CLASSIFICATION AND GRADING OF PIG CARCASSES

J. L. ADAM
Ruakura Agricultural Research Centre, Hamilton

SUMMARY

Grading survey data for 6,008 pig carcasses from five meat export works and abattoirs in New Zealand are presented. The data included pork carcasses in the cold carcass weight range of 50 to 110 lb, and also baconer carcasses between 111 and 180 lb.

The data indicated that the subjective grading of pork did not allocate carcasses to grades according to lean content as indicated by fat depth (measurement C) taken by introscope. While bacon carcasses were graded according to midline back-fat depths, these fat depths did not always reflect the depth of fat off the midline at the C position.

Fat depth C was found to be more highly correlated with fat-to-lean ratio at the last rib than were midline back-fat depths. The comparative failure of grading based on midline fat depth to reflect C fat and therefore the fat-to-lean ratio in the loin, was considered a practical limitation of current bacon carcass grading.

It was suggested that current carcass grading would be improved by taking a fat depth measurement off the midline, and by recognizing differences between sexes.

THE PURPOSE of grading is to indicate the commercial value of a carcass in order to provide a basis for payment to the producer. If the carcasses are of a very uniform type then weight alone may serve to group them into grades, but this ideal situation is seldom attained with pigs. More usually carcass grade is determined either by measuring the thickness of subcutaneous fat plus rind on the split carcass or by the percent yield of the most valuable fat trimmed joints (Harrington, 1958).

In New Zealand, pig carcasses are classified as either pork (up to 110 lb cold dressed weight) or bacon (111 to 180 lb). Culled breeding stock and entire males are graded under porker specifications regardless of carcass weight. The two classes of carcasses are graded by different methods, both of which are intended to assess leanness. In the case of pork, leanness is assessed visually on the unsplit carcass. For baconer grading, a continuous cut is made in the rind and subcutaneous fat over the vertebral column between the tail and head. The allocation of baconer carcasses to a grade is then based on the depth of subcutaneous fat plus rind on the exposed surface

TABLE 1: NEW ZEALAND GRADING SPECIFICATIONS FOR COLD CARCASS WEIGHT, SHOULDER AND LOIN BACK-FAT TEN DEPTHS

Bacon Grade	*Cold Carcass Wt (lb)*	*Max. Back-fat Depth (⅛ in.) Shoulder*	*Loin*
Prime 1	111-120	11	6
	121-160	12	7
Prime 2	111-120	13	8
	121-160	14	9
Prime	161-180	16	11
Second	111-120	None	None
	121-160		

(Table 1). In addition to these separate grading procedures, carcasses in both classifications are assessed visually for conformation, lean meat and fat quality.

It is a general belief at present that the consumer prefers meat with a high proportion of lean-to-fat in joints and cuts. Hence it is of interest to consider how well current grading procedures agree in their assessment of similar carcasses. The most obvious base against which to make this evaluation is lean yield by dissection. However, the destruction of carcasses involved in such a procedure makes this approach impractical. As an alternative a linear measurement of subcutaneous fat depth including rind was used, measurement C.

Fat depth C has been shown to be more highly correlated with the percentage and yield of lean meat in the carcass than fat depths taken over the carcass midline or vertebral column (Joblin, 1966a; McMeekan, 1941). The C measurement has been shown to be highly repeatable (Joblin, 1966a). In addition this measurement can also be used on unsplit carcasses, an obvious advantage for pork, without resulting in any significant mutilation.

In this paper the results of a grading survey are presented together with a discussion on how well carcasses are graded according to their content of lean meat.

MATERIALS AND METHODS

GRADING SURVEY

A pilot grading survey was carried out at four meat export works and one abattoir. Four of the killing centres were in the North Island. The data collected by the Research and Meat Divisions, New Zealand Department of

Agriculture, were from 6,008 carcasses (gilts and castrated males) of 50 to 180 lb cold carcass weight. This number represented slightly less than one percent of the annual kill.

The output of only one works was sampled at regular intervals throughout the year. The remaining killing centres were sampled twice during the period of peak kill in late spring and early summer. No data were collected from carcasses weighing over 110 lb in the South Island.

