The prediction of saleable meat yield in lamb carcasses

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Jones, S. D. M., Robertson, W. M., Price, M. A. and Coupland, T. 1996. **The prediction of saleable meat yield in lamb carcasses.** Can. J. Anim. Sci. **76**: 49–53. A total of 281 lamb carcasses covering three weight groups (18–22.9, 23–25.9 and 26–30 kg) and fatness (< 3 mm, 3–5 mm and > 5 mm) were used to determine the usefulness of several carcass measurements for predicting saleable meat yield. Carcasses were measured for fat and muscle depth, 3–4 cm from the mid-line between the 10th and 11th ribs, 12th and 13th ribs and immediately adjacent to the 13th rib using a Hennessey Grading Probe. This technique also determined total tissue depth at 11 cm from the mid-line between the 10th and 11th and 12th and 13th ribs. The depth of tissues over the 12th rib, 11 cm from the mid-line was measured with a ruler. Carcasses were also visually assessed for muscle development (conformation score) on a 5-point scale (1 = thinly fleshed; 5 = thickly fleshed). All carcasses were fabricated into primal cuts which were trimmed to 5 mm of fat and deboned to provide an estimate of saleable meat yield. Ewe lamb carcasses had a higher proportion of kidney fat than wethers in all weight and fat groups (which ranged from 2.6 to 17.9 g kg^{-1} carcass weight). Saleable meat yield decreased as carcasses became fatter, whereas weight group had little influence on saleable meat yield within a fat group. Ewe lamb carcasses had lower saleable meat yields than wether lamb carcasses, mainly because of their higher amounts of kidney fat. A ruler measurement of tissue depth over the 12th rib combined with carcass conformation score provided the most precise prediction ($R^2 = 0.61$; RSD 17.1) of saleable meat yield. It was concluded that a simple manual system based on these two measurements provided an adequate prediction of saleable meat yield. The accuracy of the procedure would be increased by excluding kidney fat from carcass weight for the prediction of saleable meat yield.

Key words: Lamb, carcass, composition, probe, fat, grade

Jones, S. D. M., Robertson, W. M., Price, M. A. et Coupland, T. 1996. **Prédiction du rendement boucher des carcasses d'agneau**. Can. J. Anim. Sci. **76**: 49–53. Un total de 281 carcasses d'agneaux recouvrant 3 classes de poids (18–22,9, 23–25,9 et 26–30 kg) et d'épaisseur du gras de couverture (<3 mm, 3–5 mm et >5 mm) ont été utilisées pour déterminer l'utilité de plusieurs mesures de la carcasse pour prédire le rendement boucher. Les mesures de l'épaisseur du gras et du muscle étaient prises à 3–4 cm de la ligne dorsale entre les 10ᵉ et 11ᵉ et entre les 12ᵉ et 13ᵉ côtes, ainsi qu'immédiatement à côté de la 13ᵉ côte au moyen de la sonde de classement Hennessey (HGP). L'appareil mesurait également l'épaisseur tissulaire totale à 11 cm de la ligne dorsale entre la 10ᵉ et la 11ᵉ et entre la 12ᵉ et 13ᵉ côtes. La profondeur des tissus au niveau de la 12ᵉ côte à 11 cm de la ligne dorsale était mesurée à la réglette. En outre, on évaluait à vue le développement musculaire (pointage de conformation) selon une échelle de 5 points, 1 charnure mince, 5- charnure épaisse. Pour l'estimation du rendement boucher, toutes les carcasses étaient débitées en coupes primaires, ramenées à une couverture de gras de 5 mm et désossées. Les carcasses d'agnelles contenaient une plus forte proportion de graisse périrénale, soit de 2,6 à 17,9 g kg^{-1} de plus par kilo de carcasse, que celles des agneaux castrés et cela dans toutes les classes de poids et de niveau d'engraissement. Le rendement boucher diminuait à mesure que s'élevait le niveau d'engraissement, mais à l'intérieur d'une même classe du niveau d'engraissement, il était relativement peu influencé par le poids. Le rendement boucher était moindre pour les agnelles que pour les agneaux castrés, principalement à cause de la plus forte quantité de graisse périrénale chez les premières. C'est la combinaison de la mesure à la réglette de l'épaisseur des tissus au niveau de la 12ᵉ côte avec le pointage de conformation qui prédisait avec le plus de précision le rendement boucher ($R^2 = 0{,}61$; ETR 17,1). Il ressort de ces recherches qu'un système manuel simple de mesure de ces deux critères produit une prédiction satisfaisante du rendement en viande marchande. La méthode y gagnerait encore en exactitude par l'élimination de la graisse périrénale du poids de la carcasse.

