An evaluation of the lamb and mutton carcase grading system in the Republic of South Africa. 2. The use of fat measurements as predictors of carcase composition

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A total of 104 carcases were selected on the market in three age groups and four mass classes representative of the six fat classes of the classification system for carcase evaluation. Four subcutaneous fat thickness measurements were taken on the intact carcass. Carcases were deboned and the composition was determined. Fat, moisture, ash and protein analyses were performed on all the deboned carcasses. Between, as well as within age groups, there was some variation of single fat measurements and of combinations of such measurements which included or excluded carcase mass when used as predictors of the variation that occurred in certain carcase characteristics. The fat measurement between the 3rd and 4th lumbar vertebrae, 25 mm from the midline, was the most accurate predictor of differences in carcase composition. When two or more measurements were used in combination with carcase mass, the accuracy of predicting carcase composition was higher than the use of a single fat measurement. The visual evaluation of carcase fatness was a more reliable predictor of carcase composition than a single fat measurement.

In totaal is 104 karkasse op die mark geselekteer en aangekoop vir karkasevaluasie. Karkasse is geselekteer in drie ouderdomsgroepe en vier massagroepe waarin ses vetheidsklasse in die klassifikasiestelsel verteenwoordig was. Vier onderhuidse vetdiktemate is op die intakte karkasse gemeet, waarna die karkasse ontbeen en die fisiese samestelling bepaal is. Die proteïen, vet-, vog en asinhoud van die ontbeende karkasse is ook bepaal. 'n Redelike variasie het voorgekom tussen enkele vetmate sowel as tussen kombinasies van vetmate, met of sonder karkasmassa, binne sowel as tussen ouderdomsgroepe as beramers van die verklaarbare variasie van sekere karkaseienskappe. Uit 'n praktiese oogpunt was die vetmaat geneem tussen die 3de en 4de lumbale werwels, 25 mm vanaf die middellyn, die mees akkurate objektiewe maatstaf om verskille ten opsigte van karkasweefselinhoud tussen karkasse te beraam. Die beramingsakkuraatheid van 'n enkele vetmaat het verhoog indien dit in kombinasie met een of meer vetdiktemate en die karkasmassa gebruik is. Die visuele evaluering van die vetheid van die karkas is 'n beter beramer van karkassamestelling as 'n enkele vetmaat.

Keywords: Lamb, mutton, carcase grading, carcase composition, fat measurements

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Introduction

Subcutaneous fat thickness measurements are useful predictors of carcase composition. Such measurement not only serves as a description of the deposition of the fatty tissue at the point where it is measured, but also as an indirect measure of the development of the fat as well as muscle tissue in the whole carcase. Sample joints are the most accurate predictors of carcase composition (Kempster, Cuthbertson & Harrington, 1982). The problem is that the cost involved in sample dissection is relatively high and it is also an unpractical method to use in a classification system. The choice of the most practical fat measurement will depend on: the precision with which the fat measurement is expected to predict carcase lean content; the cost of taking these prediction measurements — this will reflect ease, speed and accuracy with which the measurements can be recorded, and the carcase depreciation involved; and the stability of the prediction equations in indicating treatment differences or differences between the types of lamb being compared (Kempster, 1981; Hedrick, 1983).

The purpose of this study was to find the most practical and accurate fat measurement for the prediction of carcase composition to be applied in a classification and grading system; and to compare the value of a visual evaluation of carcase fatness and that of a single fat measurement as predictors of carcase composition.

Procedure

Carcases were selected on a slaughterline of the largest abattoir in South Africa and arrayed into four mass groups, i.e. 10,1 – 15,0 kg; 15,1 – 20 kg; 20,1 – 25 kg, and more than 25 kg. From these mass groups two 'lean'and two 'fat' carcases were selected per grade. In the grades Super Lamb, Prime B and Top C fatness code 3 was taken as 'lean' and fatness code 4 as 'fat'. For the grades Lamb 1, Bl an Cl fatness code 2^- was taken as 'lean' and fatness code 2^+ as 'fat'. Fatness code 5 was taken as 'lean' and fatness code 6 as 'fat' for the grades Lamb 2, B2 and C2. For Lamb 3 carcases fatness code 1^- was taken as 'lean' and fatness code 1^+ as fat. The subcutaneous fatness score as well as the conformation score was allocated to each carcase by the official graders. For certain mass groups no carcases were included because in the normal market situation such carcases did not

Therefore only 104 carcases were selected instead of 160 carcasses.