The data collected on all carcasses excluded sex but included

(1) Carcass grade (non export).
Pork (Anon., 1962).
Bacon (Anon., 1940, Table 1).

(2) Cold carcass weight — this was derived from the hot weight of the eviscerated carcass, taken within 20 min of stunning, less a variable allowance for shrinkage.

(3) Fat depth C, measured with an introscope, 4 cm to left of the carcass midline immediately posterior to the last rib.

For carcasses of between 111 and 180 lb cold weight, the following two midline measurements of back-fat thickness were taken by means of a ruler.

(4) Shoulder back-fat depth — the depth of subcutaneous fat plus rind over the third thoracic spinus process.

(5) Loin back-fat depth — the minimum depth of subcutaneous fat plus rind in the region of the last thoracic vertebra.

In the analyses of the data no account was taken of regional differences because of the sampling procedures. However, the possibility of biases due to geographical regions cannot be excluded.

Feeding Trial

In addition to the survey data one available replicate of a feeding trial (Joblin, 1964) was used to investigate the relationships between selected back-fat depths and the ratio of fat-to-lean on the cut surface at the level of the last rib.

The trial involved two boars of similar growth rate selected for high and low back-fat and mated to random groups of sows. The castrate and gilt progeny of these

matings were fed at a high and low level of feeding until slaughter at 187 lb live weight.

From photographs taken after curing, the fat-to-lean ratio (B.R.R.) was determined (Lucas and Mitchell, 1962) and C fat depth measured (Buck *et al.*, 1962). Shoulder and loin back-fat depths were measured in the manner outlined for the survey data.

RESULTS

Grading Survey

The proportion of pork and bacon weight pigs allocated to the various grades according to existing grading schedules is given in Table 2. The survey results showed that pork carcasses were allocated to two of the three available grades under existing grading specifications and 98.2 per cent were first grade. Baconer carcasses were allocated to all grades except the prime grade for carcasses of between 161 and 180 lb, as no carcass met the necessary specifications. For carcasses in the bacon weight range, 91% met the specifications for the two top grades.

The distribution of all pork carcasses according to weight (Table 3) showed that only 2.7% had a cold carcass weight of less than 60 lb. While the remaining car-

TABLE 2: PERCENTAGE OF PORK AND BACONER CARCASSES IN VARIOUS GRADES

	Grade (%)		
	First	*Second*	*Manuf*
Pork carcasses (up to 110 lb): Nos. 2451	98.2	1.8	0.0
	Prime 1	*Prime 2*	*Second*
Bacon carcasses (111 to 180 lb): Nos. 3657	57.3	33.8	8.9

TABLE 3: PERCENTAGE OF ALL PORK CARCASSES AND CARCASSES WITHIN GRADES CLASSIFIED ACCORDING TO CARCASS WEIGHT

Cold Carcass Weight Range (lb)	*All Carcasses (%)*	*Pork Grade (%)*		
		First	*Second*	*Manuf*
⩽ 60	2.7	2.6	6.8	0
61-70	14.7	14.9	6.8	0
71-80	26.9	27.3	6.8	0
81-90	19.9	20.1	6.9	0
91-100	17.3	17.3	15.9	0
101-110	18.5	17.8	56.8	0
Total	100.0			

TABLE 4: PERCENTAGE OF ALL BACON CARCASSES AND THOSE WITHIN GRADES CLASSIFIED BY WEIGHT

Cold Carcass Weight Range (lb)	*All Grades (%)*	*Bacon Grade (%)*		
		Prime 1	*Prime 2*	*Second*
111-120	15.4	18.2	13.1	5.5
121-130	28.8	33.6	23.6	16.9
131-140	35.1	34.8	36.8	31.2
141-150	14.9	10.7	18.8	27.3
151-160	4.8	2.3	7.0	13.2
161-170	0.7	0.3	0.6	3.1
171-180	0.3	0.1	0.1	2.8
Total	100.0			