Mots clés: Agneau, carcasse, composition, sonde, graisse, classe

In many countries the assessment of meat yield (dissected or saleable) in lamb carcasses has largely been accomplished commercially using visually assessed criteria such as shape and fat cover. While several British studies (Chadwick et al. 1986; Kempster et al. 1986) have concluded that a 6-point visual score for lamb carcass fatness predicted carcass lean percentage with precision equal to or better than probe or ruler measures of tissue thickness, there is always the concern that subjective methods have more potential for error and dispute than objective measurements when used commercially. Consequently, simple manual techniques for measuring tissue thicknesses in lamb carcasses or semi-automation of these measurements by grading probes require assessment under field conditions. Kirton et al. (1984) suggested measurement of tissue depth over the 12th rib (GR) with a ruler or with a grading probe between the

Abbreviations: HGP, Hennessey Grading Probe; **GR**, tissue depth over 12th rib at 11 cm from mid-line

Table 1. Number of lambs by warm carcass weight and fat groups

Carcass weight group	Fat Group (HGP fat) < 3 mm	3–5 mm	> 5 mm	Total weight group
18–22.9 kg				
Ewe	16	34	11	
Wether	31	20	6	118
23–25.9 kg				
Ewe	7	16	18	
Wether	17	24	15	97
26–30 kg				
Ewe	1	12	15	
Wether	5	18	15	66
Total fat group	77	124	80	281

11th and 12th ribs at a location 11 cm from the carcass mid-line as potential sites for grading lamb carcasses for lean content. Jones et al. (1992) reported that the total tissue depth measurement between the 12th and 13th ribs provided an adequate assessment of lamb carcass lean content. The present study was conducted to validate these methods for predicting saleable meat yield rather than dissected lean yield, under commercial abattoir conditions. Saleable meat yield contains both meat and fat trimmed to a market specification and is used by the meat industry to value a carcass.

MATERIAL AND METHODS

A total of 281 lamb carcasses were used in the study. The lamb carcasses were selected in a commercial slaughter plant by an experienced grader immediately prior to carcass chilling to cover three weight ranges (18–22.9 kg, 23–25.9 kg and 26–30 kg warm carcass weight) and three fatness ranges (< 3 mm, 3–5 mm and > 5 mm based on HPG values of fat thickness between the 12th and 13th ribs 3–4 cm from the carcass mid-line). The numbers of lambs in each of the weight and fatness sub-classes are shown in Table 1. Ewe and wether lambs were represented in all weight and fat sub-classes. However, only one ewe lamb carcass was available in carcasses with < 3 mm fat in the 26–30 kg carcass weight range.

All dressed carcasses were probed with a HGP (Hennessey Grading Systems, Auckland, New Zealand). Lamb carcasses were evaluated within 30–45 min following stunning. Carcass measurements were collected on three main locations for the left carcass side. HGP measurements were taken 3–4 cm from the mid-line (approximate mid-point of the m. longissimus thoracis) between the 10th and 11th and 12th and 13th ribs and at the last rib (fat and muscle thickness at all locations) as well as measurements of total tissue depth between the 10th and 11th ribs and the 12th and 13th ribs. In addition, a sharpened steel ruler was used to measure total tissue thickness over the 12th rib at the GR site 11 cm from the carcass mid-line. Carcass muscle thickness was assessed by an experienced carcass grader on a 5-point scale (1 = long shanks, thinly fleshed throughout; 5 = extremely thickly fleshed throughout). Carcasses were chilled for approximately 24 h before recording cold carcass weight. Warm and cold carcass weights (including kidney fat) were recorded for all lambs. Loin eye area was traced for the cold left carcass side at the 13th rib and subsequently estimated using an electronic planimeter as described by Jones et al (1992).

