BCC-2 for Objective Beef Carcass Classification and Prediction of Carcass Composition

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Background

Subjective classification of conformation and fatness has traditionally been carried out over a number of years within the Danish classification system in accordance with the EU EUROP-system. Carcasses are graded in classes from 1 to 15 for conformation and from 1 to 5 for fatness. Development of an objective classification system has been a major requirement from beef producers. The Danish Beef Classification Center (BCC-1) was developed as a prototype in the period 1986-91. Based on promising new results from the BCC-1 (Madsen & Thodberg,1994) it was decided to develop a second generation, the "BCC-2".

Objectives

The development has been carried out to meet detailed and specific requirements from the Danish beef industry. Contrary to the BBC-1, the BCC-2 should by fully objective, have better classification performance, higher capacity and be able to classify surface fat colour. Furthermore it should be based on state of the art technology and operate without manual probe measurements and without a cabinet. The BCC-2 should also be able to predict the carcass composition.

Methods

The BCC-2 has been installed in-line at the end of the slaughterline in a commercial slaughterhouse (Kolding) since March 1995 and has been operating almost continuously during the development stage. By April 1996 the BCC-2 has measured more than 30,000 carcasses.

The BCC-2 is based on colour vision technique and operates at a rate of maximum 80 carcasses/hour but can be tuned for higher capacity. Pictures are taken of the left carcass half when it is positioned on a frame in front of a green background screen. The carcass is lit by two specially designed halogen lamps that ensure an even illumination.

Meat and fat thicknesses were measured manually with a probe in the BCC-1. In the BCC-2 this information is provided by more detailed extraction of information from the pictures and a volumetric measurement by a light striping system. The three dimensional structure of the carcass is captured indirectly from an analysis of light stripes projected onto the carcass from an angle. Depending on the muscularity or thickness of the carcass, the individual light stripes will appear more or less deflected from a straight line when viewed from the camera angle. By interpolating the lines a virtual mapping of the carcass depth can be included in the calculation of conformation, composition etc. A thorough daily calibration method ensures that the BCC-2 classification results can be reproduced in other installations.

In April/May 1995 more than 3500 carcasses were measured and an inspector from the Danish Beef Classification Board classified the carcasses at the point of weighing. These data have been used for training the BCC-2 for EUROP-classification and fat colour. The carcasses are assumed to be representative with regard to variation in season, weight, category, EUROP-class and breeds in Denmark.

Cutting trials for composition prediction were carried out in June to September 1995 where 476 carcasses consisting of 205 young bulls, 109 heifers and 162 cows of varying weight, fatness and yield were cut according to a standardized method that is close to the standard used in the industry.

When measuring in the BCC-2, the video camera records 2.5 megabytes of information for each carcass. In the vision computer all important features are extracted thus reducing the input to the classification algorithms to 4320 bytes ≈ 540 parameters supplemented with the weight of the carcass. Complex intermediate steps are carried out in the data processing. In the algorithms both linear regression and neural networks were applied. Standard error of prediction (SEP) rather than standard error of calibration (SEC) were calculated using a training and independent test set or similar methods. The resulting SEP values thus represent real performance. R^2 was estimated as: $R^2 = 1- SEP^2$ /variance of predicted variable.

Results and discussion

The BCC-2 performance in predicting carcass composition is shown in Table 1. It meets the industry's specified requirements for accuracy very well. Compared to results with the BCC-1 (Madsen & Thodberg, 1994), where saleable meat was predicted with R^2=75% and SEP=1.23% in 230 carcasses, the yield is predicted slightly less accurately even when correcting for a higher standard deviation of 2.45% versus 2.33%. This difference is thought to be partly due to larger anatomical variations in the carcasses and partly a less accurate cutting reference. However the BCC-2 still predicts saleable meat with a 18% lower SEP than predicted from subjective classification and weight, as compared to 7% lower for the BCC-1.

Jones et al. (1995) reported R^2=61% and RSD=1.5% on 497 carcasses also using a visionsystem. Despite that the methods of measuring, cutting and the nature of carcasses differs which make comparison difficult, it seems reasonable to expect that the obtainable accuracy with such vision systems are limited to the order SEP's of 1.25% to 1.5% depending on method and variation in animals. It should be noted that accuracy in the cutting procedure may account for a SEP of up to 1% alone. The practical alternative to the BCC-2 is predicting composition from the subjective EUROP classification and carcass weight, but the BCC-2 has SEP's that are 6 to 25% lower. In other terms eg. the weight of a hindquarter of a mean weight of 58 kg can be predicted within ± 2.5 kg in 95% of the cases.