TABLE 5: DISTRIBUTION OF CARCASS WEIGHT ACCORDING TO GRADES

Cold Carcass Weight Range (lb)	*Nos. Carcasses*	*Bacon Grade (%)*		
		Prime 1	*Prime 2*	*Second*
111-120	562	68.0	28.8	3.2
121-130	1051	67.0	27.8	5.2
131-140	1284	56.7	35.4	7.9
141-150	545	41.1	42.6	16.3
151-160	178	27.5	48.3	24.2
161-170	24	25.0	33.3	41.7
171-180	11	9.0	9.2	81.8

casses were fairly evenly distributed between 61 and 110 lb, there was an indication of a slightly higher proportion of carcasses in the weight range of 71 to 80 lb. The distribution of carcasses according to weight within the first grade was similar to that for all pork carcasses regardless of grade. However, within the second grade, 56.8% of carcasses had carcass weights between 101 and 110 lb.

The distribution of all baconers according to weight indicated that 79.3% of the carcasses weighed less than 140 lb (Table 4). Within the prime 1 grade, 86.6% of carcasses weighed less than 140 lb, but this figure decreased to 73.5% within the prime 2 grade and finally reached 53.6% for second grade carcasses. The effect of increases in carcass weight on grade can be seen more clearly in Table 5. While 68% of carcasses weighing between 111 and 120 lb were placed in the first grade, this percentage decreased to 41.1% for carcasses of between 141 and

150 lb. In contrast, there was an increase in the proportion of carcasses in the prime 2 and second grades with increases in carcass weight up 150 lb.

The C fat depths for pork (Table 6) showed that there was practically no difference between first and second grades in average fat depths (Table 6); second grade carcasses were the more variable. Average C fat depth increased for successive 10 lb increments in carcass weight,

TABLE 6: MEAN INTROSCOPE C VALUES FOR GRADES AND CARCASS WEIGHT RANGES

	Back-fat Depth Introscope C (mm)	
Grade (Pork)	*Mean*	*S.D.*
First	13.0	4.1
Second	13.6	6.8
Manufacture	—	—
Cold Carcass Weight Range (lb)		
60	9.8	3.7
61-70	11.1	3.6
71-80	11.8	3.4
81-90	12.4	3.6
91-100	14.6	4.0
101-110	15.9	4.1

TABLE 7: MEAN INTROSCOPE C, SHOULDER AND LOIN BACK-FAT DEPTHS FOR GRADES AND CARCASS WEIGHT RANGES

	Introscope C (mm)		*Back-fat Depth Shoulder (⅛ in.)*		*Loin (⅛in.)*	
Grade (Bacon)	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
Prime 1	17.8	3.5	11.0	1.1	5.4	1.0
Prime 2	21.6	3.9	13.2	0.9	7.0	1.0
Second	26.6	6.1	15.5	1.5	8.1	2.5
Cold Carcass Weight Range (lb)						
111-120	17.9	4.2	11.2	1.5	5.5	1.3
121-130	19.1	4.4	11.6	1.5	5.9	1.3
131-140	20.1	4.3	12.1	1.6	6.2	1.7
141-150	21.4	4.8	12.7	2.0	6.7	1.4
151-160	23.0	6.4	13.1	1.9	7.2	1.6
161-170	30.4	6.9	13.3	2.0	7.7	1.5
171-180	34.7	7.4	15.5	2.0	7.8	1.6

and it appeared that there was slightly less variation within a 10 lb carcass weight range than within grades.

Mean back-fat thickness measurements for baconer carcasses showed that all three measurements were different in the three different grades (Table 7). There was some overlap between grades in both shoulder and loin back-fat depths, but this appeared more pronounced for the C fat depth. All three fat depths increased with a corresponding increase in carcass weight. In contrast to pork there was an indication of greater variability within 10 lb carcass weight ranges than within each of the two grades of prime 1 and 2. The results for bacon show that there is a large overlap in fat cover between adjacent 10 lb carcass weight ranges. A similar results was also found for pork carcasses. This overlap was large enough to preclude the use of carcass weight as the sole grading criterion.