Four fat measurements were taken after cooling on each intact carcase as follows:

V1 — between the 3rd and 4th sacral vertebrae, 25 mm from the carcase midline

V2 — between the 3rd and 4th sacral vertebrae, 50 mm from the carcase midline

V3 — between the 3rd and 4th lumbar vertebrae, 25 mm from the carcase midline

V4 — between the 12th and 13th vertebrae, 25 mm from the carcase midline.

Carcases were accurately split with a handsaw and the right side of each carcase was divided into five primal cuts, i.e. neck, shoulder and shank, breast, back and leg (Casey, 1982). The mass of each primal cut was measured and the cut dissected into subcutaneous fat, lean (lean = proportion of meat with intramuscular fat and without subcutaneous fat) and bone.

The masses of these three components of each cut as well as the kidney and kidney fat of each carcase were measured. Chemical analysis was done on the deboned right side (subcutaneous fat and lean) of all the carcases in order to calculate the percentage protein, moisture, ash and fat in the right side of each carcase (AOAC, 1965).

Chemical fat was regarded as carcase fat and the total mass of protein, moisture and ash as carcase muscle. The individual fat measurements were used as predictors of carcase composition. Different combinations of fat measurements including and excluding carcase mass were also correlated with carcase tissue content. Data were analysed with simple correlation analyses and multiple regression analyses (coefficients of determination (*CD*) and residual standard deviation (*RSD*) were also calculated).

Results and Discussion

Mean values for the carcase composition of carcases are shown in Table 1. From Table 1 it is evident that there was little difference in the carcase composition of lambs and of all age groups together — for example the total fat percentages were 23,0% and 23,1% respectively. Lambs constitute 70% of all sheep slaughtered in South Africa. The carcase composition of lambs seems to be a good indicator of the composition of all types found on the market.

Coefficients of determination (*CD*) and residual standard deviation (*RSD*) for the different fat measurements estimating carcase characteristics in the different age groups are shown in Table 2. The fat measurements with the highest *CD*'s and the lowest *RSD* to explain the variation that occurred in subcutaneous fat percentage for carcases of the different age groups were: Lambs — V1, B-age group — V4, C - age group - V3 and all age groups — V1.

To explain the percentage variation that occurred in the percentage lean in the carcase, the following fat measurements in the different age groups have the highest *CD*'s and *RSD*'s , i.e. Lambs — V1, B-age group — V3, C-age group — V3 and all age groups — V1. Although the fat measurement V1 has a higher *CD* there was no difference in the accuracy between this fat measurement and fat measurement V3 to predict the percentage lean in the carcase of all age groups together (*RSD* = 2,44 for V1 and V3). For the prediction of bone the fat measurements V4 has the highest *CD*'s and lowest *RSD* for the B-age group, C-age group and for all the age groups. In lamb carcases V3 has the highest *CD* (64,1) and lowest *RSD* (1,36) for predicting the percentage of bone. The fat measurement measured between the 3rd and 4th lumbar vertebrae, 25 mm from the midline (V3) of the carcase, was the best predictor of total fat percentage (highest *CD*, lowest *RSD*) for the B-age group, C-age group and all age groups. The V1 fat measurement has the highest *CD* but not the lowest *RSD* for lamb carcases. The V3 fat measurement, however, has a lower *RSD* (3,32) and would therefore be a more accurate predictor of total fat percentage for lamb carcases. The fat score, on an 18-point scale, is of great importance because this is the method which the graders use to classify carcases visually in different fat classes according to the visible fat on the carcase. The visual evaluation of fatness is widely used in the different classification and grading systems throughout the world (Kempster, *et al.*,1982).