Cold carcasses (both sides) were fabricated into the major primal cuts (leg, saddle or back and shoulder), which were trimmed to commercial specifications (maximum of 5 mm fat) similar to those described by the National Association of Meat Purveyors (1988). Kidney fat was included with the primal saddle, but was weighed separately and excluded from the finished cut weight. Each finished cut was weighed to the nearest 10 g. Saleable meat trim from the boneless rough cuts (shank, flank and breast) was visually prepared to contain 800 g kg^{-1} lean and weighed. Carcass saleable yield was estimated as the sum of the trimmed and deboned legs, saddle, shoulders and meat trim expressed as a proportion of warm carcass weight (with and without kidney fat). Trimming of cuts to a fat thickness of 5 mm to estimate saleable meat yield is a more variable procedure than removal of all visible fat tissue from the lean, but was the chosen approach in the present study in order to determine the commercial value of the carcass. Warm carcass weight was used as the independent variable for calculating saleable meat yield since a lamb grading system would be expected to be developed for the warm rather than cold carcasses.

Data were analyzed by analysis of variance using a general linear model procedure (SAS Institute, Inc. 1989). The model included carcass weight, fatness and gender as main effects and the first-order interactions. All means are expressed as least squares means and differences among specific treatments were tested using LSD (SAS Institute, Inc. 1989). The value of the carcass measurements for predicting saleable meat yield was determined by stepwise multiple regression (SAS Institute, Inc. 1989).

RESULTS AND DISCUSSION

Effect of Weight, Fatness and Gender on Kidney Fat, Loin Eye Area and Saleable Meat Yield

Kidney fat proportions increased in all weight groups as carcasses became fatter (Table 2). Kidney fat proportion averaged 25 g kg^{-1} of carcass weight in lean lambs (< 3 mm) and increased to about 40 g kg^{-1} of carcass weight in fat lambs (> 5 mm fat). Within fat group, carcass weight only had small effects on kidney fat proportions. Ewe carcasses consistently had a higher proportion of kidney fat than wethers in all weight and fat sub-classes. The difference ranged from a low of 2.6 to a high of 17.9 g kg^{-1} carcass weight.

Since kidney fat is included as part of the definition of warm carcass weight in Canada, the variation in kidney fat proportion found due to gender will contribute as a source of unexplained variation for the prediction of saleable meat yield. Thus the use of measurements of fat thickness to predict saleable meat yield when carcass weight includes kidney fat might be expected to result in an overprediction of meat yield in ewe carcasses and an underprediction in wether carcasses, unless separate regression equations are

Table 2. Least squares means (ISE) of kidney fat, loin eye area and saleable meat yield

