PREDICTION OF LIVE AND CARCASS COMPOSITION OF YOUNG CHAROLAIS BULLS USING ULTRASONIC SCANNING, VELOCITY OF ULTRASOUND AND ADIPOSE CELL SIZE

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SUMMARY

The study was carried out on 79 young Charolais bulls at 15 or 19 months of age, fattened at a single location. Fat depth by ultrasonic scanning at 6 sites and velocity of ultrasound (VOS) at 4 sites were measured before slaughtering. At slaughter the size of adipose cells was measured on a sample of subcutaneous fat and velocity of ultrasound was measured at 6 sites.

Carcass fat and lean percentages were estimated using a prediction equation from the dissection of the 6th rib and the weights of perirenal and precrural fat depots. Actual weights of thoracic, abdominal and trimmed subcutaneous fat were added to the predicted carcass fat weight to estimate the total body fat content as a percentage of empty body weight. Means and standard deviations were: 13.4%± 1.6, 12.1% ± 1.9 and 72.8% ± 1.7 respectively for carcass and body fat contents and carcass lean content.Predictive values of techniques were compared using step-wise regressions.

The best *in vivo* total body fat content prediction was obtained by adipose cell size (R^2=.63 rsd=1.17), followed by live VOS (R^2=.59 rsd=1.26) and fat depth scanning (R^2=.51 rsd=1.37). Ranking in predicting carcass lean content was: live VOS (R^2=.47 rsd=1.29), fat depth scanning (R^2=.42 rsd=1.38) and adipose cell size (R^2=.25 rsd=1.52). Including live weight or fatness score improved only slightly the predictive values.

At slaughter accuracy of VOS measurements was R^2=.71 rsd=0.87 for predicting carcass fat content and R^2=.65 rsd=1.05 for carcass lean content. Accuracy was improved by including the measurement of fat thickness on the 6th rib.

VOS measurements appeared to be effective in predicting both body and carcass composition. Measurement of cell size is more related to total body fatness. Further investigations are needed to confirm the potential utility of the VOS in performance testing for breeding objectives and in carcass grading for commercial purposes.

INTRODUCTION

The control of fatness level in cattle is limited by the lack of objective measurement techniques. Objective measurement of fatness is needed a) in breeding programmes for selecting animals with higher lean growth capacity and lower fattening capacity, b) in nutrition studies aimed to develop feeding systems that limit fat depots, c) at slaughter for an objective classification of carcasses on their composition. Different estimation methods based on different techniques have been developed and are presently available (FISHER, 1990). Three of these techniques appear to be of potential use owing to their potential accuracy and cost as compared to the limited method of scoring:

· ultrasonic scanning of cattle for measuring the subcutaneous fat depth (SIMM, 1983)

· measurement of the size of subcutaneous adipose cells (ROBELIN and AGABRIEL, 1986)

· measurement of the velocity of ultrasound (MILES et al, 1984, 1987).

The two latter techniques can be used *in vivo* or at slaughter. The present study has been designed to compare the corresponding methods on their potential accuracy to predict body and carcass composition.

MATERIALS AND METHODS

The study was carried out on 79 young Charolais bulls born in an experimental unit of INRA at Avord where a divergent selection on muscle growth capacity was conducted. After weaning at 8 months, male calves were fattened with a complete pelleted diet and slaughtered at 15 (n=42) or 19 months (n=37) of age in the experimental slaughterhouse of INRA at Theix in groups of 6 to 8.

Live measurements were taken the week preceding slaughter:

. fatness was scored (LFSc) by a technician of the experimental unit from 1=very lean to 5=very fat (AGABRIEL et al, 1986)

. images of subcutaneous tissues were obtained by ultrasonic scanning (Toshiba) at 6 sites: at the 10th and the 13th ribs and the 3rd lumbar, a first measurement was taken close to the mid-dorsal line and a second one 20 cm laterally. Only one technician of the experimental unit scanned all the animals. Fat depth (LFDp) was measured on images by two of the authors and results were averaged.

. measurements of the velocity of ultrasound (VOS) were taken at 4 anatomical sites clearly described by MILES et al (1984): two sites through the loin, just behind the shoulder and at the 3rd lumbar, and two sites through the thigh. Each animal was measured successively on the 4 sites and series of measurement were repeated three or eventually four times. Only the two best series, in term of homogeneity of results, were kept for computing average values.

