EVALUATION OF VELOCITY OF ULTRASOUND, VIDEO IMAGE ANALYSIS, AND LIGHT REFLECTANCE PROBES IN CARCASS CLASSIFICATION SCHEMES

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INTRODUCTION

There is a continuing need in the meat industry to improve methods of carcass description and primarily to estimate accurately and precisely the lean meat content, thereby improving market efficiency. The problems posed in the three red meat species cattle, sheep and pigs are different and as a consequence the approaches to classification are different. In pig carcass classification, the general objective has been to sort pigs on the basis of backfat thickness, but there has been disagreement on the value of attempted further refinement through subjectively assessed degree of muscling, or 'type' classification. The evolution of automatic probes for pig carcass classification based on light reflectance or electrical conductivity, has now reached the point where muscle depths as well as fat thicknesses can be measured objectively, but the information on carcass leaneness is only slightly improved by measuring the depth of m.longissimus (Newman and Wood, 1989; Diestre, Gispert and Oliver, 1989). In cattle and sheep carcass classification the extent of subcutaneous fat cover and carcass conformation, both subjectively assessed, have been the traditional criteria used to estimate the yield of saleable meat, and until recently there have been few innovative approaches to improve objectivity in these species. Some studies have applied the pig technology of probing to ruminants, with varying degrees of success (Kempster, Chadwick, Cue and Grantley-Smith, 1986; Phillips, Herrod and Schafer, 1987).

Major objectives in carcass classification research are, therefore,

(a) To objectively quantify muscle development in pigs to complement fat depth measurements and improve the accuracy of lean prediction.

(b) To develop objective techniques to predict composition in cattle and sheep carcasses which could replace current subjective visual assessment procedures.

Video-image analysis (VIA) is a technique which has potential use in commercial classification. It enables quantification of surface phenomena of carcasses to be made, covering a wide range of aspects including carcass shape, fat cover in ruminants, and carcass blemishes. It is non-contact, very rapid, and can be fully automated. The technique has been applied to beef carcass thigh conformation and fat distribution (Sorensen, Klastrup and Petersen, 1988) and to beef carcass tissue proportions at the plane of quartering (Cross, Gilliland, Durland and Seideman, 1983).

Velocity of ultrasound (VOS) is a novel method which can measure lipid concentration in meat tissues based on the differential speed of transmission of ultrasound through adipose and non-adipose soft tissues. It has been used successfully in live animals (Miles, Fursey and York, 1984) and more recently has been applied to beef carcasses (Miles, Fisher, Fursey and Page, 1987). The principal advantage of this method is that intermuscular fat - the major depot in cattle and sheep-influences the speed measurement which in fact reflects total lipid in the core of tissue lying between the transmitting and receiving transducers. The association with percentage lean derives from the close relation between this compositional trait and the ratio of lipid to non-lipid volumes of soft tissues. This paper reports some data on the quantification of pig carcass shape using VIA, and presents further results obtained using VOS on beef carcasses. A preliminary examination of the value of light reflectance probe fat and lean thickness measurements as predictors of beef carcass composition is also included.

MATERIAL AND METHODS

VIA

Details of the system are the subject of a patent application.

Basically, the system comprises a number of fixed position self compensating CCD (close coupled device) cameras linked to a digital image analyser (Automatix AV90). Automatic carcass lighting and specialist software were employed. For each carcass, the system makes a number of objective measurements of several carcass profiles. For beef, these measurements provide the information allowing quantitative interpretation of both fat cover and carcass conformation to be made. For pigs, the image analysis system only produces carcass conformation data.

The data reported here relate to eight pigs, four Large White and four Pietrain boars ranging in carcass weight from 72 to 96 kg. After measurement of P2, eye muscle dimensions and VIA imaging, they were fully dissected into lean, fat and bone. From carcass images taken from three different aspects, a composite value reflecting carcass 'fullness' per unit length and nominally labelled 'volume' was calculated.