Carcass measurement wt group	Gender	< 3 mm	Fat group 3–5 mm	> 5 mm
			Kidney fat (g kg $^{-1}$ carcass wt)	
18–22.9 kg	Overall	24.6*a* (1.7)	28.5*a* (1.6)	37.8*b* (2.9)
	Ewe	29.4*x* (2.8)	34.1*x* (1.9)	43.5*x* (3.4)
	Wether	19.9*y* (2.0)	23.0*y* (2.5)	32.1*y* (4.6)
23–25.9 kg	Overall	25.8*a* (2.5)	27.6*a* (1.8)	41.6*b* (2.0)
	Ewe	30.1 (4.3)	32.6*x* (2.8)	42.9 (2.7)
	Wether	21.5 (2.7)	22.6*y* (2.3)	40.3 (2.9)
26–30.0 kg	Overall	25.9 (6.2)	33.0*a* (2.1)	42.7*b* (2.1)
	Ewe		42.0*x* (3.3)	49.6*x* (2.9)
	Wether		24.1*y* (2.7)	35.8*y* (2.9)
			Loin eye area cm^2	
18–22.9 kg	Overall	13.0 (3.1)	13.6 (2.8)	12.9 (5.1)
23–25.9 kg	Overall	14.3 (4.7)	14.6 (3.2)	14.2 (3.4)
26–30.0 kg	Overall	16.5 (10.8)	15.3 (3.7)	14.7 (3.6)
			Saleable meat yield (g kg^{-1} carcass)	
18–22.9 kg	Overall	775*a* (3.1)	766*b* (2.8)	734*c* (5.0)
	Ewe	772 (5.0)	758*x* (3.4)	731 (6.0)
	Wether	777 (3.6)	774*y* (4.4)	738 (8.1)
23–25.9 kg	Overall	766*a* (4.5)	760*a* (3.2)	730*b* (3.5)
	Ewe	754*x* (7.5)	753*x* ((5.0)	732 (4.7)
	Wether	779*y* (4.8)	768*y* (4.1)	729 (5.1)
26–30.0 kg	Overall	768*a* (10.9)	748*a* (3.7)	728*b* (3.6
	Ewe		733*x* (5.7)	715*x* (5.1)
	Wether		763*y* (4.7)	740*y* (5.1)
			Saleable meat yield (-kidney fat g kg^{-1})	
18–22.9 kg	Overall	794*a* (2.2)	788*b*(2.0)	763*c* (3.7)
	Ewe	796 (3.6)	784 (2.5)	764 (4.4)
	Wether	793 (2.6)	792 (3.2)	762 (5.9)
23–25.9 kg	Overall	787*a* (3.3)	782*a* (2.2)	761*b* (2.6)
	Ewe	777*x* (5.5)	778 (3.6)	764 (3.5)
	Wether	796*y* (3.5)	785 (3.0)	759 (3.8)
26–30 kg	Overall	789*a* (8.0)	774*a* (2.7)	760*b* (2.7)
	Ewe		766*x* (4.2)	753*x* (3.8)
	Wether		782*y* (3.4)	767*y* (3.8)

a–c Overall means are compared across fat group, gender means are compared within fat group ($P < 0.05$).
x,y Gener means are comared within fat group ($P < 0.05$).

used for meat yield in ewe and wether carcasses. Loin eye area was not significantly influenced by fat group, weight group or gender (Table 2; data for gender not shown). However, loin eye area did show a trend of increasing with carcass weight.

Saleable meat yield consistently decreased with increased carcass fatness, but was not influenced to any extent by weight group within a fat group. This indicated that fatness is the most important variable influencing saleable meat yield. On average, saleable meat yield was decreased by 40 g kg^{-1} from the leanest to the fattest group of carcasses. Ewe carcasses generally had lower yields of saleable meat than wether carcasses. A second analysis which excluded the effect of kidney fat (saleable yield expressed as a proportion of carcass weight – kidney fat) considerably narrowed the difference in saleable meat yield between ewe and wether carcasses. These results suggest that carcass weight should be redefined in Canada to exclude kidney fat, which is a low value product. Otherwise the inclusion of kidney fat as part of carcass weight encourages the marketing of fatter lambs.

Prediction of Saleable Meat Yield

Regression equations were calculated to predict saleable meat yield and combinations of measurements were evaluated (Table 3) including or excluding carcass weight in the regression model. The results from Table 3 showed that warm carcass weight is not a useful predictor of saleable meat yield. GR measured by ruler over the 12th rib was the most useful single measurement for the prediction of saleable meat yield (R^2 = 0.55). This measurement combined with carcass conformation score or loin eye area provided the best practical series of two measurements to

Table 3. Prediction of the proportion of saleable meat yield (g kg^{-1} of warm carcass weight including fat) in lamb carcasses