Just before slaughter, live weight was recorded. Just after slaughter empty body and hot carcass were weighed and the following information was recorded:

· subcutaneous fat was taken off the thigh for measuring the mean diameter of the adipose cells (ACD) (ROBELIN and AGABRIEL, 1986)

. carcass conformation (CCSc) and fatness (CFSc) were scored by a single trained technician according to the EUROP classification (DE BOER et al (1974)

. measurement of the velocity of ultrasound (VOS) was taken at 6 anatomical sites as defined by MILES et al (1990). The same procedure as on live animals was used for selecting among the 3 or 4 repeated series of measurements.

Only one half of the carcass was trimmed to prevent any bias in scoring, in measuring velocity of ultrasound and in estimating carcass composition. Thoracic, abdominal and trimmed subcutaneous fat were weighed, as well as the cannon bones. The following day, the 6th rib cut was removed. The rib eye area (REA) and the subcutaneous fat thickness (CFTh) were measured before the rib was dissected into muscle, fat and bone. Carcass fat and muscle contents were estimated using equations established by ROBELIN and GEAY (1975) and based on weights of the carcass, the tissues in the 6th rib, the perirenal and precrural fat depots and the cannon bones. Actual weights of thoracic, abdominal and trimmed subcutaneous fat were added to the predicted carcass fat weight to estimate the total body fat content as a percentage of empty body weight.

Data were analysed across slaughter groups to compare the predictive value of information provided by each method using step-wise regression procedures. The dependent variables to predict were: total body fat content, carcass fat and muscle contents. The independent variables were grouped as followed:

basic live measurements

. live weight (LW) and live fatness score (LFSc)

new live measurements

. 6 fat depth measurements obtained by ultrasonic scanning (LFDp)

. 4 live measurements of the velocity of ultrasound (LVOS)

. mean diameter of adipose cells (ACD), considered as a potential live predictor owing to the possibility of biopsy.

basic slaughter measurements

. carcass weight (CW), carcass conformation (CCSc) and fatness score (CFSc), rib eye are (REA) and fat thickness (CFth) on the 6th rib

new slaughter measurements

. 6 measurements of the velocity of ultrasound on carcass (CVOS)

. mean diameter of adipose cells (ACD)

For each method two step-wise regressions were determined. The first one used the information provided by the new methods only. In the second one, the new measurements were combined with the basic ones on live animals or carcasses.

RESULTS

The mean performance of the 79 young Charolais bulls is reported in table 1. Carcass weight averaged 400 kg and the mean classification was U⁻ 2⁼ in the EUROP scale. A rather low variability of composition traits has been found among the experimental animals, with standard deviations between 1.6 and 1.9 for the different tissue proportions although slaughtering at two different ages should have induced an increased variability. However, in these late maturing cattle, fat depots represented less than 18% of the carcass gain between 15 and 19 months of age. Therefore carcass fatness did not increase markedly between 15 and 19 months: 13.8% vs 13.0%. It should also be mentioned that carcass composition was estimated using prediction equations. The apparent variability could be reduced for that reason as well as the apparent predictive value of the measurements.

Table 1: mean performance of the experimental young Charolais bulls (n=79)

			Mean	s.d.
Live weight	LW	kg	651.2	77.9
Carcass weight	CW	kg	400.4	53.2
Carcass fatness score	CFSc	(1-15)	5.1	1.5
Adipose cell diameter	ACD	μm	101.7	17.8
Fat thickness on 6th rib	CFTh	mm	4.9	2.8
Conformation score	CCSc	(1-18)	13.2	1.2
Rib eye area	REA	cm^2	56.4	8.2
Carcass lean weight		kg	291.5	39.2
Carcass fat weight		kg	53.9	11.4
5th quarter fat weight		kg	15.2	5.3
Subcutaneous trimmed fat weight		kg	2.0	2.2
Carcass lean content		%	72.8	1.75
Carcass fat content		%	13.4	1.57
Total body fat content		%	12.1	1.92

Predictive value of live measurements

Percentages of the variances (R^2) explained by the performance measured on live animals and the corresponding residual standard deviations (rsd) are given in table 2.

Despite a rather low variability in body composition, the new techniques explained more than 50% of the variation of total body fat content, while live fatness score and live weight explained together less than 30%. Among these new techniques, adipose cell diameter, with a single measurement, provided higher accuracy (R^2=.63 rsd=1.17) than the two other techniques. As three out of the four VOS measurements had an individual accuracy higher than 30%, and only one out of the six fat depth scanning measurements, VOS technique showed a higher total accuracy (R^2=.59 rsd=1.26) than the fat depth scanning (R^2=.51 rsd=1.37). In that latter regression, five fat depth measurements were needed. Including live weight and live fatness score did not improve significantly the predictive value of the three new techniques.