Feeding Trial

The correlation between each of the three back-fat depths and the B.R.R. calculated for each sex, showed that fat depth C was the most highly correlated. The correlation coefficients between C and the B.R.R. were 0.49 ($P < 0.05$) and 0.83 ($P < 0.001$) for castrates and gilts, respectively. The lower correlation for castrates was due to bias of level of feeding ($P < 0.05$). For the same C fat depth, castrates on the higher feeding level had a higher B.R.R. than their contemporaries on the lower feeding level. Regression equations to predict the B.R.R. from C fat depth are given in Table 8. No differences due to sex were found between the regression equations and an equation was calculated for all animals. In this equation the regression constant did not differ from zero ($P < 0.05$).

TABLE 8: REGRESSION EQUATIONS FOR PREDICTING THE BACK RASHER RATIO FROM FAT DEPTH C

Sex	*Coeff.*	*Const.*	
Castrate	0.060	0.20	0.34*
Gilt	0.061	0.11	0.14*
All	0.061	0.16	0.26
	0.068	—	0.26

*0.34 > 0.14 ($P < 0.05$)

DISCUSSION

The use of C back-fat depth as an indirect method of estimating carcass lean in this survey can be challenged on the grounds of relative accuracy, and bias due to breed and sex. While it has been shown that measurement C gives a more accurate estimate of carcass lean than midline back-fat depths (Buck *et al.*, 1962; Joblin, 1966a), an even greater accuracy can be achieved by the use of dissected sample joints (Cuthbertson and Pease, 1968) and from specific gravity (Joblin, 1966b). Of these, only the specific gravity technique offered a possible alternative since its use would not detract from the value of the carcass. However, owing to practical difficulties and biases due to breed and sex (Standahl, 1965) this procedure was discarded in favour of introscope C back-fat thickness.

Although back-fat depths provide an obvious and convenient indirect method of estimating lean, with the C measurement being highly repeatable, comparatively little is known about biases introduced by breed and sex. Differences have however been found between breeds having the same thickness of back-fat (Buck *et al.*, 1962). These workers also showed that gilt carcasses contained 2.4% more lean than those of castrates for the same back-fat measurements. Similarly, Joblin (1966a) found gilt carcasses contained 2.3% more lean than those of castrates at the same thickness of C back-fat. It is unlikely that different breeds can be recognized and incorporated into modern production line grading, but sex can be readily and quickly ascertained on the eviscerated carcass. However, sex was not recorded in this pilot survey.

Despite the limitations associated with introscope C back-fat depth, this measurement was found to be more highly correlated with the B.R.R. than were midline shoulder or loin fat depths. Since the first use of this particular back rasher ratio (Lucas and Mitchell, 1962), it has been shown to be highly related to the proportion of lean in the carcass (Smith *et al.*, 1967). In addition, introscope probes taken off the carcass midline have also been shown to be useful indicators of "eye" muscle area (Marshall *et al.*, 1968).

Three observations from the survey data were of particular interest. It was noticeable that most pork carcasses were in the first grade, and that the mean C fat depth differed little between the top two grades. In addition, the standard deviation for C fat depth indicated that 15% of pork carcasses would probably have a C fat depth

of a bacon carcass, yet would have smaller "eye" muscles. On the other hand, second grade pork carcasses had either very large or very small depths of fat at C. While it was possible that all carcasses carried a desired level of fat cover, it is nevertheless unlikely. A more probable explanation was the failure of the subjective method of appraisal to differentiate between degrees of fat cover.

The second observation was that the grading of bacon on split carcass measurements appeared to be more effective than the system used for pork, in that all back-fat measurements increased with a decrease in grade. However, there was some overlapping between grades in midline shoulder and loin back-fat depths. A similar finding was reported from a survey by Fredeen and Bowman (1968) in which grade was also determined by midline back-fat depths.

The third observation was that while midline back-fat depths overlapped between grades, the standard deviations calculated within grades indicated that the overlap was greatest for C fat depth. This would suggest that present bacon grading did not always reflect the depth of fat off the midline. This observation is in agreement with that of Harrington (1958). The comparative failure of the current bacon grading procedures to detect carcasses with excess fat in the highly priced back or loin joint appears an important practical limitation. While cutting carcasses at the level of the last rib has been suggested as a method of detecting unwanted fat on the dorsolateral edge of the "eye" muscle, this is rarely practical for grading purposes. However, as an alternative, C fat depth did identify carcasses carrying excess fat in the region of the "eye" muscle.

