OBJECTIVE BEEF CARCASS CLASSIFICATION

A REPORT OF A TRIAL OF THREE VIA CLASSIFICATION SYSTEMS

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FOREWORD

The McKinsey Report (Enterprise Ireland, September 1998) and the Report of the Beef Task Force (Department of Agriculture, Food and Rural Development, June 1999) recommended that the Irish beef industry should move towards a mechanical carcass classification system as soon as possible. This could then form the basis of a quality based payment schedule agreed between producers and processors. A pilot study of three of the commercially available systems was carried out by The National Food Centre, Teagasc and The Department of Agriculture, Food and Rural Development in collaboration with Dawn Meats (Midleton) Ltd. This report contains the results and conclusions of that study.

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SUMMARY

Three beef carcass classification systems that use Video Image Analysis (VIA) technology were tested in two trials at Dawn Meats Midleton, Co. Cork. The systems were BCC2, manufactured by SFK Technology, Denmark, VBS2000, manufactured by E+V, Germany, and VIAscan, manufactured by Meat and Livestock Australia. The first trial, conducted over a 6-week period in July/August 1999, involved calibrating the systems on a sample of carcasses representative of the Irish slaughter population then validating these on a further sample obtained at the same time. The second trial, conducted in the first two weeks of March 2000, was a further validation trial on an unrelated sample. The reference for the calibration and validation exercises were determined by a panel of three experienced classifiers using the EUROP gird with subclasses for conformation class and fat class (15 classes for each). In the first trial the accuracy of the systems at predicting saleable meat yield in a sample of steer carcasses was also assessed.

In the first trial, after calibration, the systems predicted the scores of the reference panel for the validation set to within 1 subclass for 92.8%, 91.0% and 96.5% of the carcasses for conformation and for 80.4%, 72.0% and 74.6% of the carcasses for fat class, for BCC2, VIAscan and VBS2000 respectively. The performance of all three systems was clearly superior for the prediction of reference conformation class than for the prediction of reference fat class. There were some biases (systematic over- or under-scoring) either overall or within certain classes for conformation class and fat class predictions. There was also variation in the accuracy within classes for all three systems for conformation class and fat class predictions. Saleable meat yield was predicted with a similar high accuracy (rsd = 1.1- 1.2%) by all three systems.

A further calibration exercise was undertaken by the manufacturers of the systems, by combining all the data from the calibration and validation sets. These new calibrations were then tested in a second trial also at Dawn Meats, Midleton in March 2000. The results of this second trial were either similar or slightly better than the first trial. The percentage of carcasses predicted to within one subclass of the reference panel was 97.0%, 94.2% and 95.4% for conformation class and 79.6%, 76.1% and 74.4% for fat class for BCC2, VIAscan and VBS2000 respectively. Given that the sample of carcasses in this second trial differed in characteristics that may be expected to affect the performance of the systems, for instance the spring sample was fatter on average and the fat was less yellow than the summer sample, this result indicates that the recalibration exercise yielded reasonably robust prediction equations. However, some

biases were again evident, particularly for conformation class, with all systems tending to underscore classes R and U.

Several conclusions can be drawn from these trials which were the first comparative trials in the world of any VIA beef carcass classification systems and the first time that any of the systems had been tested on Irish carcasses. Firstly, the differences in accuracy between the systems were relatively small, with a range in the second trial of about 3% for conformation class and about 5% for fat class. Secondly, the accuracy for conformation class was much higher than for fat class for all systems, which is in agreement with published results from trials of individual systems. Thirdly, even after the recalibration exercise there were some important biases that would be of concern to the industry. Finally, all systems were able to predict saleable meat yield with a similar high accuracy (rsd's of slightly over 1%).

The EU Beef Management Committee was recently presented with draft proposals for the authorisation of mechanical beef carcass classifications systems. Based on the results from these two trials it is unlikely that any of the three systems that were evaluated would pass the proposed authorisation criteria. If the biases that were evident in the results could be reduced then it is possible that one or all of the three systems could pass the proposed criteria for conformation class. However, based on these results, none of them would be likely to pass even the first proposed criterion for fat class, namely that at least 88% of the predictions should be within 1 subclass of the reference panel. If the Irish industry is committed to having a quality based payments structure for cattle linked to objective classification systems, then there are few options available at the moment. One possible option would be to seek to have the proposed authorisation criteria for fat class reduced to a more realistic level in relation to the present state of the technology so that one or more of the systems would be likely to be authorised. The authors are not aware of any other technology that would be likely to meet the proposed criteria for authorisation. The only other possibility would be to use the systems in the interim and to base a payment structure on their prediction of the EUROP classification scale or of meat yield though visual classification would still be required for EU price reporting and market support purposes.

1. INTRODUCTION

In Ireland, beef carcasses are classified by Department of Agriculture, Food and Rural Development classifiers. Carcasses are classified according to the official EU scheme (EC 1208/1981) for conformation (E, U, R, O, P) and fat cover (1-5). In the Irish scheme fat class 4 is subdivided into Low (L) and High (H) and conformation class P is subdivided into 3 subclasses. Some countries subdivide each class into 3 to give 15 subclasses each for conformation and fat class. In addition to being used as the basis of a payment schedule to producers, the scheme is used for price-reporting purposes and to determine eligibility for intervention.

Because the scheme depends on human judgement, it is criticised by some as being subjective and inconsistent. This lack of confidence in the reliability of the classification makes it difficult to agree quality-based payment schedules that reflect the true value of carcasses to the industry. A lack of effective incentives for producing quality carcasses has undoubtedly contributed to a decline in carcass quality, particularly the percentage of overfat carcasses (Keane, 1999).

Machines that can automatically classify carcasses would be more acceptable as the basis of realistic quality-based payments. Such machines should command the confidence of all interested parties provided they can be shown to be at least as accurate as the present system.

Using technology known as Video Image Analysis (VIA), machines have been developed to classify carcasses in five countries - Denmark (SFK, BCC-2), Germany (E+V, VBS2000), Australia (Meat and Livestock Australia, VIAscan), France (Normaclass) and Canada (Lacombe CVS). These have been described in more detail by Allen (1999). VIA involves taking images of a carcass with one or more cameras then applying specialised software to extract data from them, such as lengths, areas, volumes, angles and colours. Further software is then used to process these data to predict the conformation class and fat class. Two of the machines, BCC2 and VBS 2000, also project striped light onto the carcass and measure its curvature, thereby gaining information about the 3-dimensional shape. Since the process is automatic, once the machines have been calibrated they should be more consistent than well-trained classifiers.

A further advantage of these machines is that they can use the data extracted from the images to predict the saleable meat yield content of a carcass. The saleable meat yield is of interest to the processor because it is closely related to the realisable value. The classification gives a reasonably good indication of the saleable meat yield but previous tests have shown that the VIA systems are able to predict saleable with greater accuracy than classifiers (Borggaard et al, 1996 and Sonnichsen et al, 1998). Even though it is not likely that saleable meat yield will replace EUROP classification in the near future, this information would be of use to the beef processor in deciding which carcasses to bone out to different specifications.

Two trials were conducted with the objective of testing the accuracy of three of these systems for predicting EUROP classification scores and saleable meat yield. While VIA systems have been tested previously in separate trials (Ferguson et al, 1995, DMRI, 1996, Borggaard et al, 1996, Tong et al 1997 and Sonnichsen et al, 1998) this was the first time that more than one system was tested in the same trial and the first time that any system was tested on Irish carcasses. Having assessed the accuracy of the systems on Irish carcasses a further objective was to make recommendations to the industry and the EU about the likely potential of this technology.