To test the robustness of the BCC-2 139 carcasses were measured twice with an interval of a few seconds by withdrawing the frame and repositioning it to remeasure the carcass. The R squared for the repeated measurements was above 0.99 for all main parameters. Root – mean – square-errors (RMS) of the deviation of repeated measurements are given in the table and meet the requirements very well.

Table 1. BCC-2 predicting composition in 476 carcasses. SEP, means and std. deviation as % of carcass weight*, LD area in cm²

	Specified demands for BCC-2			Predictions from Subjective – EUROP by classifier and weight		BCC-2 prediction				Cutting results	
Carcass trait	R^2	SEP	RMS**	R^2	SEP	R^2	SEP	SEP, grammes per ½ carcass	RMS repeated measurement n=139	Mean	Standard deviation
Saleable meat	0.65	1.35	0.30	0.56	1.63	0.70	1.34	1670	0.20	75.5	2.45
Fat trim	0.80	1.15	0.30	0.57	1.01	0.66	0.90	1120	0.14	5.22	1.54
Bone	0.75	1.1	0.20	0.68	1.48	0.82	1.11	1380	0.15	18.9	2.62
Hind quarter	0.60	1.1	0.30	0.47	1.26	0.66	1.01	1250	0.16	47.5	1.72
Hind quarter cuts	0.65	1.0	0.30	0.59	1.10	0.64	1.04	1290	0.18	33.7	1.73
LD muscle	0.55	0.6	–	0.49	0.45	0.66	0.37	460	–	5.43	0.63
LD area, cm²	0.65	8	1.40	0.80	6.65	0.85	5.76	–	1.03	61.5	15.0

*) Mean carcass weight 245.2 kg std. 59.9 kg **) repeated measurements

In Table 2 the performance for EUROP and fat colour classification are shown. Again the BCC-2 meets the industry requirements very well and also performs better than the BCC-1. Fatness is more difficult to predict than conformation, however that is partly due to the fact that the reference is less accurate for this parameter as fatness seems more difficult to classify consistently. BCC-2 performance is compared to the agreement between Classifier and Inspector which is common practice in most Scandinavian countries. Only 3069 carcasses were classified by the plant Classifier out of the 3473 carcasses classified by the Inspector due to missing data, however due to the large numbers the figures should be comparable. The BCC-2 is in better agreement with the reference for conformation and fatness. The fat colour scale was new for the Inspector and Classifier but surprisingly good results were obtained.

As comparison with repeated BCC-2 classification RMS-values are shown for repeated Inspector classification within 1 hour, at weighing and in the chiller, respectively. The results of repeated measurements are a good argument for using objective classification. They show that subjective classification is difficult to conduct consistently under practical conditions even for experienced Inspectors. BCC-2 results for both EUROP classification and fat colour meet the requirements very well.

Another important parameter is the percentage of classifiable carcasses. Under normal production conditions about 95–99% of carcasses can be classified depending on the quality of the slaughter process, trimming due to e.g. disease etc.

Table 2. BCC-2 predicting EUROP-classification and fat colour

	Specified demands for BCC-2		Subjective –EUROP Classifier vs. Inspector			BCC-2 prediction			Repeatability			
									Requirement BCC-2	BCC-2 n=139	Inspector, at weighing vs. chiller n=979	
Carcass trait	R^2	SEP	N	R^2	SEP	N	R^2	SEP	RMS	RMS	R^2	RMS
Conformation 15-scale	0.90	0.75	3069	0.90	0.73	3471	0.93	0.57	0.20	0.12	0.95	0.51
Fatness 15-scale*	(0.65**)	(0.55**)	3069	0.63	1.15	3473	0.75	0.97	0.30	0.17	0.85	0.80
Fat colour 10-scale	0.65	–	823***	0.82	0.73	3478	0.89	0.59	0.30	0,07	0.94	0.43

*) Fatness scale extended with subclasses **)Demands on 5-scale ***) both classified in chiller

Conclusion

Currently the BCC-2 in Kolding is the only Danish installation. During the summer of 1996 the industry is expected to decide on further installations. The classification performance meets the industry requirements very well. The technical performance of the system has been tested over more than a year and proved to be sufficiently reliable. The BCC-2 is a good alternative to subjective classification and offers in addition an accurate prediction of the carcass composition.

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