To predict the visual evaluation of fatness (fat score) the following fat measurements have the highest *CD*'s and lowest *RSD*'s for the different age groups, i.e. Lambs — V3; B age group — V1; C age group — V3 and all age groups — V3.

Table 1 Carcase characteristics of carcases selected on the market

Characteristic	Lamb carcases (n = 40)		Carcases of all age groups (n = 104)	
	$\bar{X}$	*SD*	$\bar{X}$	*SD*
Subcutaneous fat (%)	8,51	3,51	8,20	3,31
Lean (%)	73,93	3,07	74,56	3,14
Bone (%)	14,10	2,24	13,62	2,16
Kidney Knob (%)	3,46	1,60	3,62	1,80
Total fat (%)	23,01	6,23	23,09	6,36
Fat score (1 - 18)	9,20	4,98	9,30	4,60
V1 (mm)	8,96	6,35	9,50	5,51
V2 (mm)	6,60	4,61	7,90	4,95
V3 (mm)	7,53	4,58	7,60	4,14
V4 (mm)	3,88	3,16	3,80	2,67
Carcase mass (kg)	17,50	4,36	21,26	5,63

V1 — Measured between the 3rd and 4th sacral vertebrae, 25 mm from the carcase midline.

V2 — Measured between the 3rd and 4th sacral vertebrae, 50 mm from the carcase midline.

V3 — Measured between the 3rd and 4th lumbar vertebrae, 25 mm from the midline.

V4 — Measured between the 12th and 13th vertebrae, 25 mm from the midline

Table 2 Variation in different carcase characteristics explained by different fat measurements (*CD* and *RSD*) in the different age groups

	% Variation explained and *RSD*			
	V1	V2	V3	V4
Lamb carcases (0 p.i.)				
Subcutaneous	75,2[a]	75,1	61,4	60,4
fat (%)	(2,87)[b]	(2,93)	(3,11)	(3,12)
Lean (%)	68,8	65,9	52,3	47,4
	(1,74)	(1,82)	(2,15)	(2,26)
Bone (%)	48,9	46,7	64,1	57,5
	(1,62)	(1,66)	(1,36)	(1,48)
Total fat (%)	71,4	65,4	61,3	61,2
	(3,47)	(3,72)	(3,32)	(3,85)
Fat score (1 – 18)	68,8	72,3	81,1	62,2
	(2,82)	(2,66)	(2,20)	(3,11)
B age group (1–6 p.i.)				
Subcutaneous	64,1	57,5	64,0	74,8
fat (%)	(2,09)	(2,27)	(2,08)	(1,75)
Lean (%)	34,0	23,4	49,7	32,0
	(2,69)	(2,89)	(2,35)	(2,73)
Bone (%)	37,4	35,8	38,8	50,4
	(1,47)	(1,48)	(1,45)	(1,30)
Total fat (%)	54,3	50,4	65,7	61,6
	(4,23)	(4,39)	(3,64)	(3,87)
Fat score (1–18)	72,5	67,9	59,5	69,5
	(2,32)	(2,51)	(2,81)	(2,44)
C age group (>6 p.i.)				
Subcutaneous	55,4	48,4	55,4	50,0
fat (%)	(2,00)	(2,15)	(1,95)	(2,11)
Lean (%)	23,5	20,2	25,5	18,4
	(2,74)	(2,80)	(2,70)	(2,83)
Bone (%)	17,2	20,3	34,7	44,9
	(2,15)	(2,11)	(1,91)	(1,75)
Total fat (%)	35,2	35,7	55,8	48,4
	(5,67)	(5,65)	(4,68)	(5,05)
Fat score (1–18)	44,5	57,7	62,2	56,6
	(3,30)	(2,88)	(2,72)	(2,91)
All age groups				
Subcutaneous	62,1	54,3	60,3	60,9
fat (%)	(2,53)	(2,71)	(2,54)	(2,52)
Lean (%)	40,5	28,9	40,2	33,1
	(2,44)	(2,66)	(2,44)	(2,58)
Bone (%)	33,3	33,6	47,0	48,5
	(1,77)	(1,77)	(1,58)	(1,56)
Total fat (%)	52,9	48,2	58,8	55,1
	(4,41)	(4,63)	(3,87)	(4,24)
Fat score (1–18)	61,8	62,9	69,0	62,1
	(2,83)	(2,79)	(2,55)	(2,83)