2. APPROACH

Three VIA beef carcass classification systems were selected for evaluation in these trials:

- BCC2, manufactured by SFK Technology, Denmark,
- VBS2000, manufactured by E+V, Germany
- VIAscan, manufactured by Meat and Livestock Australia.

These were installed side by side on the slaughter line at Dawn Meats, Midleton, Co Cork. Because the systems were in very close proximity to one another (total minimum line length of 10.5m) there were practical problems with the spacing and orientation of carcass sides that had to be overcome by manual means. None of the systems was therefore in the optimum arrangement that would be designed into a fully operational installation. To ensure that the comparisons of accuracy were fair only carcasses for which all three systems had a good image were used in the data analysis. Badly damaged carcasses were also excluded from the data set.

Reference classification scores were the determined by a panel of three experienced classifiers from the Department of Agriculture, Food and Rural Development (DAFRD) using the EUROP grid with subclasses (15 x 15 grid). In the first trial, which ran for a 6-week period in the summer of 1999 (July/August) 7,247 carcasses were classified for both conformation and fat class. Images of these carcasses were captured and stored by the three systems. Reference classification scores for 4,278 carcasses (calibration set) were released to the systems manufacturers for the purpose of optimising the prediction algorithms for the sample population. Predictions were then made retrospectively by each system for the remaining approximately 2,969 carcasses (validation set) to determine the ability of the systems to predict the reference classification scores.

The left sides of a sample of 400 steer carcasses were boned-out to a standard specification to determine saleable meat yield. These were divided into calibration (260) and validation sets (140) to determine the accuracy of saleable meat yield prediction, expressed as the residual standard deviation (root mean square error). Both sides of 50 of these selected carcasses were boned-out to determine the repeatability of the saleable meat yield determination. The lean trim was adjusted to a standard lean content using a rapid microwave method before calculating the saleable meat yield. The primal yield was calculated by subtracting the lean trim and flank from the saleable meat yield.

The EUROP predictions were analysed as deviations from the reference panel scores on both 5-point (main classes) and 15-point (3 subclasses per main classs) scales. The percentage of carcasses for which the prediction agreed with that of the reference panel (correspondence) was calculated. The effects of the factors conformation class, fat class, sex category and weight group on the percentage correspondence between the systems and the reference panel were examined. Correlations between predicted and reference scores and the residual standard deviations for fat class and conformation class predictions were also determined.

The validation results were in line with those previously published for these systems but there was evidence that the calibrations were not optimised for the test population. The reference classification scores for the validation set were released to the systems manufacturers so that, using all available data, the calibrations could be improved. These new calibrations were then tested in a further trial also at Dawn Meats, Midleton in the first two weeks of March 2000. The VIAscan and VBS2000 systems had remained installed in the factory while the BCC2 had been removed after the first trial and a different system was installed for the second trial. In total 2,226 carcasses were classified by the reference panel and the three systems. This trial was as near to a 'live' test of the systems as was possible. All the systems capture the carcass weight and sex category from the scales terminal before predicting the classification scores. While it is relatively simple to connect a single system to the scales terminal it proved to be impractical to link three all systems to it. Hence, predicted classification scores were given shortly after the end of each day after the weight and sex category data had been supplied on disc and loaded into the systems.

The predicted scores were compared with the reference scores as in the first trial and the deviations were analysed. As in the first trial the effects of the factors conformation class, fat class, sex category and weight group on the percentage correspondence between the systems and the reference panel were examined and correlations and residual standard deviations for fat class and conformation class predictions were determined. Saleable meat yield was not determined in the second trial for cost and practical reasons.

3. RESULTS AND DISCUSSION

3.1 Results of the first trial (July/August 1999)

3.1.1. The sample population

The distribution of carcasses in the calibration and validation sets with respect to conformation class and fat class are shown in Tables 1 and 2. The two data sets were well balanced with similar percentages of carcasses in each of the main conformation and fat classes and even within the cross classes. The main difference between the two sets was a higher percentage of fat class 3 carcasses and a correspondingly smaller percentage of fat class 5 carcasses in the validation set. The two data sets were also similar with respect to the proportions within each sex category (Table 4).

Table 1 Number (%) of carcasses by conformation class and fat class for the calibration set

First trial

	Conformation class				
Fat class	U	R	O	P	Total
1	5(0.1)	13(0.3)	47(1.0)	268(6.3)	**333(7.8)**
2	7(0.2)	45(1.1)	124(2.9)	150(3.5)	**326(7.6)**
3	17(0.4)	76(1.8)	273(6.4)	241(5.6)	**607(14.2)**
4	25(0.6)	337(7.9)	1388(32.4)	334(7.8)	**2084(48.7)**
5	4(0.1)	154(3.6)	696(16.3)	74(1.7)	**928(21.7)**
Total	**58(1.4)**	**625(14.6)**	**2528(59.1)**	**1067(24.9)**	**4278**

Table 2 Number (%) of carcasses by conformation class and fat class for the validation set

First trial

	Conformation class				
Fat class	U	R	O	P	Total
1	1(.03)	5(0.2)	27(0.9)	222(7.5)	**255(8.6)**
2	6(0.2)	13(0.4)	85(2.9)	125(4.2)	**229(7.7)**
3	13(0.4)	86(2.9)	365(12.3)	174(5.9)	**638(21.5)**
4	12(0.4)	226(7.6)	898(30.2)	212(7.1)	**1348(45.4)**
5	0	97(3.3)	358(12.1)	44(1.5)	**499(16.8)**
Total	**32(1.1)**	**427(14.4)**	**1733(58.4)**	**777(26.2)**	**2969**

Table 3 Distribution (%) of carcasses by conformation class and fat class for the full data set (n = 7247)

First trial

	Conformation class				
Fat class	U	R	O	P	Total
1	01	0.2	1.0	6.8	**8.1**
2	0.2	0.8	2.9	3.8	**7.7**
3	0.4	2.2	8.8	5.7	**17.2**

4	0.5	7.8	31.5	7.5	**47.4**
5	0.1	3.5	14.5	1.6	**19.7**
Total	**1.2**	**14.5**	**58.8**	**25.4**	**100**

Table 4 Distribution of carcasses (%) by sex category in the calibration and validation sets, the full data set and the national kill (1999) (data from DAFRD)

	Young bulls	Bulls	Steers	Cows	Heifers
Calibration set	0.7	0.8	54.6	27.1	16.8
Validation set	0.4	1.0	57.1	27.2	14.2
Full data set	0.6	0.9	55.6	27.2	15.7
National kill	1.1	0.7	53.7	21.0	23.5

Table 5 Distribution (%) of carcasses by conformation class and fat class for the national kill (1999) (Data from DAFRD)

Conformation class						
Fat class	E	U	R	O	P	Total
1	.01	0.1	0.1	0.4	2.9	3.5
2	.01	0.2	0.7	1.8	3.0	5.8
3	.02	0.8	4.4	8.1	3.8	17.1
4	.01	2.9	20.8	28.8	4.6	57.1
5	0	0.6	5.8	9.3	0.8	16.5
Total	.05	4.5	31.9	48.4	15.2	100.0

The distribution of carcasses in the national kill (1999), with respect to conformation class and fat class is shown in Table 5 for comparison with the sample population (Table 3). The main difference between the sample population and the national population was the total lack of carcasses of E conformation class (v 0.05% of national kill) and the smaller percentage of U conformation carcasses in the trial sample (1.2% v 4.5%). With respect to sex category, the trial sample had a higher percentage of cow carcasses (27.2% v 21.0%) and a smaller percentage of heifers (15.7% v 23.5%) than the national population (Table 4).

3.1.2. Conformation class predictions

The percentage correspondence between the systems and the reference panel on the 5-point scale was 86.4%, 80.4% and 79.5% for VBS2000, VIAscan and BCC2 respectively (Table 6). BCC2 under scored and VIAscan over scored on average. VBS2000 showed no average bias but biases were evident within some conformation classes for all systems (Tables 9-11).

