by calculating the combined yield of 6 wholesale cuts, namely leg, topside, silverside, top rump, rump, loin and forerib. This is not fully satisfactory since the forerib was separated from the middlerib between the 7th and 8th ribs and so this artificial "French" cut was 2 ribs shorter than is really desirable. The correlations given above showed that the percentage yield of this cut was certainly highly correlated with the index of wholesale carcass value, but it gave no more accurate prediction than the same cut less forerib, that is the commercial hindquarter trimmed of internal fat and with the thin flank removed. This particular piece, usually termed a "hindquarter ex flank and suet" is a recognized cut on Smithfield market in London and there would be no difficulty in its disposal.

The correlations also showed, however, that a 25% increase in predictive accuracy could be achieved if the leg cut were removed. The resulting piece, in which all the highest price cuts of the hindquarter are combined together (the loin, rump and round) should be in high demand since the purchaser would not have the trouble of disposing of the cheaper cuts of the hindquarter, but on the other hand it might introduce some handling difficulties since it cannot be hung up in the normal manner. A considerable loss in accuracy occurs if the yield of this piece can be obtained for one side only.

The adoption of this reduced hindquarter as an experimental cut would avoid the difficulties of introducing the "French" cut with little, if any, loss in accuracy. On the other hand, it would do little to alleviate the problems of standardization, for the removal of the internal fats and the flank has been shown to be the most difficult part of the cutting procedure to standardize.

It is unfortunate that by the nature of the survey it was not possible to obtain certain carcass measurements such as length of body and loin, depth of carcass and circumference of round before the sides were quartered. An examination of the relation of these measurements to the index of wholesale carcass value and to the yields of particular cuts would have been of value in indicating whether such measurements have any importance in carcass evaluation other than pure description (Harrington, 1958; Pomeroy, 1958). It is hoped to carry out a further investigation with these objects in view.

SUMMARY

1. Both sides of 68 carcasses of Aberdeen-Angus cross steers and heifers were broken down into wholesale joints by the same butcher using a modification of the London & Home Counties style of cutting. Thirty-four of the cattle were fattened on grass in the summer of 1955 and the other 34 in yards during the following winter.

2. Sides of steer carcasses averaged some 50-60 lb. heavier than those of heifers both in summer and winter, and the yard-fattened cattle gave sides averaging 10-20 lb. heavier than those from grass-fattened cattle.

3. The cuts along the underline of the animals (brisket and flanks) were increasing in weight at proportionally the greatest rate and the shin and hind-leg cuts at about half this rate, with those along the top of the back intermediate.

4. At a side weight of 300 lb., steers were significantly lighter than heifers in the weight of kidney knob, cod fat, thin flank, forequarter flank, loin and rump, whereas they were significantly heavier than heifers in weight of leg, shin, topside, top rump and the neck cuts (clod and sticking). These differences suggested that at this weight of side, heifers were at a more advanced stage of development than steers.

50

5. Animals fattened in yards yielded, at a side weight of 300 lb., a greater weight of rump, top rump, silverside and the neck cuts than did animals fattened on grass. The latter showed greater development of brisket, thin flank and skirt at this weight. A slight alteration in cutting technique during the test could have affected this treatment comparison.

6. Coefficients of variation, measuring variability, among animals of the same type and carcass weight, of the mean weight of the 2 examples of a particular cut from each carcass ranged from 2.1% to 12.2% for the main joints. The kidney knob, cod fat and skirt showed greater variation, the coefficients being 25.5%, 15.9% and 13.9% respectively.

7. Rising (right) sides averaged 2.7 lb. heavier than close (left) sides, and gave a significantly greater weight of loin, middlerib and, in heifers, kidney knob. Close sides gave a significantly greater weight of the neck cuts and silverside.

8. Measures of cutting variations showed that the kidney knob, cod fat, skirt and flank cuts were the most difficult to remove in a standard manner.

9. The index of wholesale carcass value (calculated from the cutting yields and average wholesale prices) ranged from 17.806 pence/lb. to 19.568 pence/lb. among the 136 sides and tended to decrease as weight of side increased.

10. The sexes did not differ significantly at a side weight of 300 lb. in the index of wholesale value, whereas yard-fattened animals at this weight gave sides worth 0.17 pence/lb. more than those fattened on grass.

11. The index of wholesale carcass value varied more among animals fattened on grass than among those fattened in yards.

12. The index of wholesale carcass value was highly correlated with the percentage yield of the combined loin, rump and round from both sides, the standard error of prediction being 0.098 pence/lb. compared with the overall standard deviation for the index of 0.258 pence/lb. There was a considerable decrease in the accuracy with which the index could be predicted if this yield was measured from one side only, or if the leg cut was not removed.

13. The need for standardization of cutting methods, the use of indices of carcass value in experimental work, and the introduction of certain experimental cuts as an aid to the measurement of carcass conformation, are discussed.

ACKNOWLEDGEMENTS

We are most grateful to J.Sainsbury Ltd. for arranging this survey and for allowing us to describe the results of our analyses, and to Mr. Frank Gerrard for his advice on wholesale prices.