Table 2: predictive value of live measurements for body and carcass composition prediction

		Total body fat content		Carcass lean content	
		overall s.d.= 1.92		overall s.d.= 1.75	
		R^2	rsd	R^2	rsd
Basic measurements					
Live weight	LW	.29	1.63	.01	1.74
Fatness score	LFSc	.10	1.83	.07	1.69
New measurements					
Fat depth scanning (6 sites)	LFDp	.51	1.37	.42	1.38
Velocity of ultrasound (4 sites)	LVOS	.59	1.26	.47	1.29
Adipose cell diameter	ACD	.63	1.17	.25	1.52
New measurements combined with basic measurements					
Fat depth scanning (6 sites)		.58	1.29	.42	1.38
Velocity of ultrasound (4 sites)		.65	1.16	.49	1.27
Adipose cell diameter		.66	1.12	.25	1.52

Prediction of carcass lean content was less accurate. Fat depth scanning (4 measurements needed) and VOS (3 measurements needed) provided total accuracies less than 50%, R^2=.42 rsd=1.38 and R^2=.47 rsd=1.29 respectively, and accuracy of prediction with adipose cell diameter was only R^2=.25 rsd=1.52. As both live weight and live fatness score appeared to be independent of carcass lean content, they were not needed to improve accuracy.

Predictive value of slaughter measurements

Percentages of the variances explained by the performance measured at slaughter and the corresponding residual standard deviations are given in table 3.

Table 3: predictive value of slaughter measurements for carcass composition prediction

		Carcass fat content		Carcass lean content	
		overall s.d.= 1.57		overall s.d.= 1.75	
		R^2	rsd	R^2	rsd
Basic measurements					
Carcass weight	CW	.15	1.44	.00	1.74
Fat thickness on 6th rib	CFTh	.59	1.00	.47	1.26
Carcass Fatness score	CFSc	.29	1.32	.16	1.69
Carcass Conformation score	CCSc	.10	1.48	.00	1.74
Rib Eye Area	REA	.07	1.51	.21	1.69
New measurements					
Velocity of ultrasound (6 sites)	CVOS	.71	0.87	.65	1.05
Adipose cell diameter	ACD	.50	1.10	.25	1.52
New measurements combined with basic measurements					
Velocity of ultrasound (4 sites)		.86	0.62	.78	0.85
Adipose cell diameter		.75	0.81	.61	1.10

At slaughter, only four out of the six VOS measurements on hot carcasses were needed to reach an accuracy of R^2=.71 rsd=0.87, and that was better than the accuracy for predicting total body fat content using live VOS. On the contrary, the adipose cell diameter appeared to be less accurate to predict carcass fat content (R^2=.50 rsd=1.10) than it was to predict total body fat content. Prediction of carcass lean content was much better with four VOS measurements at slaughter (R^2=.65 rsd=1.05) than the prediction obtained with the adipose cell diameter.. Measurement of fat thickness on the 6th rib on carcass provided a relatively good prediction of carcass fat content (R^2=.59 rsd=1.00) and carcass lean content (R^2=.47 rsd=1.26). Step-wise regressions with basic slaughter measurements showed that fat thickness, rib eye area and carcass weight already explained 69% (rsd=0.88) and 58% (rsd=1.14) of variations in carcass fat and lean contents respectively. Including adipose cell diameter improved slightly the prediction accuracy of fat and lean content, R^2=.75 rsd=0.81 and R^2=.61 rsd=1.10 respectively. Combining five carcass VOS measurements with these three basic measurements reached the highest level of accuracy for predicting carcass fatness (R^2=.86 rsd=0.62) and lean content (R^2=.78 rsd=0.85).

DISCUSSION

Although fat thickness measured on the cold carcass was confirmed to be a good predictor of carcass composition (ABRAHAM et al 1980, MILLER et al 1988), each of the six fat depth scans had a poor predictive value and using all of them did not provide an accuracy equivalent to the measurement of fat thickness on the carcass. Discrepancy between the actual subcutaneous fat depth and the fat depth measured on images could be an explanation of such results (MILLER et al 1988, FAULKNER et al 1990, BULLOCK et al 1991). The repeatibility and interpreter effect has to be analysed.