Table 6 Percentage correspondence with the reference panel for conformation class by the three systems (5-point scale)

First trial

	System		
	BCC2	VIAscan	VBS2000
% Correspondence	79.5	80.4	86.4
% Over scored by 1 class	1.9	15.1	6.8

% Under scored by 1 class	18.7	4.5	6.8
Total	**100**	**100**	**100**

On the 15-point scale between 91% and 96.5% of the carcasses were predicted within one subclass (1/3rd of a full class on the 5-point scale) of the reference classification (Table 7), VBS2000 again having the highest percentage.

Table 7 Percentage correspondence with the reference panel for conformation class by the three systems (15-point scale)

First trial

	System		
	BCC2	VIAscan	VBS2000
% Correspondence	39.9	45.0	56.3
% Over scored by 1 class	5.5	30.9	21.7
% Under scored by 1 class	47.4	15.1	18.5
Total	**92.8**	**91.0**	**96.5**

Predicted conformation classes were more highly correlated with the reference scores for the 15-point scale (0.93, 0.92 and 0.91 for BCC2, VBS2000 and VIAscan respectively) than for the 5-point scale (0.84, 0.80 and 0.80 for VBS2000, BCC2 and VIAscan respectively) (Table 8). The residual standard deviations for predicted conformation class scores were correspondingly smaller for the 15-point scale (0.7 – 0.8 of a subclass, equivalent to 0.23 – 0.27 of a whole class) than for the 5-point scale (0.36 – 0.40 of a whole class).

Table 8 Correlation coefficients and residual standard deviations for predicting reference conformation scores from three systems

First trial

	R	rsd
15-point scale		
BCC2	0.93	0.70
VIAscan	0.91	0.80
VBS2000	0.92	0.75
5-point scale		
BCC2	0.80	0.40
VIAscan	0.80	0.40
VBS2000	0.84	0.36

The percentage correspondence of BCC2 was higher for carcasses with poorer conformation (Table 9). The percentage correspondence of VIAscan and VBS2000 was lower for U carcasses (Tables 10 and 11). The percentage correspondence of all three systems was fairly consistent across fat classes (Tables 9-11), but all systems had the highest percentage correspondence for fat class 1 carcasses.

Table 9 Percentage correspondence with the reference panel for conformation class for BCC2 (5-point scale) (percentages in brackets are based on less than 10 carcasses)

First trial

		Conformation class				
Fat Class	**Deviation**	**U**	**R**	**O**	**P**	**Total**
1	**0**	(100)	(66.7)	41.4	98.7	**91.6**
	+1	(0)	(16.7)	48.3	0.9	**1.9**
	-1	(0)	(0)	10.3	-	**5.8**
2	**0**	(71.4)	92.3	55.8	99.2	**82.0**
	+1	(0)	7.7	4.7	.08	**2.1**
	-1	(14.3)	0	39.5	-	**15.5**
3	**0**	38.5	65.1	66.6	98.9	**74.5**
	+1	61.5	29.1	1.7	1.1	**2.2**
	-1	0	5.8	30.7	-	**22.8**
4	**0**	66.7	57.1	78.2	96.3	**77.5**
	+1	33.3	41.6	1.5	2.8	**1.7**
	-1	0	1.3	18.9	-	**19.8**
5	**0**	-	58.4	85.8	97.7	**80.3**
	+1	-	45.5	2.2	2.3	**2.0**
	-1	-	1.0	11.7	-	**17.3**
Total	**0**	**57.6**	**58.8**	**75.6**	**98.1**	**79.5**
	+1	**0**	**2.1**	**2.0**	**1.5**	**1.9**
	-1	**39.4**	**38.6**	**21.4**	**-**	**18.7**

Table 10 Percentage correspondence with the reference panel for conformation class for VIAscan (5-point scale) (percentages in brackets are based on less than 10 carcasses)

First trial

		Conformation class				
Fat Class	**Deviation**	**U**	**R**	**O**	**P**	**Total**
1	**0**	(0)	(50.0)	72.4	96.9	**92.7**
	+1	(0)	(16.7)	17.2	3.1	**5.0**
	-1	(100)	(33.3)	10.3	-	**2.3**
2	**0**	(42.9)	84.6	80.2	90.6	**85.0**
	+1	(0)	0	10.5	8.7	**8.6**
	-1	57.1	15.4	9.3	-	**6.0**
3	**0**	15.4	84.9	83.0	72.4	**79.0**
	+1	0	7.0	11.9	27.0	**15.1**
	-1	84.6	8.1	5.1	-	**5.8**
4	**0**	50	86.3	80.9	62.8	**78.6**
	+1	0	4.0	15.7	37.2	**17.0**
	-1	50	9.7	3.5	-	**4.4**
5	**0**	-	86.9	79.2	43.2	**77.5**
	+1	-	2.0	18.3	56.8	**18.5**
	-1	-	11.1	2.5	-	**4.0**
Total	**0**	**33.3**	**85.6**	**80.8**	**78.1**	**80.4**

	+1	**0**	**4.2**	**15.2**	**21.7**	**15.1**
	-1	**66.7**	**10.2**	**4.0**	**-**	**4.5**

Table 11 Percentage correspondence with the reference panel for conformation class for VBS2000 (5-point scale) (percentages in brackets are based on less than 10 carcasses)

First trial

		Conformation class				
Fat Class	**Deviation**	**U**	**R**	**O**	**P**	**Total**
1	**0**	(100)	(33.3)	72.4	96.0	**92.0**
	+1	(0)	(33.3)	3.5	3.6	**4.2**
	-1	(0)	(33.3)	20.7	-	**3.1**
2	**0**	(28.6)	84.6	80.2	95.3	**87.1**
	+1	(0)	0	2.3	3.2	**2.6**
	-1	57.1	15.4	16.3	-	**8.6**
3	**0**	23.1	79.1	91.9	82.2	**86.2**
	+1	0	0	1.9	17.8	**5.9**
	-1	76.9	20.9	5.7	-	**7.6**
4	**0**	33.3	73.0	93.9	67.4	**85.7**
	+1	0	0	3.4	32.1	**7.3**
	-1	66.7	27.0	2.4	-	**6.7**
5	**0**	-	66.7	90.3	56.8	**82.7**
	+1	-	1.0	8.3	43.2	**9.9**
	-1	-	31.3	0.8	-	**6.8**
Total	**0**	**30.3**	**72.6**	**91.7**	**82.8**	**86.4**
	+1	**0**	**0.7**	**4.0**	**16.7**	**6.8**
	-1	**66.7**	**26.5**	**3.8**	**-**	**6.8**

All systems had the highest percentage correspondence for cows and the lowest for steers, but the sex differences were small for VBS2000 (Table 12).

Table 12 Percentage correspondence with the reference panel for conformation class by each system for three sex categories (15-point scale)

First trial

		System		
		BCC2	VIAscan	VBS2000
Steers	% Correctly classified	76.2	77.2	84.7
	% Over scored by 1 class	2.1	18.5	6.9
	% Under scored by 1 class	21.0	4.2	8.0
Cows	% Correctly classified	84.6	85.5	88.8
	% Over scored by 1 class	1.3	11.5	7.4
	% Under scored by 1 class	13.4	3.1	3.3
Heifers	% Correctly classified	79.0	85.1	86.9
	% Over scored by 1 class	0.9	8.2	5.1
	% Under scored by 1 class	19.2	6.8	7.5

Two extreme weight classes were derived from the validation set. Those carcasses that were more than two standard deviations lighter than the mean (i.e. below approximately 210 kg) were designated as the light category and those more than two standard deviations heavier than the mean were designated as the heavy category. All systems had a higher percentage correspondence for light than for heavy carcasses and the difference was greater than 10% for all systems (Table 13).