	Without carcass weight		Including carcass weight	
Carcass measurements	RSD[z]	R^{2y}	RSD	R^2
Warm carcass wt	25.4	0.13	–	–
Ruler (12th rib GR)	18.4	0.55	18.4	0.55
Ruler (12th rib GR) + loin eye area	16.9	0.61	16.9	0.61
Ruler (12th rib GR) + leg conform. sc.	17.1	0.61	17.1	0.61
HGP (GR 12th/13th)	21.1	0.40	21.1	0.40
HGP (10th/11th)	20.7	0.43	20.7	0.43
HGP (fat & muscle depth, 10th/11th)	19.6	0.49	19.5	0.49
HGP (fat & muscle depth, 12th/13th)	20.9	0.42	20.7	0.43
HGP (fat & muscle depth, last rib)	20.8	0.42	20.5	0.44
HGP (fat & muscle depth, 10th/11th) + conform. score	19.3	0.50	19.1	0.51

[z]Residual standard deviation.
[y]R^2 = coefficient of determintation.

Table 4. Prediction of the proportion of saleable meat yield (g kg^{-1} of warm carcass weight excluding fat) in lamb carcasses

	Without carcass weight		Including carcass weight	
Carcass measurements	RSD[z]	R^{2y}	RSD	R^2
Warm carcass wt	18.5	0.10	–	–
Ruler (12th rib GR)	13.7	0.50	13.7	0.51
Ruler (12th rib GR) + loin eye area	13.2	0.54	13.2	0.54
Ruler (12th rib GR) + leg conform. sc.	13.0	0.56	13.0	0.56
HGP (GR 12th/13th)	15.5	0.37	15.5	0.37
HGP (10th/11th)	15.2	0.40	15.1	0.40
HGP (fat & muscle depth, 10th/11th)	14.4	0.46	14.3	0.47
HGP (fat & muscle depth, 12th/13th)	15.0	0.41	14.9	0.42
HGP (fat & muscle depth, last rib)	15.1	0.40	15.0	0.41
HGP (fat & muscle depth, 10th/11th) + conform. score	14.2	0.47	14.1	0.48

[z]Residual standard deviation.
[y]R^2 = coefficient of determintation.

predict saleable meat yield ($R^2 = 0.61$), but the former combination is the most useful for grading warm lamb carcasses. In contrast, HGP measurements (GR or fat + muscle) all had a lower precision for the prediction of saleable meat yield (Table 3).

When carcass weight range is relatively narrow, it contributes little to the prediction of meat yield (Kirton et al. 1984; Garrett et al. 1992). In Canada, because the preferred weight for lamb carcasses is within the 20–28 kg range, including weight is unlikely to improve the precision of predicting saleable meat yield. In contrast, GR which provides an indirect measure of overall carcass fatness is likely to be of far greater benefit than carcass weight for predicting saleable meat yield. While this study confirms the work of Kirton et al. (1984) that GR is a useful measure of lamb carcass composition (in this case saleable lean rather than dissected lean), the results suggest that GR measurement is more precise when measured by a ruler over the 12th rib rather than a total measurement of tissue depth between the ribs by the HGP. Kirton et al. (1984) found that total tissue depth (measured by a probe), GR (measured by a ruler) and measurements of fat thickness over the m. longissimus thoracis all had similar precision and value for predicting carcass meat yield and Chadwick et al. (1986) reported that probe measures of fatness and tissue depth were of more value than ruler measurements. The present study also found that measurements of muscling (loin eye area or carcass muscle thickness) provided a small but useful increase in the amount of variance explained for the prediction of saleable meat yield. In contrast, the results of other studies (Kempster et al. 1982; Garrett et al. 1992; Jones et al. 1992) have shown conformation score to be of little value. The differences found in the results of this study compared with others is likely to be related to the endpoint chosen (saleable meat yield, which contains fat and bone, rather than lean yield) and the fairly narrow but commercially realistic weight range of carcasses examined.