[a]*CD* Coefficient of determination
[b]*RSD* Residual standard deviation

Over the range of carcase characteristics and age groups studied, considerable variation exists between fat mesurements in the accuracy of predicting carcase composition. Fat measurements V1 and V3 showed the highest prediction values for carcase compostion. Carcase fatness has a very important influence on the retail value of the carcase and this characteristic is currently determined visually in the different fat classes (1 – 6) by the official graders. Therefore it seems that the fat measurement taken between the 3rd and 4th lumbar vertebrae, 25 mm from the midline, is the most useful and reliable predictor of superficial carcase fatness as well as of carcase fat content. It was also found in a survey (n = 468) that this fat measurement was the most reliable predictor of carcase fatness (Bruwer, Naudé & Vosloo, 1987). A range of this fat measurement is currently stipulated in the classification and grading system as a guideline for each fat class. From the results of this study it is shown that this fat measurement, (V3) is the most reliable reference fat measurement to be used in the classification system.

Table 3 shows the *CD*'s and *RSD*'s of different combinations of fat measurements, with and without carcase mass. Only the best combinations of a series are shown for lamb carcases and for all the age groups as lamb carcases constitute 70% of the lamb and sheep slaughter market. From these results it appears that a combination of two or more fat measurements increased the prediction accuracy of carcase composition for lamb carcases as well as carcases of all age groups. The prediction of total fat percentage in lamb carcases increased by 17,2% when the four fat measurements (V1, V2, V3 & V4) were used instead of one fat measurement (V3) and by 10,7% for all the age groups. The accuracy for predicting fat score improved by 5,0% for lamb carcases and by 10,7% for carcases in all the age groups. The accuracy of predicting carcase composition was further increased when these fat measurements were used in combination with carcase mass. In the case of lamb carcases the inclusion of carcase mass with a single fat measurement (V3) improved the accuracy of predicting total fat percentage in the lamb carcase by 11,9%. These results support the findings of Kempster & Cuthbertson (1977), Kirton & Johnson (1979) and Thompson & Atkins (1980) that a combination of fat measurements with carcase mass provided the best prediction of percentage carcase composition. However the practical situation on the South African market presently does not allow the use of more than one fat measurement where sheep are slaughtered at 600 an hour on one line. Therefore fat thickness measured between the 3rd and 4th lumbar vertebrae, 25 mm from the midline of those fat thicknesses evaluated, seems to be the best single fat measurement to be used in the classification system for the prevailing conditions in South Africa. This fat measurement is currently used in the South African classification and grading system.

Table 4 shows results of the visual evaluation of carcase composition by the official graders and objective evaluation of carcase composition by using the single fat measurement V3. For predicting subcutaneous fat percentage, the visual evaluation has a higher *CD* (68,9 vs 60,3) and lower *RSD* (1,85 vs 2,53) than the single fat measurement V3. Visual evaluation actually describes the visible fat on the carcase and it is therefore not surprising that it is more accurate than the single fat meas-

Table 3 Variation in different carcase characteristics explained by different combinations of fat measurements (*CD*), with and without carcase mass (CM), together with the residual standard deviation (*RSD*)