Table 13 Percentage correspondence with the reference panel for conformation class by each system for two weight categories (15-point scale)

First trial

Weight category		System		
		BCC2	VIAscan	VBS2000
Light	% Correctly classified	85.2	90.3	90.5
	% Over scored by 1 class	0.4	3.9	3.0
	% Under scored by 1 class	14.0	5.8	5.8
Heavy	% Correctly classified	72.9	69.5	79.6
	% Over scored by 1 class	6.5	25.1	10.7
	% Under scored by 1 class	19.3	5.5	9.1

3.1.3. Fat class predictions

Percentage correspondence between the systems and the reference panel on the 5-point scale was 72.2%, 69.5% and 66.8% for BCC2, VBS2000 and VIAscan respectively (Table 14).

Table 14 Percentage correspondence with the reference panel for fat class by the three systems (5-point scale)

First trial

	System		
	BCC2	VIAscan	VBS2000
% Correctly classified	72.2	66.8	69.5
% Over scored by 1 class	10.9	16.7	16.9
% Under scored by 1 class	16.5	16.1	13.2
Total	**99.6**	**99.6**	**99.6**

On the 15-point scale between 72 and 80.4% of carcasses were predicted within one subclass (1/3rd of a full class on the 5-point scale) of the reference classification (Table 15). The ranking of the systems was the same as for the 5-point scale.

Table 15 Percentage correspondence with the reference panel for fat class by the three systems (15-point scale)

First trial

	System		
	BCC2	VIAscan	VBS2000

% Correctly classified	34.4	28.0	29.4
% Over scored by 1 class	19.3	22.1	23.9
% Under scored by 1 class	26.7	21.9	21.3
Total	**80.4**	**72.0**	**74.6**

Predicted fat class scores were more highly correlated with the reference scores for the 15-point scale (0.94, 0.92 and 0.92 for BCC2 for VIAscan and VBS2000 respectively) than for the 5-point scale (0.90, 0.87 and 0.87 for BCC2 for VIAscan and VBS2000 respectively) (Table 16).

Table 16 Correlation coefficients and residual standard deviations for predicting reference fat class scores from three systems

First trial

	R	rsd
15-point scale		
BCC2	0.94	1.14
VIAscan	0.92	1.38
VBS2000	0.92	1.38
5-point scale		
BCC2	0.90	0.49
VIAscan	0.87	0.56
VBS2000	0.87	0.55

The residual standard deviations for predicted fat class scores were correspondingly smaller for the 15-point scale (1.14 – 1.38 of a subclass, equivalent to 0.38 – 0.46 of a whole class) than for the 5-point scale (0.49 – 0.56 of a whole class) (Table 16).

There were no large average biases for any of the systems for either of the scales but all three systems had biases within some fat classes (Tables 17-19). BCC2 and VIAscan had a higher percentage correspondence for the extreme fat classes whereas the percentage correspondence of VBS2000 was highest for fat class 4. Apart from a low percentage correspondence by VIAscan for the small number (32) of U carcasses, conformation class had little effect on the percentage correspondence of the systems.

Table 17 Percentage correspondence with the reference panel for fat class for BCC2 (5-point scale) (percentages in brackets are based on less than 10 carcasses)

First trial

		Conformation class				
Fat Class	**Deviation**	**U**	**R**	**O**	**P**	**Total**
1	**0**	(100)	(66.7)	86.2	92.4	**91.2**
	+1	(0)	(16.7)	10.3	6.9	**7.0**
	-1	-	-	-	-	**-**
2	**0**	(42.9)	69.2	59.3	46.5	**52.4**
	+1	(0)	15.4	12.8	11.2	**11.2**
	-1	(57.1)	15.4	27.9	36.1	**36.1**
3	**0**	76.9	74.4	68.7	56.3	**66.3**
	+1	7.7	9.3	15.6	13.7	**13.7**
	-1	15.4	16.3	13.8	18.5	**18.5**

4	**0**	66.7	68.6	70.5	59.5	**68.4**
	+1	8.3	16.4	13.9	14.5	**14.5**
	-1	25	15.0	14.2	15.9	**15.9**
5	**0**	-	79.8	86.7	86.4	**85.3**
	+1	-	-	-	-	**-**
	-1	-	19.2	13.1	14.3	**14.3**
Total	**0**	**66.7**	**72.3**	**73.1**	**67.6**	**72.2**
	+1	**6.1**	**11.2**	**11.3**	**11.0**	**10.9**
	-1	**27.3**	**16.1**	**14.3**	**16.4**	**16.5**

Table 18 Percentage correspondence with the reference panel for fat class for VIAscan (5-point scale) (percentages in brackets are based on less than 10 carcasses)

First trial

Conformation class						
Fat Class	**Deviation**	**U**	**R**	**O**	**P**	Total
1	**0**	(0)	(50)	78.6	78.9	**77.9**
	+1	(100)	(50)	21.4	20.2	**21.3**
	-1	-	-	-	-	**-**
2	**0**	(28.6)	61.5	54.7	61.4	**57.9**
	+1	(42.9)	30.8	27.9	13.4	**20.6**
	-1	(28.6)	7.7	16.3	25.2	**21.0**
3	**0**	46.2	60.5	60.8	63.2	**61.1**
	+1	30.8	29.1	26.2	12.1	**22.9**
	-1	23.1	9.3	13.0	24.1	**15.7**
4	**0**	58.3	63.3	68.1	66.1	**66.9**
	+1	41.7	29.7	17.7	8.4	**18.5**
	-1	0	7.1	14.0	23.7	**14.3**
5	**0**	-	75.8	72.8	52.3	**71.6**
	+1	-	-	-	-	**-**
	-1	-	24.2	27.2	40.9	**27.8**
Total	**0**	**45.5**	**65.4**	**67.1**	**67.6**	**66.8**
	+1	**39.4**	**23.0**	**16.5**	**12.9**	**16.7**
	-1	**15.2**	**11.4**	**16.4**	**18.3**	**16.1**

Table 19 Percentage correspondence with the reference panel for fat class for VBS2000 (5-point scale) (percentages in brackets are based on less than 10 carcasses)

First trial

Conformation class						
Fat Class	**Deviation**	**U**	**R**	**O**	**P**	**Total**
1	**0**	(0)	(50.0)	58.6	64.4	**63.2**
	+1	(100)	(50.0)	34.5	31.6	**32.6**
	-1	-	-	-		**-**
2	**0**	(42.9)	46.2	61.6	65.4	**62.2**
	+1	(42.9)	46.2	30.2	21.3	**26.6**
	-1	(0)	0	5.8	11.8	**8.6**
3	**0**	76.9	54.7	65.5	64.4	**64.0**

	+1	23.1	37.2	27.8	16.1	**25.8**
	-1	0	7.0	6.2	19.5	**9.8**
4	**0**	75	70.8	73.9	77.2	**73.9**
	+1	16.7	21.2	14.2	8.8	**14.6**
	-1	8.3	8.0	11.6	13.5	**11.3**
5	**0**	-	68.7	68.9	63.6	**68.4**
	+1	-	-	-	-	**-**
	-1	-	30.3	30.6	34.1	**30.8**
Total	**0**	**66.7**	**66.1**	**70.2**	**68.0**	**69.5**
	+1	**27.3**	**20.7**	**15.3**	**18.5**	**16.9**
	-1	**3.0**	**12.6**	**13.9**	**11.9**	**13.2**

Sex category had little effect on the percentage correspondence of the systems, though BCC2 tended to under score steers while VBS2000 tended to over score cows and heifers (Table 20).