The technique based on the measurement of adipose cell diameter is a specific measure of adipocity and appeared to be of potential utility in nutrition experiments where prediction of total body fat content is needed. However for performance testing bulls on lean growth capacity, the efficacy of that technique is limited by its relatively low correlation with lean content.

The results of this experiment confirm the potential efficacy of the VOS technique for predicting body and carcass composition (MILES et al 1987, 1990, PORTER et al 1990, FURSEY et al 1991). Live VOS appeared to be of potential use for predicting both fat and lean content and therefore for performance testing breeding bulls.

At slaughter, although fat thickness and rib eye area measured on the 6th rib removed from the cold carcass appeared to be relatively efficient for predicting carcass composition in this experiment, these results have to be confirmed with complete dissection since carcass composition has been estimated using equations based on dissection of this 6th rib. In conditions of commercial slaughtering, the measurement of VOS through the hot carcass appeared to be a potential alternative method.

These first results need to be confirmed with new samples of cattle representing the range of variation in composition that exist in the French beef production systems and in performance testing situations. Repeatibility, operator and interpreter effects have also to be studied for a complete analysis of the efficiency of these different methods.

ACKNOWLEDGEMENTS
This work was supported by INTERBEV and the Ministère de la Recherche et de la Technologie. The authors would like to thank B. LANDELLE (Institut de l'Elevage), L. GRESSIN and D. KRAUSS (INRA) for their technical collaboration; J. DELAJOUD (Institut de l'Elevage) and J.P. DESECURES (ACTA) for their statistical advices.

REFERENCES

ABRAHAM H.C., MURPHEY C.E., CROSS H.R., SMITH G.C., FRANCKS W.J., 1980. Factors affecting beef carcass cutability: an evaluation of USDA yield grades for beef. J. Anim. Sci., 50, 841-851.

AGABRIEL J., GIRAUD J.M., PETIT M., 1986. Détermination et utilisation de la note d'état d'engraissement en élevage allaitant. Bull. Tech. CRZV Theix, INRA, 66, 43-50.

BULLOCK K.D., BERTRAND J.K., BENYSHEK L.L.,WILLIAMS S.E., LUST D.G., 1991. Comparison of real-time ultrasound and other live measures or carcass measures as predictors of beef cow energy stores. J. Anim. Sci., 69, 3908-3916.

DE BOER H., DUMONT B.L., POMEROY R.W., WENIGER J.H., 1974. Manual on EAAP reference method for the assessment of carcass characteristics in cattle. Livest. Prod. Sci., 1, 151-154.

FAULKNER D.B., PARRET D.F., MAC KEITH F.K., BERGER L.L., 1990. Prediction of fat cover and carcass composition from live and carcass measurements. J. Anim. Sci., 68, 604-610.

FISHER A.V., 1990. New approches to measuring fat in the carcasses of meat animals. In "Reducing fat in meat animals" (J. Wood and A.V. Fisher, eds). Elsevier London, 255-343.

MILES C.A., FURSEY G.A.J., YORK R.W.R., 1984. New equipment for measuring the speed of ultrasound and its application in the estimation of body composition of farm livestock. In "*In vivo* measurement of body composition in meat animals" (D. Lister, ed). Elsevier London, 93-105.

MILES C.A., FURSEY G.A.J., PAGE S.J., FISHER A.V., 1990. Progress towards using the speed of ultrasound for beef leanness classification. Meat Sci., 28, 119-130.

MILLER M.F., CROSS H.R., BAKER J.F., BYERS F.M., RECIO H.A., 1988. Evaluation of live and carcass techniques for predicting beef carcass composition. Meat Sci., 23, 111-129.

PORTER, S.J., OWEN M.G., PAGE S.J., FISHER A.V., 1990. Comparison of seven ultrasonic techniques for *in vivo* estimation of beef carcass composition with special reference to performance testing. Anim. Prod., 51, 489-495.

ROBELIN J., GEAY Y., 1975. Estimation de la composition de la carcasse des taurillons à partir de la composition de la 6ème côte. Bull. Tech. CRZV Theix, INRA, 22, 41-44.

ROBELIN J., AGABRIEL J., 1986. Estimation de l'état d'engraissement des bovins vivants à partir de la taille des cellules adipeuses. Bull. Tech. CRZV Theix, INRA, 66, 37-41.

SIMM G., 1983. The use of ultrasound to predict the carcass composition of live cattle: a review. Anim. Breed. Abstr., 51, 853-875.