S4P14.WP

COLOUR MEASUREMENT OF BOVINE CARCASS FAT BY VIA

N.T. MADSEN, H.E. HJELMROTH and P.L. JENSEN

Danish Meat Research Institute, 4000 Roskilde, Denmark

Please refer to Folio 29.

INTRODUCTION

In Denmark bovine carcasses are classified according to EEC and Danish regulations for conformation and fatness. Visual colour classification has been carried out over a number of years within the Danish classification system. Colour classification consists of mainly an overall surface fat cover assessment but in some cases lean colour is included. Carcasses are graded in classes from 1 to 5 with 1 being extra light and 5 being dark/yellow (DBCB, 1991). Classification level depends on animal age. Colour has a significant importance for especially veal and young bulls where light colour is preferable to many consumers.

Statistics of colour classification are shown for different carcass categories in Figure 1.

Consistent visual colour assessment is difficult to maintain over time and under various environmental conditions between trained classifiers. In one investigation one classifier was compared with five different classifiers on identical carcasses in the same environment. In the experiment 90% of 191 carcasses were classified as three. Identical class was given for 85% of carcasses for all classifiers while 15% deviated one class. Comparison of first classifier with second to sixth classifier demonstrated deviations from 4% up to 28% of gradings (mean deviation was 15%). Repeated classification after ½-1½ hours resulted in a deviation by one class for 6% of carcasses. One classifier had deviations of one class for 13% of carcasses (Sørensen and Klastrup, 1987). This demonstrates the difficulty of uniform visual assessment, but may also reflect different colour perception.

Objective beef carcass classification has been desired for many years by the meat industry and the cattle producers. Payments based upon consistently determined parameters is the ultimate goal in order to achieve clear feedback from consumer to the meat industry and to the producer, thereby ensuring a basis for consumer satisfaction as well as product and profit improvement (Madsen *et al.*, 1992). A Danish system for semi objectively based classification of EUROP conformation and fatness and also carcass composition was described by Sorensen et al. (1988) and Ovesen (1991). Colour classification was not a part of this system. Therefore, the development of one of several on-line methods for early detection of carcass quality therefore was colour of fat cover.

On the basis of visual assessment colour accounts for a total price range differential up to approximately 15% of producer payment for young animals (see Figure 2). Darker colour is acceptable for older animals where only extremely dark and yellow carcasses are discriminated with a deduction of approximately 10% of producer payment.

A carcass side cannot be described as having one colour only. The surface consists of areas of different size that could be described as mainly fat, lean or sinew membranes. Even within these areas the colour is not uniform, there is no single area that is a good indicator of total surface colour. The human classifier makes a total assessment of surface colour resulting in a class. Therefore, interpretation of a video image that contains a major part of a relevant surface area is much more adequate than point measurements traditionally used in food industry colour evaluation.

MATERIALS AND METHODS

Experimental design

Several experimental designs were tested. A colour video camera (2/3" JVC-TK-TK870E) was used in the Danish Beef Classification Centre (BBC) which is described by Sørensen *et al.* (1988). The BCC is installed on a commercial slaughterline. Combinations of illumination, camera position and hardware were tested. Technical details are described by Hjelmroth and Jensen (1993), in this paper only the major characteristics of two experimental designs are described.

1. Camera distance to carcass ref. position 2.85m, height 1.78m. Resolution 512x512 pixels (approximately 4.26x3.18mm/pixel), illumination 2200 lux. Aperture 2.8.
2. Camera distance 1.35m to carcass ref. position, height 2.00m. Resolution 512x768 pixels (approximately 1.63x1.62mm/pixel), illumination 4500 lux. Aperture 5.6.

In design 1 most of the carcass was in the image, whereas only part of the backquarter is measured in design 2 (see appendix). Images were stored on optical disks for analysis. Traceable colour plates were used for calibration control. Results indicated negligible variation over time.

Measuring principle

Based on several experiments and analyses the following procedure was determined for measurement and statistical analysis. Details of video image analysis are described by Hjelmroth and Jensen (1993). In this paper only a summary description of the conversion of carcass image signals into a colour class is given and illustrated in Figure 3. The process is as follows (refer to Figure 1):