VOS

The apparatus used has been described elsewhere (Miles, Fursey and York, 1984). In this study, two versions of the frame/transducer assembly were used, differing in physical dimensions and transducer specification. This effect was removed in the statistical treatment of the data.

In total, 98 beef carcasses were measured using VOS, the thickness of SCF was measured at 25%, 50%, and 75% of the width of m.longissimus at the last rib, and the carcasses were subsequently assessed on 15 -point EAAP scales for fatness and conformation before complete physical dissection.

Automatic light reflectance probe

The instrument used was a Hennessy GP2'Q' pig probe from which reflectance profiles were logged on a Compaq portable computer by means of the Hennessy research sub-system (board and software). The algorithms in the pig programme were not used to define tissue depths. Rather, the reflectance profiles were interpreted by an operator who defined tissue boundaries. Thicknesses of subcutaneous fat, underlying muscle, and the first intermuscular depot encountered were logged at 3 sites: the so called P8 measurement on the rump (Moon, 1980); 10cm from the dorsal mid-line at the 10/11th rib and 10cm from the midline at the last rib.

Twenty-two Hereford x Friesian heifers and steers were measured in this way, and subsequently fully dissected.

RESULTS

The compostion of the samples in terms of breed and sex examined by all three techniques is given in Table 1, together with the means and standard deviations of lean proportions.

Table 1. Composition of the samples by breed and sex, and lean proportion.

Technique	Breed	Sex	n	x	S.D.
VIA	Large White	boar	4	62.1	2.37
	Pietrain	boar	4	67.7	3.56
	(All pigs)		8	64.9	4.10
VOS	Friesian (F)	bull	21	63.6	2.36
	Friesian	steer	5	56.2	5.15
	Hereford (H)	bull	30	61.5	2.89
	H x F	bull	6	65.4	1.38
	H x F	steer	30	59.4	2.17
	Limousin x F	bull	3	69.4	2.82
	Limousin x F	steer	3	64.8	0.65
	(All VOS cattle)		98	61.6	3.65
Light probe	H x F	steer	10	58.8	2.64
	H x F	heifer	12	57.6	2.66
	(all HGP cattle)		22	58.2	2.66

VIA

Results obtained from the regressions of % lean on predictor variables for each breed separately and both combined are given in Table 2.

Table 2. Residual standard deviations of percentage lean in two breeds of pig.

Predictor(s)	Large White	Pietrain	Combined
P2	0.5	2.4	4.0 (4.0%)+
P2 + CCW	0.7	1.7	2.0 (76.0%)
P2 + breed	-	-	1.7 (83.2%)
P2 + 'B'	0.5	1.8	1.2 (90.8%)
P2 + 'volume'	0.03	0.44	1.2 (91.2%)

+ Proportion of variation explained in parentheses.

P2 fat thickness + breed explained more variation in lean percent than P2 + weight (CCW). Including eye muscle depth 'B' with P2 reduced the unexplained variation further, as did the combination of VIA 'volume' and P2. VIA was most effective within breeds.

VOS

Two basic parameters are obtained from the VOS equipment: time of flight and the distance between the transducers. From these, the reciprocal of the speed of ultrasound (RV) and the lipid (= fat) thickness (FD) are calculated. Measurements were made through the shoulder (site 3, (Miles, Fisher, Fursey and Page, 1987): cranial to first rib, through m.scalenus) and through m.longissimus at the 10/11th rib intercostal space parallel to the sagittal plane of the carcass (site 4). A mean value for RV and FD was calculated for each animal.

The residual standard deviations of % lean from regression analyses obtained overall and pooled within subgroups allowing for sex, breed and sex + breed effects are given in Table 3.

Table 3. Residual standard deviations of percentage lean in cattle, using VOS measurements, fat depths and visual scores as predictors.