Since current baconer grading did not reflect fat depth C off the midline with any consistency, it seems probable that there could be considerable variations in the B.R.R. within grades and also overlapping between grades. The B.R.R. reflecting the fat-to-lean ratio seems likely to be important from a consumer point of view, and thereby influence the commercial value of the carcass. It is not known how much this ratio varies for commercial pigs in New Zealand. However, when the regression for all animals between C and the B.R.R. was applied to bacon carcasses in the grading survey, 52% of prime 1 pigs had a ratio greater than 1.0, while 30% of prime 2 carcasses were over 1.5. From a survey in the U.K., Lucas and Mitchell (1962) stated that a ratio of 1.0 was optimum, while 1.5 or more was unacceptable. Together these indicate

a need to examine the back rasher ratios of commercial pigs in New Zealand.

In addition to fat depth C as a measure of the B.R.R., a knowledge of the sex of the animal might also be considered for grading. It has been found that castrates have higher B.R.R.s than gilts (Smith *et al.*, 1967). In addition Lucas and Mitchell (1962) found that of the carcasses in their survey, 26% of those from gilts and 72% of those from castrates had a B.R.R. in excess of 1.5.

CONCLUSIONS

It appeared from the survey data that the grading of pork carcasses by subjective appraisal was not allocating carcasses to grades according to their content of lean meat as assessed by C fat depths taken by introscope. While bacon carcasses were graded according to back-fat thicknesses on the midline, there was evidence of overlapping between grades in these back-fat measurements. However, the extent of the overlap between grades was more evident for C fat depth, which suggested that midline back-fat depths did not necessarily reflect the depth of fat over the "eye" muscle. Results also showed that C fat depth was more highly correlated with the fat-to-lean ratio in the loin than midline fat depths. It was suggested that the B.R.R. was likely to influence the value of the carcass, and it appeared that current baconer grading did not accurately reflect this ratio. It was indicated that the effectiveness of grading might be improved by the use of introscope C fat depths and by considering sex in grading procedures.

ACKNOWLEDGEMENTS

K. Hargreaves and J. W. Baker for assistance in the collection of data and the Meat Division of the New Zealand Department of Agriculture for supplying additional grading information. K. Jury and D. Duganzich for statistical analyses, and A. D. H. Joblin for constructive comments and permission to use his trial data.

REFERENCES

Anon., 1940: *Meat Refrigerations.* N.Z. Govt. Publ. 1963/192.
————, 1962: *N.Z. Stand. Specif.*, N.Z. Stand. Inst. 681.
Buck, S. F.; Harrington, G.; Johnson, R. F, 1962: *Anim. Prod., 4*: 25.
Cuthbertson, A.; Pease, A. H. R., 1968: *Anim. Prod., 10*: 249.
Fredeen, H. T.; Bowman, G. H., 1968: *Can. J. Anim. Sci., 48*: 109.

Harrington, G., 1958: *Tech. Comm. No. 12.* Commonwealth Agric. Bureau, England.
Joblin, A. D. H., 1964: *Proc. Ruakura Fmrs' Conf.,* p. 240.
————, 1966a: *N.Z. Jl agric. Res., 9*: 108.
————, 1966b: *N.Z. Jl agric. Res., 9*: 227.
Lucas, I. A. M.; Mitchell, G. A., 1962: *Anim. Prod., 4*: 295 (Abstr.).
Marshall, Janet E.; Watson, J. H.; Slattery, A., 1968: *Anim. Prod., 10*: 283.
McMeekan, C. P., 1941: *J. agric. Sci., Camb., 31*: 1.
Standahl, Nils, 1965: *Acta. Agric. scand., 15*: 65.
Smith, W. C.; Tonks, H. M.; Lawrence, N., 1967: *Anim. Prod., 9*: 255.