Table 20 Percentage correspondence with the reference panel for fat class by each system for three sex categories (15-point scale)

First trial

		System		
		BCC2	VIAscan	VBS2000
Steers	% Correctly classified	72.1	67.2	70.1
	% Over scored by 1 class	9.7	17.1	14.8
	% Under scored by 1 class	17.1	15.7	14.6
Cows	% Correctly classified	70.9	67.8	66.4
	% Over scored by 1 class	12.5	13.5	20.4
	% Under scored by 1 class	15.3	17.4	11.5
Heifers	% Correctly classified	71.3	64.2	71.0
	% Over scored by 1 class	13.3	21.3	18.2
	% Under scored by 1 class	14.5	14.3	10.0

Table 21 Percentage correspondence with the reference panel for fat class by each system for two weight categories (15-point scale)

First trial

		System		
		BCC2	VIAscan	VBS2000
Light	% Correctly classified	71.4	68.9	69.7
	% Over scored by 1 class	7.1	15.6	18.7
	% Under scored by 1 class	20.7	14.5	9.3
Heavy	% Correctly classified	73.9	67.6	68.4
	% Over scored by 1 class	12.3	21.2	23.0
	% Under scored by 1 class	12.3	11.2	8.1

The percentage correspondence was similar throughout the weight range for VIAscan and VBS2000 (Table 21). BCC2 tended to under score light carcasses and VBS2000 tended to over score both light and heavy carcasses while VIAscan tended to overscore heavy carcasses.

3.1.4. Saleable meat yield

The validation set was a representative sample of the total population (mean saleable meat yield = 76.1± 2.2% v 76.4 ± 1.8% and mean primal yield = 52.9 ± 2.6% v 51.9 ± 2.4% for the validation set and full set respectively) (Table 22).

Table 22 Mean and standard deviations for side weight, saleable meat yield and primal yield for the validation set (n = 133) and full data set (n = 394)

First trial

	Side weight (kg)	Yield weight (kg)	Yield %	Primals weight (kg)	Primals %
Validation set					
Mean	164.0	122.7	76.1	85.0	52.9
sd	33.8	27.4	2.24	18.2	2.6
Full set					
Mean	164.9	123.4	76.4	83.6	51.9
sd	29.4	23.8	1.80	15.9	2.44

There was little difference between the systems in their accuracy of predicting saleable meat yield, with residual standard deviations of 1.1% (VBS2000) or 1.2% (BCC2 and VIAscan) (Table 23). The slope coefficient was not significantly different from 1 for BCC2 and VIAscan. The slope coefficient for VBS2000 was significantly greater than 1, indicating an under-prediction of percentage saleable meat yield at high saleable meat yield percentages.

Table 23 Correlation coefficients (R) residual standard deviations (rsd) and slope coefficients (b) for the prediction of saleable meat yield by three systems (N = 133)

First trial

	System		
	BCC2	VIAscan	VBS2000
R	0.84	0.85	0.87
Rsd	1.20	1.20	1.12
Slope (b)	1.03	1.10	1.14
Constant (a)	-3.22	-7.93	-11.55

While these results compare well with those of published trials (Ferguson et al, 1995, Borgaard et al, 1996 and Sonnichsen et al, 1998) and represent a reduction in the sample standard deviation of around 50%,, the systems were no more accurate at predicting saleable meat yield than were the classification scores of the reference panel based on the 15-point scales combined with weight (rsd = 1.2%, Table 24). The residual standard deviations were lower for the full data set for all models. Residual standard deviations were generally higher for the 5-point scales compared to the 15-point scales (Tables 24 and 25).

Table 24 Prediction of saleable meat yield from classification scores and side weight (15-point scale)

First trial

	Validation set (n = 133)		All data (n = 386)	
Model	R	Rsd	R	Rsd
Weight	0.58	1.84	0.50	1.56
Conformation score	0.84	1.23	0.74	1.19
Conf. score + weight	0.85	1.21	0.75	1.18
Fat score	0.31	2.14	0.28	1.73
Fat score + weight	0.60	1.81	0.50	1.56
Conf. score + fat score	0.84	1.23	0.75	1.17
Conf. score + fat score + weight	0.85	1.21	0.76	1.17

Table 25 Prediction of saleable meat yield from classification scores and side weight (5-point scale)

First trial

	Validation set (n = 133)		All data (n = 386)	
Model	R	Rsd	R	Rsd
Weight	0.58	1.84	0.50	1.56
Conformation score	0.78	1.40	0.72	1.26
Conf. score + weight	0.82	1.31	0.73	1.23
Fat score	0.24	2.19	0.24	1.75
Fat score + weight	0.61	1.79	0.50	1.56
Conf. score + fat score	0.79	1.39	0.73	1.24
Conf. score + fat score + weight	0.82	1.30	0.74	1.23

Of the classification and weight variables, conformation score was the best single predictor of saleable meat yield (rsd = 1.23 for the validation set and 1.19 for the full data set), fat score and/or carcass weight adding little to the precision (Table 24). The poor relationship of fat score with saleable meat yield (r = 0.31 for validation set and 0.28 for the full set) was due to the small amount of variation in saleable meat yield across fat classes (from 75.5 for fat class 1 to 76.8 for fat class 5). In contrast, the variation across conformation classes was larger (from 74.2 for P conformation to 78.6 for U). The fact that the saleable meat yield increased rather than decreased with increasing fat class reflects the fact that the specification used did not involve heavy trimming of fat (Table 29).

The three systems were able to predict primal yield with similar accuracy, with rsd's of 1.50 (BCC2) to 1.56 (VBS2000) (Table 26). The slope coefficient for BCC2 was significantly less than 1, indicating over-prediction of saleable meat yield percentages at high actual saleable meat yield percentages.

Table 26 Correlation coefficients (R) residual standard deviations (rsd) and slope coefficients (b) for the prediction of primal yield by three systems (N = 133)

First trial

	System		
	BCC2	VIAscan	VBS2000
R	0.82	0.80	0.80
Rsd	1.50	1.54	1.56
Slope (b)	0.80	0.98	1.05
Constant (a)	10.5	1.80	-2.15

Reference classification scores based on the 15-point scale were more accurate (rsd = 1.44 v 1.50 – 1.56) at predicting primal yield than were the systems (Tables 26 and 27) in contrast to Borggaard et al (1996). Surprisingly, the residual standard deviations for the full models were higher for the full set than for the validation set (Table 27). Conformation score was the best single predictor of primal yield and fat class was a good co-predictor. The residual standard deviation for primal yield of the full model was higher when the 5-point scales were used compared to the 15-point scales for both the validation set and the full data set (Tables 27 and 28).