57

REFERENCES

BROOKES, A.J. & LATHAM, J.O. (1957). Investigations into problems involved in the production of beef from dairy-bred steers. Emp.J.exp.Agric., 25, 339-355.

BUTLER, O.D., GARBER, M.J. & SMITH, R.L. (1956). Beef carcass composition and yield of wholesale cuts as estimated from left and right sides. J.Anim.Sci., 15, 891-895.

CHARLET, P. & FÉVRIER, R. (1952). Méthodes d'appreciation de la valeur d'un animal de boucherie. (Methods of evaluating meat animals). Ann.Nutr., [Paris], 6, C133-C157.

GERRARD, F. (1951). Meat Technology, 2nd Edition, Leonard Hill, London.

HAMMOND, J. (1956). Evaluating a beef carcass by cutting. Hereford Breed J., 3, (1), 118-119.

HARRINGTON, G. (1958). Pig carcass evaluation. Tech.Commun.Bur. Anim.Br.,Edinb., No.12, 120pp.

JONES, E.L. & RENNIE, G.K. (1956). A comparison of different breeds and crosses for beef production. Experimental Husbandry, No.1, 48-57.

LASLEY, E.L. & KLINE, E.A. (1957). Splitting and cutting errors in swine carcass evaluation. J.Anim.Sci., 16, 485-489.

LEROY, A.M. & CHARLET, P. (1953). The appraisal of meat. Proceedings of the Third Study Meeting of E.A.A.P., Siena-Rome, September, 1953. Publ.Europ.Ass.Anim.Prod.[Rome], No.4, 69-95.

McMEEKAN, C.P. (1940). Growth and development in the pig, with special reference to carcass quality characters. III. Effect of plane of nutrition on the form and composition of the bacon pig. J.agric.Sci., 30, 511-569.

POMEROY, R.W. (1958). Methods of assessing the value of the beef carcass. Paper read to the Commission on Cattle Production. European Association for Animal Production, Brussels, July, 1958.

TAYLER, J.C. (1958). Carcass quality studies in cattle: The measurement of conformation. Proc.Brit.Soc.Anim.Prod., 1958, 65-76.

YATES, F. (1934). The analysis of multiple classifications with unequal numbers in the different classes. J.Amer. Statist.Ass., 29, 51.

Cut	Overall mean weight (lb)	Average weights as %ages of side weight	Average weights as %ages of hind & fore quarter less losses	Mean weights within groups (lb)				Standard deviation A (lb)	Coefficient of variation A (%)
				Heifers on grass	Steers on grass	Heifers in yards	Steers in yards		
1. LEG	12.6	3.9	7.5	10.27	13.85	10.41	13.47	0.95	7.5
2. TOPSIDE	17.8	5.5	10.5	14.92	18.75	15.89	19.20	1.42	8.0
3. SILVERSIDE	30.7	9.5	18.2	24.98	31.61	28.22	33.62	2.54	8.3
4. TOPRUMP	15.8	4.9	9.4	12.65	16.26	14.26	17.48	1.37	8.7
5. RUMP	24.9	7.7	14.7	21.60	24.96	24.90	26.60	2.23	9.0
6. LOIN	33.2	10.2	19.7	28.97	34.38	31.40	34.67	3.31	10.0
7. KIDNEY KNOB	8.2	2.5	4.9	7.18	8.54	8.47	8.29	2.18	26.6
8. THIN FLANK	14.7	4.5	8.7	13.01	15.56	13.22	15.33	2.34	15.9
9. COD FAT	9.1	2.8	5.4	9.12	9.31	9.16	8.93	1.60	17.6
10. SKIRT	1.9	0.6	1.1	1.78	2.04	1.68	1.99	0.30	15.8
- HINDQUARTER LOSS	0.8	0.3	-	0.67	0.75	0.84	0.94	-	-
11. FORERIB	12.2	3.7	7.9	10.60	13.00	10.89	12.89	1.42	11.6
12. MIDDLERIB	35.8	11.0	23.2	30.20	37.57	31.50	38.68	3.00	8.4
13. STEAKPIECE	29.3	9.0	19.0	22.62	30.42	26.41	32.76	3.14	10.7
14. BRISKET	21.5	6.6	13.9	18.13	23.16	18.60	22.76	2.27	10.6
15. FOREQUARTER FLANK	16.3	5.0	10.6	13.54	16.97	14.63	17.78	1.99	12.2
16. CLOD & STICKING	31.2	9.6	20.2	23.63	32.65	28.01	34.65	2.87	9.2
17. SHIN	7.9	2.4	5.1	6.28	8.66	6.36	8.58	0.63	8.0
- FOREQUARTER LOSS	0.9	0.3	-	0.21	0.93	1.15	1.18	-	-
- SIDE	325.0	100.0	-	270.38	339.35	296.00	350.00	26.20	8.1

Table 1. The average weights of the side and of each cut, overall and within each of the four groups, with standard deviations A (pooled within groups) and coefficients of variation A (based on overall means and standard deviations A).