1. Colour video image is taken of the carcass surface.
2. Carcass surface area is separated from background by colour and intensity differences.
3. Carcass image consists of pixels each representing a Red, Green and Blue signal with values from 0 to 255.
4. Pixel values are converted into X and Y values for a XY- chromaticity diagram. X=R/(R+G+B) and Y=G/(R+G+B). When the signal is mainly red X=1 og Y=0, a mainly green signal results in X=0 and Y=1 etc. The yellow colour is a mixture of the other colours. Yellowness increases with increasing distance from a white reference point.
5. Conversion in XY-values and division with signal amplitude imply robustness to background light intensity and variation.
6. XY-values were placed in an XY-chromaticity diagram, and a "yellow triangle" was identified in which the yellow fat colours are placed. Values outside the triangle count as lean or sinews, which implies effective segregation of fat and lean and sinew membranes, respectively.
7. The yellow triangle is partitioned in maximum 20 areas of increasing "yellowness" (saturation %) due to resolution. In these experiments 10 equal sized areas of the triangle were used for cows, whereas only the lowest 10 areas were used for young bulls. Triangle border values (angle and size) were estimated from established knowledge on colour coordinates (Mac Adam, 1985).
8. Within the 10 areas the frequency of "yellow" pixels are calculated dividing number within area with total number of "yellow" pixels within the triangle.
9. A very yellow carcass has a different frequency distribution of pixels within the triangle compared to a lighter carcass with more pixels in the narrow end of the triangle. Significant differences in frequency distribution is useful for colour classification.
10. Images of cows and young bulls in different experimental designs were taken, and the frequency distribution of yellow pixels used as input data for training of a neural network to predict the visual colour grading of fat. An example of frequency distributions of randomly selected carcasses is shown in Figure 4.

Statistical principle of classification

The frequency distribution of areas of the yellow triangle are used to predict the visual colour grading. The data from experimental design 1 were split in two parts. A neural network was trained on one part and tested on the other part. The network was trained to recognize characteristic distributions for the different colour classes. A backpropagation type network was used with the 10 areas as input, 10 hidden neurons and the 5 colour classes as output. This model is most suitable for large data sets. Due to limited data a different approach was chosen for data from experimental design 2. The four first variation components from a principal component analysis were used as input in a canonic discriminant analysis.

The final statistical model will be chosen when sufficient data are available.

Visual reference for fat cover colour

Colour perception depends on mainly three factors: *illumination, object nature* and *the classifier.* Therefore negligible variation in background light and a standardized time schedule for classification are essential as colour of surface fat and lean changes with oxidation. Even between persons with a "normal" colour perception variation of interpretation of the three basic colours red, green and blue exists (CIE31/63, 1963 and Sterrenburg, 1992).
In the present experiments, a technician from the Danish Meat Research Institute classified all carcasses under normalized light conditions with minimal variation in time for classification prior to entry into the BCC. Only colour of the surface fat cover was taken into account. A class from 1 to 5 was given separately for young bulls and cows based on overall impression of the left half carcass side.

RESULTS AND DISCUSSION

Distribution of pixels within "yellow" colour areas

In Figures 5 to 7, frequency distributions are shown from the two experimental designs. Eight randomly selected carcasses for each visual class demonstrate the variation and the classifiers ability to assess consistently. Variation is due to:
- biological variation within a visual colour class
- errors in visual classification
- blood staining, dehiding problems etc.
- technical measurement "noise"
- the fact that "yellowness" measured with the system only approximately describes the visual class.

During analysis every carcass was controlled on a colour monitor. This revealed that minor errors occurred in visual classification.

Figures 5 to 7 indicate a clear tendency of the distribution mean to shift into a higher area number with increasing visual class. Distribution shape also changes significantly with increasing visual class. Although there is a considerable variation, differences are characteristic enough to be interpreted by the neural network.

Classification results

Tables 1-4 show classification performance for cows and young bulls in design 1. Comparison of procentual distribution of colour classes by visual classification and measured class, respectively, are shown for training sets and independent test sets. It is evident that data by no means cover the biological variation in fat cover colour because of low frequency of the extreme colour classes.

Classification performance on independent data demonstrates the robustness of the classification performance, see Table 2.

In design 1 classification performance is reasonable for both training and test sets. Largest deviation of test set was 5.4%, and no carcasses deviate more than 1 class. Overall 13.5% deviates by 1 class which is comparable to visual classification error of fat/lean classification.

Training on 191 cows in design 1 (Table 3), resulted in 20.4% deviating 1 class and 2% deviating 2 classes.

Testing on 141 independent cows (Table 4), was not satisfactory. A full 19.4%, visually classified as 4, were measured as 3. Overall 34% deviated by one class, while 2.8% deviated by two classes. The poor result can be due to inconsistent and not sufficiently discriminatory visual classification or insufficient number of data. Distribution frequencies for the randomly selected carcasses show more variation for cows within colour classes. The mean distributions are also difficult to segregate. As there is no "true" value by definition it is difficult to give valid explanations.

In design 2 better resolution and illumination were used and a small and a more uniform fat cover area on the back quarter was measured. Better colour measurement is achieved in design 2, which is apparent in Figure 7 where better distinction in the higher areas occurs.

A plot of the first and second principal component of cows in design 2 (Figure 8), visualizes that a model could be developed to segregate the three colour classes.