	% Variation explained and *RSD*							
	V3	V3 + CM	V3V4	V3V4 + CM	V2V3V4	V2V3V4 + CM	V1V2V3V4	V1V2V3V4 + CM
Lamb carcases								
Subcutaneous fat (%)	61,4[a]	65,0	67,3	73,1	78,8	81,0	80,2	81,8
	(3,10)[b]	(2,14)	(3,04)	(3,07)	(2,92)	(2,96)	(2,92)	(2,96)
Lean (%)	52,3	59,1	55,4	64,5	67,7	71,9	71,2	74,1
	(2,15)	(2,02)	(2,11)	(1,91)	(1,82)	(1,72)	(1,74)	(1,68)
Bone (%)	64,1	65,4	67,6	68,3	67,7	68,5	68,5	69,0
	(1,36)	(1,35)	(1,31)	(1,31)	(1,33)	(1,33)	(1,33)	(1,33)
Total fat (%)	61,3	73,2	75,5	77,2	78,2	78,9	78,5	79,1
	(3,32)	(3,31)	(3,17)	(3,10)	(3,03)	(3,02)	(3,05)	(3,05)
Fat score (1–18)	81,1	81,4	82,0	82,7	85,8	85,8	86,1	86,3
	(2,20)	(2,55)	(2,17)	(2,15)	(1,96)	(1,98)	(1,96)	(1,97)
All age groups								
Subcutaneous fat (%)	60,3	61,5	55,4	72,4	57,3	78,5	73,4	78,9
	(2,53)	(2,07)	(2,38)	(2,31)	(2,34)	(2,21)	(2,31)	(2,21)
Lean (%)	40,2	52,6	42,1	58,0	42,9	62,5	46,9	63,4
	(2,44)	(2,19)	(2,42)	(2,07)	(2,41)	(1,97)	(2,34)	(1,95)
Bone (%)	47,0	52,9	53,9	51,3	54,2	57,3	54,6	57,3
	(1,58)	(1,50)	(1,48)	(1,43)	(1,48)	(1,44)	(1,48)	(1,44)
Total fat (%)	58,8	63,3	67,7	67,8	69,2	69,7	69,5	69,8
	(3,87)	(3,89)	(3,65)	(3,66)	(3,58)	(3,57)	(3,58)	(3,58)
Fat score (1–18)	69,0	69,3	74,2	74,2	79,6	80,1	79,7	80,1
	(2,55)	(2,21)	(2,34)	(2,35)	(2,09)	(2,07)	(2,09)	(2,08)

[a] *CD* Coefficient of determination
[b] *RSD* Residual standard deviation

Table 4 Comparison between visually vs objective evaluation of carcase composition (*CD* and *RSD* are shown)

	% Variation explained and *RSD*	
	Fatscore (1 – 18)	Fat measurement (V3, mm)
Subcutaneous fat (%)	68,9	60,3
	(1,85)	(2,53)
Lean (%)	39,7	40,2
	(2,46)	(2,44)
Bone (%)	57,3	47,0
	(1,42)	(1,58)
Total fat (%)	62,8	58,8
	(3,88)	(3,87)

measurement V3 in predicting persentage subcutaneous fat. Should it be decided to move in the direction of actually measuring the fat thickness on the carcase in the grading system instead of visually scoring fatness, more than one fat measurement should be measured to give an accurate discription of carcase fatness. This would only be possible in an automated classified and grading system. Visual evaluation also has the highest *CD*'s for the prediction of the percentage bone (57,3 vs 47,0) and total fat (62,8 vs 58,8) in the carcase when compared with the single fat measurement, V3. The results are in agreement with those obtained by Kempster, Avis, Cuthbertson & Harrington (1976). Kempster & Cuthbertson (1977) and Wolf, Smith, King & Nicholson (1981).

Conclusion

The fat measurement currently used in the South African classification system is measured between the 3rd and 4th lumbar vertebrae, 25 mm from the midline. In this study it was found that this fat measurement is probably the most accurate and practical predictor of carcase composition to be used as a reference measurement in the classification system of those fat thicknesses tested. The prediction accuracy of carcase compostion was increased when two or more fat measurements were used with and without carcase mass. The visual evaluation of carcase fatness is a more reliable predictor of carcase composition than a single fat measurement.

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