CLASSIFICATION OF BOVINE CARCASSES BY MEANS OF VIDEO IMAGE ANALYSIS AND REFLECTANCE PROBE MEASUREMENTS

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SUMMARY

The investigation was based on the application of a prototype beef carcass classification centre consisting of a video image analysis system, an optical probe measuring device and electronic carcass weighing. 2,948 carcasses were put through the centre; 389 of these were dissected and further carcass measurements obtained. Prediction by multiple regression equations was carried out with the following RSD- values: Saleable meat 1.5%, fat trim 1.4%, bone content 1.3%, EUROP conformation 1.0 subclass and EUROP fatness 0.6 class. RSD-values at repeated measurements were in the order of half these figures. It was concluded that after final production engineering including some software enhancements the classification centre would be suitable for industrial carcass classification.

INTRODUCTION

Classification of bovine carcasses in the EEC is based on the subjective EUROP grading system for conformation and fatness and is used widely in Denmark as a basis for payment to the producer with a substantial price differential attached to the system. In order to secure the best possible basis for carcass quality payment and to ensure a good correlation to yield and value of saleable meat, work was started some years ago on the development of an objective system for classification of beef carcasses according to carcass composition. The investigation has been supported by the Danish beef industry.

Earlier work on establishing the basis for evaluation of carcass composition parameters and on the concept of applying Video Image Analysis (VIA) for beef classification has been published earlier (Sørensen, 1984). Since then the VIA method has been tested in combination with the measurement of tissue depths using an optical probe system. This has provided the basis for the development of a semi-automatic prototype beef carcass classification centre. This paper describes the results obtained during a three month test of the classification centre prototype under practical production conditions.

EXPERIMENTAL METHODS

The appearance of the classification centre is shown in figure 1. In short the centre consists of a transport system for the carcass, a classification enclosure where the VIA measurements take place, an operative platform equipped with keyboard, display and monitors, an optical reflectance probe measuring pistol with monitor, an electronic weighbridge on the rail and PLC and computing facilities for system control and calculation of classification results. The VIA-system is further described by Petersen et al. (1987) whereas details on the Danish optical probe is reported by Nielsen et al. (1984). The classification centre was installed at a commercial slaughterhouse at the end of the slaughterline, i.e. immediately after dressing and veterinary meat inspection.

The centre was operated at a line speed of approx. 30 carcasses/hour (max. capacity 75 carcasses/hour). During each classification cycle the following information was obtained:

- VIA coordinates of the carcass contour (lateral projection)
- VIA distribution of grey tone values within carcass contour (green illumination)
- Fat cover thickness (mm) at the rump, 10 cm laterally from the tail root on both left and right carcass side
- Fat cover over the *Longissimus dorsi* muscle and *Longissimus dorsi* muscle thickness between the 13. thoracic and the 1. lumbar vertebrae on both left and right carcass side at a lateral distance of 9-14 cm depending on carcass weight.
- Hot carcass weight
- Carcass category, identification, etc. (entered via a keyboard)

The results were later compared with EUROP conformation and fatness as assessed by the authorised classifiers at the slaughterhouse. A subsample of the classified carcasses were subjected to additional

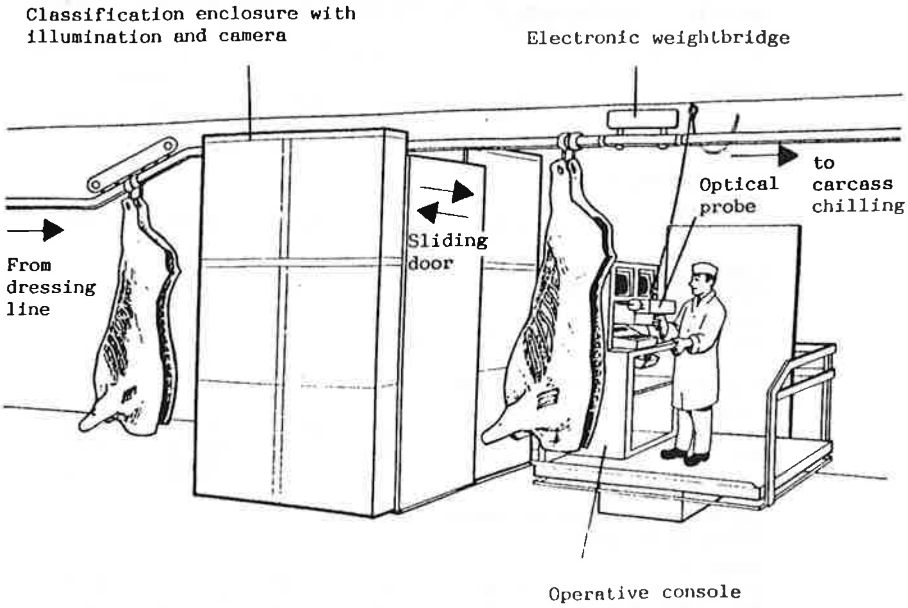

Figure 1: Schematic drawing of the classification centre. The electronic connections, PLC and classification computer rack are not shown.