Cut	Increase in weight of cut per 10 lb increase in side weight	Overall mean weights (lb) adjusted to a side wt. of 300 lb	Mean weights within groups (lb) adjusted to side weights of 300 lb.				Significance of			Standard deviation B (lb)	Coefficient of variation B (%)
			Heifers on grass	Steers on grass	Heifers in yards	Steers in yards	A	B	C		
1. LEG	0.20	11.7	10.86	13.07	10.49	12.48	***	-	-	0.80	6.8
2. TOPSIDE	0.38	16.7	16.05	17.25	16.04	17.29	**	-	-	1.01	6.0
3. SILVERSIDE	0.79	28.5	27.31	28.51	28.54	29.68	-	*	-	1.50	5.3
4. TOPRUMP	0.38	14.6	13.77	14.78	14.41	15.60	*	*	-	0.96	6.6
5. RUMP	0.76	23.5	23.86	21.96	25.20	22.79	***	**	*	1.06	4.5
6. LOIN	0.11	30.8	32.25	30.02	31.84	29.13	**	-	*	1.62	5.3
7. KIDNEY KNOB	0.40	7.6	8.37	6.94	8.63	6.27	*	-	-	1.94	25.5
8. THIN FLANK	0.65	13.4	14.92	13.02	13.48	12.10	*	*	-	1.63	12.2
9. COD FAT	0.28	8.7	9.94	8.22	9.27	7.55	**	-	-	1.38	15.9
10. SKIRT	0.06	1.8	1.96	1.80	1.70	1.68	-	*	-	0.25	13.9
- HINDQUARTER LOSS	-	0.8	0.76	0.63	0.85	0.79	-	-	-	-	-
11. FORERIB	0.35	11.4	11.64	11.62	11.03	11.13	-	*	-	0.82	7.2
12. MIDDLERIB	1.12	32.9	33.51	33.18	31.95	33.10	-	-	-	0.69	2.1
13. STEAKPIECE	0.93	26.7	25.38	26.75	26.78	28.10	-	-	-	2.03	7.6
14. BRISKET	0.77	19.6	20.41	20.13	18.91	18.90	-	***	*	1.04	5.3
15. FOREQUARTER FLANK	0.69	14.8	15.60	14.24	14.91	14.31	*	-	-	0.82	5.5
16. CLOD & STICKING	0.94	28.5	26.40	28.97	28.38	30.17	**	**	*	1.50	5.3
17. SHIN	0.15	7.3	6.72	8.07	6.42	7.83	***	-	-	0.50	6.8
- FOREQUARTER LOSS	-	0.8	0.26	0.86	1.16	1.09	-	**	-	-	-

<u>Table 2</u>. The average weights of each cut, overall and within each group, corrected to side weights of 300 lb., with the significance of the difference between sexes (A), between treatments (B) and the interaction (C). Also given are standard deviations B (pooled within groups and allowing for weight) and coefficients of variation B (based on overall adjusted means and standard deviations B) and the pooled within group regression coefficients of cut weight on side weight.
*** indicates $p < 0.001$, ** indicates $0.01 > p > 0.001$ and * indicates $0.05 > p > 0.01$

Cut	Mean diffs: between sides (R - C)	"Cutting error" variances (sides x carcass inter-action mean square)	Coefficients of variation (cutting standard error as %age of mean)
1. LEG	+ 0.15	0.460	5.4
2. TOPSIDE	+ 0.02	0.701	4.7
3. SILVERSIDE	- 0.45≠	0.633	2.6
4. TOPRUMP	- 0.22	0.792	5.6
5. RUMP	+ 0.20	1.517	4.9
6. LOIN	+ 1.08≠	1.623	3.8
7. KIDNEY KNOB Heifers	+ 0.80≠	0.704	10.2
Steers	- 0.19		
8. THIN FLANK	- 0.13	0.959	7.8
9. COD FAT	0.00	0.428	7.1
10. SKIRT	- 0.02	0.030	8.9
11. FORERIB	+ 0.12	0.515	5.9
12. MIDDLERIB	+ 2.11≠	4.703	6.1
13. STEAKPIECE	+ 0.58	5.264	7.8
14. BRISKET	+ 0.31	0.925	4.5
15. FOREQUARTER FLANK	+ 0.06	1.005	6.1
16. CLOD & STICKING	- 0.83≠	2.603	5.2
17. SHIN	- 0.05	0.037	2.4
- SIDE	+ 2.69≠	5.195	0.7

Table 3. The mean difference between sides (≠ indicates significance at the 1% level) and measures of the variation due to cutting.

	Actual mean wholesale side values (pence/lb)	Mean wholesale side values adjusted to 300 lb. side wt. (pence/lb)	COMPONENTS OF VARIANCE	
			Error (sides x carcass) variance	Between carcass variance
Heifers on grass	18.670	18.597	0.0468	0.0697
Steers on grass	18.446	18.544	0.0341	0.0706
Heifers in yards	18.800	18.791	0.0202	0.0065
Steers in yards	18.573	18.697	0.0141	0.0096

Table 4. Mean wholesale side values in the 4 groups of carcasses and components of variance.

5