Predictor	Predictor used alone	+ sex (s)	+ breed (b)	+s+b
Original S.D	3.65	3.23	3.35	2.61
RV 3,4	1.95	1.93	1.94	1.78
FD 3,4	2.00	1.84	1.97	1.69
SCF depth	2.51	2.09	2.25	2.03
Fat score	2.27	1.90	2.07	NS

The VOS parameters were more highly correlated with % lean than either subcutaneous fat depth or visual score. Fitting separate regression lines to sex and breed subgroups reduced the residual standard deviations for each predictor, but the effect was smaller for the ultrasonic measurements than for the subcutaneous fat indices. Conversely, when both sex and breed were included together, the biggest reductions in RSDs were found for the ultrasonic variables. In commercial clasification, breed would not be known for the majority of carcasses. Hence a model of best fit using stepwise regression procedures was obtained with a free choice of parameters except for breed. The model fitted separate slopes for the two sexes to fat depth and cubed fat depth data, combined with RV4. It resulted in a lower RSD for percentage lean (1.65) than that obtained fitting separate lines to fat depth data allowing for sex and breed effects (1.69, Table 3).

Prediction of percentage lean in the separate breed x sex subgroups was obtained using this model, and deviations from the values obtained from dissection are shown in Table 4. The observed values exceeded the predicted for three groups: Friesian bulls, Limousin bulls and Limousin steers, and were less than the predicted values for Hereford bulls, Hereford x Friesian bulls and steers. In most cases the deviations were small.

Table 4. Predicted minus observed values for percentage lean in different breeds and sexes using the 'best fit' model.

	Bull	Steer
Friesian	-0.2	0
Hereford	0.2	-
Hereford x Friesian	0.3	0.1
Limousin x Friesian	-1.8	-0.9

Automatic probe

When both sexes were combined, there were significant negative

correlations between lean percent and subcutaneous fat depths measured with the probe at the P8 and 10/11th rib sites, but not at the last rib. When the relations were calculated within each sex and then compared between them, they were inconsistent in that the P8 site was significantly correlated with % lean in the steers only, and the 10/11th rib site in the heifers only. The residual standard deviations of percentge lean are shown in Table 5.

Side weight alone reduced the residual standard deviation compared with any probe fat depth in either single sex sample or in the pooled sexes. Only in the pooled sex group did probe fat depth reduce the RSD when combined with side weight; within sex, fat depths were not significant. The steer sub-group was unusual in that side weight alone was very effective in reducing the RSD of percentage lean (0.99).

Also shown in Table 5 are the RSDs from prediction using EAAP fat scores. For the combined sample, the precision of prediction of % lean was greater than that using probe fat depth + side weight.

There were no significant correlations involving muscle depths or thicknesses of intermuscular fat depots in this study.

CONCLUSIONS

The results provide proof of the efficacy of VOS in estimating lean percentage in cattle carcass of mixed type: precision is at least as great as that obtained using a detailed, discriminatory visual assessment system. Further developments are in progress to improve equipment design and to test the technique under commercial abattoir conditions. Video-image analysis has potential to improve the precision of estimation of lean content in pigs when used in conjunction with measurement of backfat thickness. Too few animals were studied here to convincingly demonstrate its value but the degree of precision obtained at this preliminary stage appears to be at least comparable to that obtained from combinations of measurements of backfat and m.longissimus depth. Visual assessment of fat cover in beef carcasses is more precise than fat thickness measurements made with automatic probes as predictors of lean content. VIA also has potential for estimating fat cover as well as conformation in beef so the prospect for improving precision over that obtained using probes, and developing a truly objective system is good. Further work will compare all three methods on larger samples of carcasses.

Table 5. Residual standard deviations of percentage lean in heifers and steers using probe fat depths, side weight and fat score as predictors.

	Combined sexes	Steers	Heifers
Original S.D.	2.66	2.64	2.66
Fat depth - P8	2.44	2.26	NS
Fat depth - 10/11th rib	2.21	NS	2.06
Side weight	2.19	0.99	1.84
Side weight + P8 fat depth	1.83	NS	NS
Side weight + 10/11th rib fat depth	1.98	NS	NS
Fat score	1.59	1.78	1.51

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