A canonic discrimination analysis using the four most important variation components as input was used on half of the data and tested on the other half. This analysis resulted in a smaller deviation, 30% compared to the 36.8% in design 1. With more data a better performance than 30% misclassification is expected.

The described method measured colour only and is in theory independent of intensity. The method resembles human classification closely using an evaluation based on a larger part of the carcass. Colour appearance of fat cover areas affected by blood contamination or dehiding defects results in similar treatment as in human classification, when pixels change position within colour areas or move outside the yellow triangle. Only when pixels shift to other colour areas the frequency distribution if affected. Variations in object size is compensated by using the relative number of pixels and category dependent models. A more detailed analysis is necessary to accurately quantify practical consequences of the above mentioned factors.

Camera position determines maximum area of measurement and resolution, but with more cameras high resolution can be achieved of the total carcass side. Before final development of the system accurate specifications have to be determined with regard to the visual reference, relevant area, accuracy and repeatability.

CONCLUSION

A method and a system for objectively based classification of fat cover colour is developed for production or laboratory use.
Classification performance of the system depends on visual classification which again implies limits to possible level of agreement. But results from analysis of limited data indicates that, with a trained visual reference, acceptable performance of the system is possible for all types of carcasses.

REFERENCES

CIE 31/61. 1963. *Commission on Illumination in 1931/CIE.* Proceedings 1963.

DBCB. 1991. *Regulation for classification, weighing, marking and communication results for carcasses.* Danish Beef Classification Board, 5pp.

DBCB. 1992. *Kvalitetsstatistik.* Danish Beef Classification Board, 8pp.

HJELMROTH, H.E., and JENSEN, P.L. 1993. Objektiv farveklassificering af kreaturslagte kroppe. Work No. 17.224 - *Report* (25 January, TALGFARVE-KVÆG). Danish Meat Research Institute, Roskilde.

MacADAM, D.L. 1985. *Color Measurement, Theme and Variations.* 2nd edition. Springer Verlag. Berlin Heidelberg. 228pp.

MADSEN, N.T., MADSEN P., and ANDERSEN, B.B. 1992. Effect of carcass pricing systems on optimum slaughter weight, energy level in feed and choice of sirebreed in beef x dairy breed young bull production. *Acta. agric. Scand.* Sec A: Anim. Sci. 42:47-53.

OVESEN, E. 1991. Objective classification of beef carcasses by a beef classification centre. *Proc. 42nd Ann. Meeting of EAAP.* Satellite symposium "Beef Carcass and Meat Quality Evaluation, Dummerstorf/Rostock. pp.115-122.

STERRENBURG, P. 1992. *Colour Classification of Veal.* PhD thesis. University of Utrecht. in press. 129pp.

SØRENSEN, S.E., and KLASTRUP, S. 1987. Bedømmelsessikkerhed ved subjektiv EUROP-klassificering. Work No. 03.319/4 - *Report* (9 December, KREATURER-KLASSIFICERING). Danish Meat Research Institute, Roskilde.

SØRENSEN, S.E., KLASTRUP, S., and PETERSEN, F. 1988. Classification of bovine carcasses by means of video image analysis and reflectance probe measurements. *Proc. 34th ICMST.* pp.635-638.

Table 1. Classification performance, colour class in %, mean and standard deviations for young bulls (design 1, training set N=477).

Measured class	Visual class 1	2	3	4	5
5					
4			0.6	3.6	
3		1.5	86.8	1.0	
2		4.2	1.9	0.4	
1					

	Mean	SD
Measured	2.98	0.33
Visual	2.99	0.33
M + V	-0.02	0.26

Table 2. Classification performance, colour class in %, mean and standard deviation for young bulls (design 1, test set N=186).

Measured class	Visual class 1	2	3	4	5
5					
4			0.5	7.5	
3		2.2	79.0	5.4	
2			5.4		
1					

	Mean	SD
Measured	3.03	0.37
Visual	3.11	0.31
M + V	-0.08	0.36

Table 3. Classification performance, colour class in %, mean and standard deviation for cows (design 1, training set, N=191).

Measured class	Visual class 1	2	3	4	5
5				1.0	4.7
4			4.2	28.8	8.4
3		0.5	39.3	4.2	1.0
2		4.7	2.1	1.0	
1					

	Mean	SD
Measured	3.45	0.72
Visual	3.58	0.80
M + V	0.13	0.52

Table 4. Classification performance, class in %, mean and standard deviation for cows (design 1, test set N=141).

Measured class	Visual class 1	2	3	4	5
5			0.7	0.7	4.2
4			7.6	29.9	3.5
3		1.4	28.5	19.4	1.4
2		0.7	1.4	0.7	
1					

	Mean	SD
Measured	3.49	0.65
Visual	3.67	0.67
M + V	-0.17	0.65