Table 1: Number and distribution of carcasses according to the EUROP-classification system. Numbers in brackets are carcasses sampled for dissection.

	Young bulls & male calves		Steers & bulls		Heifers & female calves		Cows		Total	
Conformation:										
E	6	(2)	-	(-)	1	(1)	-	(-)	7	(3)
U	46	(31)	8	(5)	10	(7)	9	(5)	73	(48)
R	504	(66)	37	(6)	51	(19)	129	(20)	721	(111)
O	1114	(62)	39	(6)	174	(40)	516	(46)	1843	(154)
P	128	(33)	-	(-)	37	(14)	139	(26)	304	(73)
Fat class:										
1	76	(20)	4	(3)	19	(11)	83	(17)	182	(51)
2	1236	(97)	26	(3)	68	(20)	159	(25)	1489	(145)
3	427	(58)	47	(9)	145	(31)	416	(25)	1035	(123)
4	58	(18)	5	(2)	34	(14)	112	(18)	209	(52)
5	1	(1)	2	(-)	7	(5)	23	(12)	33	(18)
Total:	1798	(194)	84	(17)	273	(81)	793	(97)	2948	(389)

Table 2: Means and standard deviations of carcass characteristics including VIA and reflectance probe measurements

	Total sample		Dissected subsample	
	Mean	s.d.	Mean	s.d.
Carcass weight, kg	243	51	242	57
Saleable meat, %	-	-	76.2	2.1
Fat trim, %	-	-	6.9	2.1
Bones, %	-	-	18.1	2.1
Area of l. dorsi, cm²	-	-	59.9	12.9
Fat thickness (ruler), mm	-	-	4.7	3.7
Probe measurements:				
Fat thickness at rump, mm	9.4	5.2	9.9	6.2
Fat thickness at loin, mm	4.9	1.9	5.2	2.2
L. dorsi thickness at loin, mm	49.8	8.0	50.9	9.2
Some VIA measurements:				
Area of surface fat, %	61.9	6.2	62.5	6.6
Carcass length, cm	211	14	210	14
Carcass area, cm²	8,958	1,271	8,763	1,340
Convexity at thigh 1)	0.59	0.09	0.60	0.10

1) Deviation of the carcass contour from a line between the tail root and the distal part of the thigh.

Table 3: Performance of classification equations, based on multiple regression 1)

Trait:	Meat, %	Fat, %	Bone, %	EUROP Confor-mation 2)	EUROP Fatness
Carcass weight:					
Coeff. of correlation	0.40	0.17	0.47	0.53	0.44
Equation based on weight and subjective grading:					
Coeff. of correlation	0.74	0.75	0.77	-	-
Classification centre equations:					
Coeff. of correlation	0.73	0.77	0.79	0.84	0.67
Res. stand. dev.	1.5%	1.4%	1.3%	1.0 sub-class	0.6 class
Repeatability of classification centre equations 3):					
Coeff. of correlation	0.94	0.71	0.97	0.98	0.91
Res. stand. dev.	0.6%	0.7%	0.3%	0.4 sub-class	0.2 class

1) All coeff. of correlation are significant diff. from 0 (p<0.001)
2) Divided into 15 subclasses (P+ to E+)
3) Based on 45 carcasses

dissection into saleable meat, fat trim and bones following the Institute's standard procedure. Furthermore, the carcass length (EAAP) and the area of longissimus dorsi muscle at 1.-2. lumbar vertebrae were recorded for these carcasses.

The number and distribution of the test material are shown in table 1. Compared to the national classification statistics, the sample is not exactly representative, but it does reflect the normal national variation within and between categories.

Data from the VIA system describing carcass length, area, relative dimensions, curvature at the thigh and distribution of surface fat was combined with probe measurements of fat and meat thickness and the weight of the carcass to multiple regression equations describing carcass composition and EUROP grades. The equations included correction factors for carcass category, for dorsal splitting, and for carcasses originating from the Jersey breed. The classification centre was equipped with means for controlling the probe measurement by comparison of measurements from left and right side and rejecting deviations above predefined levels. If probe measurements in the loin were rejected, the carcass was not re-measured but instead an alternative classification equation was applied. All calculations were carried out using the Statistical Analysis System. Residual Standard Deviation is denoted as RSD.

RESULTS

Means and standard deviations of basic carcass characteristics together with major probe and VIA measuring results are shown in table 2. Table 3 shows the predictive value of the multiple regression equations used for description of the carcass traits, together with the correlation between repeated measurements on the same carcasses. For comparison, the correlations to carcass weight and to the best equation based on weight and EUROP-grading (fatness, conformation, category) are also shown.