Table 27 Prediction of primal yield from classification scores and side weight (15-point scale)

First trial

	Validation set (n = 133)		All data (n = 386)	
Model	R	Rsd	R	Rsd
Weight	0.01	2.59	0.03	2.44
Conformation score	0.60	2.07	0.46	2.16
Conf. score + weight	0.73	1.77	0.55	2.04
Fat score	0.36	2.41	0.48	2.14
Fat score + weight	0.50	2.24	0.55	2.04
Conf. score + fat score	0.83	1.44	0.76	1.59
Conf. score + fat score + weight	0.83	1.44	0.76	1.59

Table 28 Prediction of primal yield from classification scores and side weight (5-point scale)

First trial

	Validation set (n = 133)		All data (n = 386)	
Model	R	Rsd	R	Rsd
Weight	0.01	2.59	0.03	2.44
Conformation score	0.62	2.03	0.47	2.16
Conf. score + weight	0.70	1.85	0.53	2.08
Fat score	0.41	2.37	0.49	2.13
Fat score + weight	0.55	2.18	0.55	2.04
Conf. score + fat score	0.82	1.50	0.74	1.64
Conf. score + fat score + weight	0.82	1.51	0.74	1.64

Table 29 Mean saleable meat yield percentage (number of sides) by conformation class and fat class

First trial

	Conformation class				
Fat Class	U	R	O	P	Total
1	-	77.8 (3)	74.7 (9)	75.4 (1)	75.5 (13)
2	77.2 (1)	77.7 (7)	76.0 (32)	73.9 (24)	75.4 (64)
3	78.7 (10)	78.2 (33)	76.2 (44)	74.2 (20)	76.7 (107)
4	78.9 (14)	78.1 (36)	76.4 (71)	74.4 (23)	76.8 (144)
5	76.8 (2)	77.3 (18)	76.6 (46)	-	76.8 (66)
Total	78.6 (27)	77.9 (97)	76.3 (202)	74.2 (68)	76.5 (394)

Removing the flank and trim from the saleable meat yield to obtain primal yield had the effect of increasing the range across fat classes and reversing the trend with respect to fat class. The relationship between primal yield and fatness was in the expected direction, primal yield being highest for fat class 1 (54.7%) and lowest for fat class 5 (49.8%) (Table 30).

Table 30 Mean primal yield percentage(number of sides) by conformation class and fat class

First trial

	Conformation class				
Fat Class	U	R	O	P	Total
1	-	55.9 (3)	54.4 (9)	53.1 (1)	54.7 (13)
2	54.8 (1)	55.4 (7)	53.6 (32)	51.2 (24)	52.9 (64)
3	55.0 (10)	54.7(33)	52.3 (44)	50.4 (20)	52.9 (107)
4	53.5 (14)	52.8 (36)	50.9 (71)	48.8 (23)	51.3 (144)
5	50.5 (2)	50.3 (18)	49.6 (46)	-	49.8 (66)
Total	53.9 (27)	53.3 (97)	51.5 (202)	50.2 (68)	51.9 (394)

3.1.5. Overall conclusions from the first trial

(1) The percentage correspondence between the systems and the reference panel was higher for conformation class than for fat class for all three systems.

(2) For the 5-point scale, predicted fat class scores were more highly correlated with the reference scores than were predicted conformation scores. However, the residual standard deviations were higher for fat class predictions due to the higher sample population standard deviation for fat class score in the validation set.

(3) The performance of all three systems appears to be better for both conformation class and fat class when they are judged on the 15-point scale rather than on the 5-

point scale. A deviation of a single subclass is small in absolute terms and would be a reasonable tolerance to allow the systems.

(4) The systems achieved above average percentage correspondence for conformation class predictions for cows and light carcasses. The reason for this should be investigated. These two effects may be related since many cows fell within the light weight category and it may simply reflect the higher than average percentage correspondence for P conformation carcasses.

(5) All three systems predicted saleable meat yield with a similar high accuracy. The residual standard deviation of 1.1 - 1.2% compares favourably with other published trials. However, it was not expected that the classification scores and weight would predict saleable meat yield with similar accuracy. Moreover, primal yield, which excluded the flank, the fattest and most variable cut, was predicted with a smaller error by the classification scores and carcass weight than by the systems. The fact that the specification used did not involve heavy trimming of fat does not explain this result. It must be remembered that the reference classification was determined by a panel of three experienced classifiers so a higher standard would be expected than from a single classifier.

(6) Based on percentage correspondence with the reference classification scores, the systems appear to perform better at predicting conformation class than at predicting fat class. However, this may to a large extent reflect the greater variation in fat class compared to conformation class in the population (population sd = 3.43 for fat class v 1.88 for conformation class).

(7) The accuracy of the systems, as measured by the residual standard deviations, for both conformation class and fat class using the 15-point scale appear to be reasonable and could probably be improved with more data and the experience gained in this trial.

(8) The overall conclusion is that this was a well-conducted trial with some positive outcomes for the VIA systems. There is evidence in the results that a high standard was achieved for the reference classification. This was the objective as it was considered necessary to have a very good reference against which to calibrate the systems. The main limitation of the trial was the relatively small number of U conformation carcasses.

3.2. Results of the second trial (March 2000)

3.2.1. The sample population

The number and percentage of carcasses in each cell of the classification grid are shown in Tables 31 and 32 for the 5-point and 15-point scales respectively. Almost 4% of the carcasses were classified as U and E conformation, which is nearer to the national average than was the case in the first trial. Very lean carcasses were underrepresented in the sample with only 5 of fat class 1^-. The number and percentage of carcasses in each sex category are shown in Table 33. There were only 6 bull carcasses in the sample and a larger percentage of steer carcasses (69.5% v 55.6%) than in the first trial. Cows and heifers were almost equally represented, as was the case in the first trial.

Table 31 Number (%) of carcasses by conformation class and fat class (5-point scale) (N = 2226)

Second trial

	CONFORMATION CLASS					
FAT CLASS	E	U	R	O	P	TOTAL
1	0	1(0.0)	1(0.0)	8(0.4)	49(2.2)	59(2.7)
2	0	4(0.2)	9(0.4)	29(1.3)	72(3.2)	114(5.1)
3	1(<0.1)	14(0.6)	87(3.9)	257(11.5)	159(7.1)	518(23.3)
4	1(<0.1)	45(2.0)	288(12.9)	685(30.8)	190(8.5)	1209(54.3)
5	0	19(0.9)	92(4.1)	179(8.0)	36(1.6)	326(14.6)
TOTAL	2(>0.1)	83(3.7)	477(21.4)	1158(52.0)	506(22.7)	100.0

Table 32 Number of carcasses by conformation class and fat class (15-point scale)

Second trial

	CONFORMATION CLASS													
FAT CLASS	E^-	U^+	U	U^-	R^+	R	R^-	O^+	O	O^-	P^+	P	P^-	TOTAL (%)
1^-	0	0	0	0	0	0	0	0	0	0	1	3	1	5(0.2)
1	0	0	0	0	0	0	0	0	1	3	2	4	12	22(1.0)
1^+	0	0	0	1	0	1	0	2	0	2	5	12	9	32(1.4)
2^-	0	2	0	0	0	1	0	1	5	4	2	11	3	29(1.3)
2	0	0	0	0	0	1	2	1	4	0	6	6	4	24(1.1)
2^+	0	0	0	2	0	5	0	3	5	6	20	19	1	61(2.7)
3^-	0	0	2	2	4	8	13	5	18	16	22	12	1	103(4.6)
3	0	0	2	1	4	15	17	20	43	43	52	16	0	213(9.6)
3^+	1	0	2	5	7	10	9	21	45	46	51	5	0	202(9.1)
4^-	1	0	8	6	25	32	29	37	82	68	99	3	0	390(17.5)
4	0	1	9	5	19	44	41	55	145	92	54	3	0	467(21.0)
4^+	0	0	6	10	22	38	38	48	112	46	29	2	0	352(15.8)
5^-	0	0	1	9	7	17	17	13	47	23	24	1	0	159(7.1)
5	0	0	2	6	4	14	16	7	40	17	8	0	0	114(5.1)
5^+	0	0	0	1	5	10	2	8	22	2	3	0	0	53(2.4)
TOTAL	2	3	32	48	97	196	184	221	569	368	378	97	31	2226
(%)	(<0.1	(<0.1	(1.4)	(2.2)	(4.4)	(8.8)	(8.3)	(9.9)	(25.6)	(16.5)	(17.0)	(4.4)	(1.4)	

	)	)												

Table 33 Distribution of carcasses by sex category

Second trial

Category	Young bull	Bull	Steer	Cow	Heifer	TOTAL
Number	2	4	1548	351	341	2226
Percentage	0.1	0.2	69.5	15.8	15.3	100

3.2.2. Conformation class predictions

The percentages of carcasses correctly classified for conformation class and within 1 class or subclass of the reference score are shown for each system in Tables 34 and 35 for the 5-point and 15-point scales respectively. On the 5-point scale, between 80.5% (VIAscan) and 84.4% (BCC2) of the predictions agreed with the reference panel (Table 34). VBS2000 tended to overscore carcasses while no serious overall biases were evident for the other two systems. On the 15-point scale, between 48.7% (VIAscan) and 58.2% (BCC2) of predictions agreed with the reference panel, with between 94.2% (VIAscan) and 97.0% (BCC2) falling within one subclass of the reference panel score (Table 35). The tendency for VBS2000 to overscore was again apparent and on this scale BCC2 tended to underscore. There was no apparent overall bias for VIAscan.