The results in Table 4 are analogous to those in Table 3 except that saleable meat yield was expressed as a proportion of carcass weight less kidney fat. In all cases the RSD values for saleable meat yield were lower (more precise) than the ones for saleable meat yield expressed as a proportion of carcass weight including kidney fat. This confirms the previous results and provides further justification for excluding kidney fat as part of warm carcass weight. A recent study by Garrett et al. (1992) also suggested that kidney fat had to be accounted for if left in the carcass following dressing to have a reliable prediction of commercial meat yield. In the same study the results showed that kidney fat was either the first or second variable to be considered in regression models for the prediction of meat yield and was more important than probe recorded fat, carcass weight and leg conformation for the prediction of meat yield.

The best equations for predicting saleable meat yield were as follows:

$$\text{Saleable meat yield}^1 = 78.92 - 0.51\ (\text{Ruler GR, 12th rib}) + 1.25\ (\text{carcass conformation score})$$
$$R^2 = 0.61 \quad \text{RSD } 17.1$$
$$\text{Saleable meat yield}^2 = 80.33 - 0.35\ (\text{Ruler GR, 12th rib}) + 0.83\ (\text{carcass conformation score})$$
$$R^2 = 0.56 \quad \text{RSD } 13.0$$

where ^{1} = saleable meat yield as a percent of warm carcass weight and ^{2} = saleable meat yield as a percent of warm carcass weight excluding kidney fat.

For each carcass assessed in the study, the above two equations were used to predict saleable meat yield. The predicted meat yield was then subtracted from the actual saleable meat yield and the standard deviation of the difference calculated. For carcasses where saleable meat yield was assessed with kidney fat included and excluded, the results are shown in Table 5. Standard deviations were relatively stable across weight and fatness groups averaging

Table 5. Standard deviation of the difference (actual – predicted g kg^{-1}) for saleable meat yield (kidney fat included and excluded)

Weight group	Gender	< 3 mm		3–5 mm		> 5 mm	
		SMY1[z]	SMY2[y]	SMY1	SMY2	SMY1	SMY2
18 –22.9 kg	Overall	15.7	12.3	16.2	12.1	17.6	14.0
	Ewe	20.3	16.6	16.6	12.8	21.4	16.8
	Wether	13.1	8.9	15.8	10.8	8.5	4.8
23 – 25.9 kg	Overall	16.9	13.1	18.6	13.5	16.8	12.4
	Ewe	17.6	11.2	24.4	17.7	14.7	11.4
	Wether	13.6	11.6	14.1	10.2	17.3	11.5
26 – 30 kg	Overall	13.3	11.2	15.9	12.1	18.1	13.6
	Ewe	–	–	14.5	11.1	15.5	13.1
	Wether	13.6	11.1	14.3	12.4	19.2	13.9

Fat group spans the < 3 mm, 3–5 mm and > 5 mm columns.

[z]SMY1 = Saleable meat yield, kidney fat included as part of carcass weight.
[y]SMY2 = Saleable meat yield, kidney fat excluded as part of carcass weight.

about 1.65%. This indicates that 68% of the carcasses would have a predicted saleable meat yield within 16.5 g kg^{-1} of the actual yield. For carcasses where saleable meat yield was assessed with kidney fat excluded from carcass weight, the standard deviations were lower (Table 5) in all cases. This result again confirms that kidney fat is a source of confounding variation for the prediction of saleable meat yields in lambs.

CONCLUSIONS

According to the findings of this study, redefining lamb carcass weight to exclude kidney fat is recommended. This will improve the accuracy of assessing carcass value and discourage feeding lambs to heavier weights to increase dressed-out yield. A ruler measurement of GR at the 12th rib combined with carcass conformation score should be introduced in lamb grading to assess saleable meat yield. Pricing schedules can be developed based on predicted saleable meat yield to reward carcasses with high saleable yields and discount carcasses with less than average meat yields. Since lamb processing in Canada is a small industry with only one dedicated plant that slaughters up to 200 lambs per hour, the investment in a grading probe system is probably not worthwhile when the needs of the industry can be met with a manually based ruler system.

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