The results show in general, that approximately the same information about carcass composition could be derived statistically from the EUROP grades and the carcass weight as from the objective measurements. The reproducability was, however, better for the objective system than found for subjective grading (unpublished data).

Results from the VIA measurements (not shown) describing the shape of the thigh and the "density" of the carcass (e.g. kg/cm carcass length) gave together with the lean thickness measured by probe the best prediction of conformation as well as saleable meat yield and bone content. Regarding the measurements of fatness, the results from probe measurement of fat thickness were considerably more useful than measurement of the relative area of surface fat. Thus, the partial correlations (constant carcass weight) between EUROP fat class and fat thickness measurements were in the range of 0.45-0.55, whereas the similar coefficients for VIA fat cover area were as low as 0.17-0.25.

DISCUSSION

As the application of measuring equipment on the slaughterline involves considerations to robustness, costs and other constituents of practicability, it has been the concept of this development to aim at a relatively simple, robust and reliable system, given that the accuracy of the method should be at least as good as can be achieved by using subjective grading under optimal conditions. The results reported here seem to fulfil that requirement. The main improvement over subjective grading is thus the reproducibility which can be achieved.

Results reported in the literature on objective measurements are numerous, but not based on the combination of VIA and tissue depth measurements as used here. Also, the carcasses investigated are seldom covering the complete range of commercial categories. Earlier Danish work (Lykke 1978) applying mainly probe measurements of fat and lean thicknesses gave prediction of dissected lean content with a RSD of 1.5-2.4% depending on the carcass sample. Kirton et al. (1987) predicted edible meat yield using the Hennesy Grading Probe with a RSD of 2.0- 2.6%. More precise results were obtained by the use of VIA on the ribbing surface by Wassenberg et al. (1986), giving a RSD of around 1% lean. Miles et al. (1987) found using the Velocity of Ultrasound a RSD for dissected lean meat percentage of 1.79-1.90. Results comparing objective methods with the EUROP grading system are scarce. A French mechanical system for measurement of conformation has been compared with EUROP conformation (Anon., 1985). The results were comparable to those reported here (87% within one subclass) but without any measurement of fatness and carcass composition.

Kempster et al. (1982) reported a RSD-value for saleable meat percentage of 1.7 using subjective scores for fatness and conformation together with carcass weight. These results underline that major improvements in accuracy of prediction should not be expected when compared to the best possible equations derived from experienced assessors' information. This, however, is considerably more difficult to repeat, especially between graders and over time, than an objective system.

It is important to consider, that the classification method reported here is adapted to the carcass types and the dressing procedures used in the Danish meat industry. This is not least important to consider in relation to the proportion of lean young bulls in comparison to the fatter steers, and thereby the relative importance of lean/bone to lean/fat ratio. Both components of carcass composition are, however, included in the system.

According to the results reported here it would not be possible to rely solely on VIA measurements of fat cover area for prediction of fat content. The measuring problems associated with this method are probably enlarged by carrying out the classification on the hot and semi-translucent fat layer, but the anatomical irregularity of the surface is thought to be the main limit for accuracy. In contrast, the use of probe measurements on the hot carcass is according to our experience at least as precise as cold measurements, provided, a: that the measurements are obtained before entering the chilling room, b: that suitable means are taken to distribute the pressure on the carcass surface over a sufficiently large area, c: that suitable probe tips are used. It is, however, as also reported by Johnson and Vidyadaran (1981) important to avoid the use of measuring sites which are seriously affected by hide removal. As potential sources of errors cannot be fully excluded, the measurement at identical sites on both carcass sides and automatic rejection of too deviating results is strongly recommended. In the present study 6.5% of the probe measurements were rejected due to internal deviation. A further improvement in the reflectance profile algorithms would help to reduce this figure substantially, and thus reduce the need for repeated measuring and - in the worst case - rejection from automatic grading.

The VIA measurement benefits from the fact that there is no physical contact between the measuring system and the carcass, and the means required for controlling ingingingthe carcass position and angle towards the camera are fairly simple. The measurements of both split and non-split carcasses are thus possible in the same classification centre provided that appropriate corrections are made for the visual effects of dorsal splitting.

In industrial applications the combination of weighing and classification in one unit positioned immediately after dressing will reduce manpower requirements and facilitate a fast collection of a complete carcass record for payment to the producer and for disposal of the carcass.

CONCLUSIONS

Based on the investigation reported here, it is concluded that it will be possible to carry out objective classification of bovine carcasses under practical production conditions with an accuracy as good as can be achieved by experienced graders at a given time, and thus with the potential of a higher repeatability over time and between different locations. Whereas VIA and weight measurements are fully independent of the operative, the importance of the correct use of the optical reflectance probe should be stressed. It would, however, be possible to automate the probe measurements if the costs for this can be justified. It should furthermore be emphasised that proper inspection of carcasses as well as measuring results will still be necessary as faulty dressing procedures could influence the measurements.

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