Table 34 Percentage correspondence with the reference panel for conformation class by the three systems (5-point scale)

Second trial

	SYSTEM		
CORRESPONDENCE	BCC2	VIAscan	VBS2000
% Correctly classified	84.4	80.5	81.9
% Overscored by 1	7.3	8.9	12.3
% Underscored by 1	8.4	10.5	5.8
TOTAL	100	100	100

Table 35 Percentage correspondence with the reference panel for conformation class by the three systems (15-point scale)

Second trial

	SYSTEM		
CORRESPONDENCE	BCC2	VIAscan	VBS2000
% Correctly classified	58.3	48.7	52.2
% Overscored by 1	16.3	23.4	29.0
% Underscored by 1	22.5	22.2	14.2
TOTAL	97.0	94.2	95.4

The percentage correspondence of the systems with the reference panel conformation scores within each conformation class on the 5-point scale are shown in Tables 36 - 38 for systems VIAscan, BCC2 and VBS2000 respectively. VIAscan had a low percentage correspondence for U conformation carcasses with only 25.3 % correctly predicted. The other two systems had similar higher percentage correspondence rates for U carcasses at 67.5% and 62.7% for VBS2000 and BCC2 respectively. All systems had the highest percentage correspondence rate for O carcasses. All systems tended to underscore R and U carcasses. This was balanced by the incorrectly predicted P carcasses that could only be overscored, hence the apparent lack of an overall bias for VIAscan and BCC2. The overall positive bias of VBS2000 was due to a slightly lower percentage correspondence than the other two systems for the abundant P carcasses and a correspondingly slightly higher one for the smaller number of U carcasses.

Table 36 Percentage correspondence with the reference panel by conformation class for VIAscan (5-point scale)

Second trial

CONFORMATION CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
E	100.0	-	0.0	100.0
U	25.3	0.0	74.7	100.0
R	72.5	0.2	27.3	100.0
O	93.0	3.4	3.6	100.0
P	68.4	31.4	-	99.8
TOTAL	80.5	8.9	10.5	100.0

Table 37 Percentage correspondence with the reference panel by conformation class for BCC2 (5-point scale)

Second trial

CONFORMATION CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
E	0.0	-	100.0	100.0
U	62.7	0.0	37.3	100.0
R	73.0	4.6	22.4	100.0
O	93.4	2.8	3.8	100.0
P	78.3	21.7	-	100.0
TOTAL	84.4	7.3	8.4	100.0

Table 38 Percentage correspondence with the reference panel by conformation class for VBS2000 (5-point scale)

Second trial

CONFORMATION CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
E	100.0	-	0.0	100.0
U	67.5	0.0	32.5	100.0

R	77.6	4.4	18.0	100.0
O	91.7	6.8	1.5	100.0
P	65.6	34.4	-	100.0
TOTAL	81.9	12.3	5.8	100.0

The performance of each system for conformation class predictions, using the 15-point scale, is shown in more detail in Tables 39 – 41. The percentage predicted to within 1 subclass of the reference panel score declined as conformation improved beyond R^- for VIAscan and VBS2000 and declined beyond U^- for BCC2. All systems tended to overscore poorer conformation carcasses and to underscore carcasses of good conformation. These biases balanced out for VIAscan, but resulted in an overall negative bias for BCC2 and a positive one for VBS2000.

Table 39 Percentage correspondence with the reference panel by conformation class for VIAscan (15-point scale)

Second trial

CONFORMATION CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
E^-	100.0	0.0	0.0	100.0
U^+	0.0	0.0	0.0	0.0
U	6.3	0.0	53.1	59.4
U^-	2.1	0.0	54.2	56.3
R^+	13.4	1.0	66.0	80.4
R	24.5	0.5	58.7	83.7
R^-	44.6	2.7	48.4	95.7
O^+	67.9	14.5	15.4	97.7
O	59.1	29.3	10.2	98.6
O^-	53.7	34.9	10.9	99.5
P^+	47.6	38.6	9.3	95.5
P	50.5	33.0	16.5	100.0
P^-	71.0	25.8	0.0	96.8
TOTAL	48.7	23.4	22.2	94.2

Table 40 Percentage correspondence with the reference panel by conformation class for BCC2 (15-point scale)

Second trial

CONFORMATION CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
E^-	0.0	0.0	100.0	100.0
U^+	33.3	0.0	0.0	33.3
U	34.4	6.3	40.6	81.3
U^-	43.8	4.2	43.8	91.7
R^+	38.1	19.6	33.0	90.7
R	30.1	8.2	50.5	88.8
R^-	46.2	6.5	40.8	93.5
O^+	62.0	12.2	24.9	99.1

O	63.7	15.8	19.6	99.1
O-	70.0	17.4	11.7	99.2
P+	62.7	28.6	8.5	99.7
P	66.0	16.5	16.5	99.0
P-	80.6	19.4	-	100.0
TOTAL	58.2	16.3	22.5	97.0

Table 41 Percentage correspondence with the reference panel by conformation class for VBS2000 (15-point scale)

Second trial

CONFORMATIO N CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
E-	0.0	100.0	0.0	100.0
U+	33.3	0.0	33.3	66.7
U	50.0	9.4	21.9	81.3
U-	43.8	8.3	20.8	72.9
R+	34.0	15.5	34.0	83.5
R	36.7	7.7	43.4	87.8
R-	48.4	14.7	34.2	97.3
O+	61.1	24.9	11.3	97.3
O	57.0	31.6	8.2	96.8
O-	57.8	36.2	4.6	98.6
P+	47.1	44.4	6.6	98.1
P	67.0	28.9	4.1	100.0
P-	48.4	48.4	-	96.8
TOTAL	52.2	29.0	14.2	95.4

3.2.3. Fat class predictions

The percentages correctly classified for fat class and within 1 class or subclass of the reference score are shown for each system in Tables 42 and 43 for the 5-point and 15-point scales respectively. Between 66.9% (VIAscan) and 71.2% (BCC2) of predictions agreed with the reference panel on the 5-point scale (Table 42). VBS2000 tended to overscore and VIAscan tended to underscore. On the 15-point scale, between 30.2% (VIAscan) and 34.4% (BCC2) of predictions agreed with the reference panel, with between 74.4% (VBS2000) and 79.5% (BCC2) falling within one subclass of the reference panel score (Table 43). The tendency for VBS2000 to overscore and VIAscan to underscore was again apparent. There was no apparent overall bias for BCC2.

Table 42 Percentage correspondence with the reference panel for fat class by the three systems (5-point scale)

Second trial

	SYSTEM

CORRESPONDENCE	BCC2	VIAscan	VBS2000
% Correctly classified	71.2	66.9	69.9
% Overscored by 1	13.4	6.5	21.0
% Underscored by 1	14.8	25.9	8.8
TOTAL	99.4	99.3	99.7

Table 43 Percentage correspondence with the reference panel for fat class by the three systems (15-point scale)

Second trial

	SYSTEM		
CORRESPONDENCE	BCC2	VIAscan	VBS2000
% Correctly classified	34.8	30.2	30.8
% Overscored by 1	22.0	13.7	26.7
% Underscored by 1	22.9	32.3	16.8
TOTAL	79.6	76.1	74.4

The agreement of the systems with the reference panel fat class scores within each fat class on the 5-point scale are shown in Tables 44 - 46 for VIAscan BCC2 and VBS2000 respectively. For VIAscan the lowest percentage correspondence rate was for fat class 5 carcasses while for BCC2 this was lowest for fat class 2 carcasses and for VBS2000 this was lowest for fat class 1 carcasses. VIAscan tended to underscore fat class 4 carcasses whereas BCC2 tended to underscore fat class 2 carcasses. VBS2000 tended to overscore carcasses of fat classes 2, 3 and 4.

Table 44 Percentage correspondence with the reference panel by fat class for VIAscan (5-point scale)

Second trial

FAT CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
1	74.6	25.4	-	100.0
2	62.3	19.3	18.4	100.0
3	74.5	9.8	15.3	99.6
4	69.8	4.6	24.9	99.3
5	44.5	-	54.0	98.5
TOTAL	66.9	6.5	25.9	99.3

Table 45 Percentage correspondence with the reference panel by fat class for BCC2 (5-point scale)

Second trial

FAT CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
1	94.9	5.1	-	100.0
2	55.3	17.5	27.2	100.0

3	68.7	17.8	12.7	99.2
4	71.1	15.2	13.3	99.6
5	77.3	-	22.1	99.4
TOTAL	71.2	13.4	14.8	99.5

Table 46 Percentage correspondence with the reference panel by fat class for VBS2000 (5-point scale)

Second trial

FAT CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
1	52.0	48.0	-	100.0
2	55.8	37.7	3.9	97.4
3	57.9	37.2	4.6	99.8
4	74.4	17.5	8.0	99.9
5	70.1	-	29.5	99.6
TOTAL	68.8	20.9	10.1	99.7

The percentage correspondence of each system with respect to fat class is shown in more detail in Tables 47 - 48 using the 15-point scale. The percentage predicted to within 1 subclass of the reference panel score was below 50% for fat classes 5 and 5^+ for VIAscan and for fat class 1^+ for BCC2. The lowest percentage predicted to within 1 subclass of the reference panel score by VBS2000 was for fat class 2 (54.2%). The negative bias of VIAscan and the positive bias of VBS2000 were fairly consistent throughout the scale.

Table 47 Percentage correspondence with the reference panel by fat class for VIAscan (15-point scale)

Second trial

FAT CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
1^-	80	0	-	80
1	36.4	18.2	31.8	86.4
1^+	15.6	15.6	21.9	53.1
2^-	13.8	27.6	37.9	79.3
2	41.7	20.8	16.7	79.2
2^+	29.5	24.6	18.0	72.1
3^-	34.0	26.2	25.2	85.4
3	29.1	19.7	27.2	76.1
3^+	34.7	14.4	33.7	82.7
4^-	28.7	15.1	32.8	76.7
4	33.6	12.6	34.7	80.9
4^+	36.4	13.6	31.0	81.0

5^-	25.2	1.9	43.4	70.4
5	8.8	0.0	38.6	47.4
5^+	17.0	-	26.4	43.4
TOTAL	30.2	13.7	32.3	76.1

Table 48 Percentage correspondence with the reference panel by fat class for BCC2 (15-point scale)

Second trial

FAT CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
1^-	80.0	20.0	-	100.0
1	18.2	4.5	27.3	50.0
1^+	9.4	3.1	31.3	43.8
2^-	20.7	10.3	31.0	62.1
2	16.7	16.7	29.2	62.5
2^+	27.9	19.7	23.0	70.5
3^-	24.3	22.3	21.4	68.0
3	29.6	24.4	21.6	75.6
3^+	31.2	21.8	26.7	79.7
4^-	36.9	21.5	20.8	79.2
4	34.5	24.8	23.8	83.1
4^+	38.1	28.1	18.2	84.4
5^-	42.8	20.1	22.6	85.5
5	39.5	14.0	25.4	78.9
5^+	62.3	-	18.9	81.1
TOTAL	34.8	22.0	22.9	79.6

Table 49 Percentage correspondence with the reference panel by fat class for VBS2000 (15-point scale)

Second trial

FAT CLASS	% Correctly classified	% Overscored by 1	% Underscored by 1	TOTAL
1^-	40.0	20.0	-	60.0
1	36.4	22.7	9.1	68.2
1^+	31.3	12.5	18.8	62.5
2^-	27.6	37.9	3.4	69.0
2	12.5	20.8	20.8	54.2
2^+	23.0	26.2	14.8	63.9
3^-	19.4	33.0	8.7	61.2
3	24.9	27.2	11.7	63.8
3^+	27.7	31.2	12.9	71.8
4^-	35.1	32.1	8.2	75.4
4	32.3	27.8	18.4	78.6
4^+	34.9	23.0	22.4	80.4

5^-	24.5	32.1	22.6	79.2
5	41.2	9.6	30.7	81.6
5^+	28.3	-	45.3	73.6
TOTAL	30.8	26.7	16.8	74.4

3.2.4. Conclusions from the second trial

The results of this second trial were broadly comparable to those of the first trial. The main differences were an improvement in the percentage correspondence for U conformation carcasses by VBS2000 and reductions in the overall biases for conformation for VIAscan and BCC2. However, for fat class predictions larger biases were apparent for VIAscan and VBS2000 in this trial than in the first.

The results, particularly the observed biases, suggest that the calibrations, while generally improved compared to the first trial, were still not optimal for the sample population. This highlights the difficulty in calibrating objective systems against visually assessed categorical scores and the need for continuous development of the calibrations, particularly for the marginal types of carcasses.

The sample population in the second trial differed in some characteristics that could be expected to influence the accuracy of the systems. In particular, the carcasses in the second trial were on average fatter than in the first trial. Furthermore, the fat was less yellow in the second trial. Both these factors could be explained by the fact that in the early spring most of the cattle would be coming out of houses with a diet of silage and concentrates whereas in the summer they would be coming off pasture. The fact that the results from the second trial were at least as good as those from the first trial given these differences in important characteristics suggests that the prediction equations were quite robust to these factors. However, based on these results, none of the systems would be likely to pass the criteria in the draft regulations that were recently presented to the EU Beef Management Committee, particularly for fat class predictions.

4. OVERALL CONCLUSIONS

These two trials have expanded the knowledge of the potential of the VIA systems for beef carcass classification. Comparative data is available for the three systems for the first time. Despite differences in hardware and software between the systems, differences in their accuracy of predicting EUROP classification were not large but none of them would be likely to pass the proposed criteria for authorisation of mechanical systems by the EU.

This was also the first time that any of the systems had been tested on Irish carcasses. The performance of the systems on Irish carcasses would appear to be similar to results reported for other European populations for BCC2 and VBS2000. VIAscan has been calibrated and tested for EUROP classification for the first time and would appear to be capable of achieving an accuracy in the same range as the other two systems.

All the systems achieved a high accuracy of predicting saleable meat yield and primal yield and this could form the basis of a future grading system for beef carcasses. The fact that classification scores from the reference panel were at least as accurate as the systems for yield predictions does not mean that these systems have nothing to offer in this regard. Firstly, the standards achieved by the panel could not be expected of individual classifiers on a continuous basis. Secondly, producers would have more confidence in a mechanical system.

Further work needs to be done to improve the VIA systems, particularly in removing the biases. It is hoped that this will not be stifled by the proposed authorisation criteria of the EU, as this would not be in the best long term interest of the industry.

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