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Instrumental objective measurement of veal calves carcass colour at slaughterhouse

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ABSTRACT - A total of 6700 veal calves were used to compare the ability of chromameter CR300 in measuring the veal meat colour on-line at slaughterhouse and to develop a prediction equation of colour score based on relationship between instrumental and visual assessments. A total of 5000 carcasses were used to develop equation of prediction while 1700 were used to test it. The meat colour was assessed subjectively in 3 different slaughterhouses by the slaughterhouse's judges 10h *post mortem* and objectively by chromameter CR300 45 *post mortem* on the *Rectus abdominis*. The prediction equation classified correctly 79% of carcasses and was characterized by an R^2 of 78%. Furthermore it has to be underlined that the chroma contributes to the total R^2 with a 0.21 partial R^2 . This data confirmed that chromameter CR300 can be used on-line to measure objectively veal meat colour at the end of the slaughter line.

Key words: Meat, Veal calves, Colour, Chromameter.

Introduction - Consumers are generally believed to assess veal quality on the lean colour. As a direct consequence the veal industry relies heavily on lean colour for carcass grading and determination of carcass value. At present throughout the Italian veal industry, lean colour is appraised visually at the end of slaughter line, using different people, subjective muscles observation and different illumination condition. This evaluation should be based on 4 colour classes scale (1=white, 4=red). Ideal lean colour is a pale, creamy pink; however, most slaughterhouse consider a greyish-pink lean colour acceptable (Lagoda *et al.*, 2002). Furthermore pH is considered one of the most important factors to determine final colour of meat, as paleness of meat increase from 1 to 24 h *post mortem* proportionally to pH drop (Swatland, 1985). Meat colour could be used as an important tool to modulate breeders management, and to improve animal welfare, thus there is an urgent need in veal meat processing to supplement the subjective system of classification with an objective system of veal colour measurement. Eikelenboom (1989) suggested that the Minolta chromameter II could be used to develop a veal colour classification system based on objective measurement. Basing on these findings several studies try to develop a colour equation of prediction that could relate instrumental and visual assessment. Denoyelle and Berny (1999), Hulsegge *et al.* (2000), and Lagoda *et al.* (2002), found a strict correlation between visual assessment and measurement carried out with chromameter Minolta CR300 and CR310. Basing on L^* (luminosity), a^* (redness) and b^* (yellowness) different equation of prediction were developed but no one of these was proposed. Thus, the objective of the present study was to develop an equation of prediction considering not only L^* , a^* and b^* , but also on proportions of redness and yellowness (hue angle) and colour saturation (chroma) as important coordinates in colour definition.

Material and methods - A total of 6700 veal Holstein Friesian calves from different breeds, age, and sex were used. They were killed in 3 slaughterhouse in north of Italy. On average, the carcasses weighed 139.87 kg, had a conformation score between "U" and "R" and a fatness score close to "3" (EC

Reg. 103/2006). Trimmed carcass weight was recorded at the end of slaughter line approximately 45 minute after slaughter. The carcasses were classified at approximately 10 hours post mortem into different colour classes by visually matching the colour to a 4-point scale where 1=white, 2=light-pinkish, 3=pinkish and 4=red (Denoyelle and Berny, 1999). The visual assessment was performed by the slaughterhouse's judge. Colour measurements were carried out with Minolta chromameter CR300 at 45 min post mortem at the end of slaughterline. Measurements were taken on the *Rectus abdominis* muscle, on the external side, after removing skin. Results were expressed as L*, a*, b*, in the CIELAB system, with a D65 lightsource (Cassen *et al.*, 1995). The a* and b* values are measures of a colour continuum between respectively red and green and blue and yellow. Greater L* values correspond to lighter meat, while lower L* values correspond to dark meat. Hue angle (HA) and Chroma (Chr) were calculated from a* and b* values as follows (Liu *et al.*, 1996): Hue angle = arctangent (b*/a* x [360°/(2 x 3.14)]); Chroma = (a*² + b*²)^{0.5}. At a constant degree of lightness and saturation, hue angle describes colour by indicating the angle at which a vector radiates into the red-yellow quadrant, while chroma is a measure of colour saturation (Liu *et al.*, 1996). A multiple stepwise regression analysis was carried out by SAS (2001), between the visual colour score and L*, a*, b*, hue angle and chroma. Equation of prediction was developed with 5000 carcasses and tested with the remaining 1700. Performance and accuracy of the subjective evaluation was estimated by the R² value and by the percentage of carcasses whose score predicted by the chromameter (after bringing them near the closest entire number) correspond to the score given by visual assessment.

Results and conclusions - Average L*, a* and b* value measured on veal carcasses were respectively 47.44, 13.44 and 1.47. In each slaughterhouse, as was predictable, moving from whitest to darkest meat determined a decrease in lightness and an increase in redness, while yellowness doesn't show a strict correlation to meat colour. These results were confirmed by correlations between L*, a*, b* values and visual assessment, respectively -0.62435 (P<0.0001), 0.52346 (P<0.0001) and -0.02128 (ns). As consequence of correlations results, L* was preferred to a* to discriminate data to utilize in the development of prediction equation. After evaluation of Gaussian distribution of L* as regards to colour score and of the frequency distribution of visually different graded carcass according to L*, equations of prediction were developed with 80% of carcasses aiming to eliminate objective evaluation mistakes. Table 1 shows the results of multiple stepwise regression.

Quadratic terms for the variables L*, a* and b*, were introduced in the model; because of the linear relationship between L*, a* and b* and visual assessment, these terms improved only marginally the R² of the model, but, in order to provide the best accuracy, they were considered for the development

Table 1. Multiple stepwise regression between instrumental measurements and visual assessment of veal carcass colour.

	Partial R ²	Model R ²
L*	0.5575	0.5575
Chr	0.2089	0.7665
L ²	0.0095	0.7759
L* x a*	0.0007	0.7766
b ²	0.0027	0.7793
b*	0.0003	0.7796

of the equation of prediction. Basing on multiple stepwise analysis the subsequent prediction equation was proposed:

$$\text{Colour score} = 10.50106 - 0.38185(L^*) - 0.02906(b^*) + 0.00316(L^{*2}) - 0.00678(b^{*2}) - 0.00602(L^* \times a^*) + 0.47206(\text{Chr})$$

Of 1700 carcasses the percentage of carcasses correctly classified with the chromameter CR300 was 79.0%. Lower accuracy of prediction (66%) was observed for colour class 3 while for colour classes 1, 2 and 4 the accuracy was respectively 73%, 89% and 80%.

Colour classification highlighted in this trial is in agreement with Denoyelle and Berny (1999) and seems to be similar to Hulsegge *et al.* (2001), although in this last trial carcasses were classified on a 10-point scale. Differences could be highlighted with Denoyelle and

Berny (1999) and Hulsegge *et al.* (2001) that reported L^* mean values of the *m. Rectus abdominis* similar to those reported in this study, but lower a^* mean values and higher b^* mean values. These differences could be explained to some extent by different ways of operate the chromameter; Sterenburg (1992) reported a significant difference in colour characteristics between two Minolta CR300 devices operated from two different person on the same carcass. Furthermore in our trial, because of need to accelerate slaughterline's operations, only one measurement per carcass was taken instead the three taken in the study of Denoyelle and Berny (1999). The high correlation of L^* and a^* values and the limited correlation of b^* value with visual colour assessment are in agreement with results reported by Denoyelle and Berny (1999), Hulsegge *et al.* (2001) and Lagoda *et al.* (2002). Furthermore Denoyelle and Berny (1999) reported a low correlation between physical measurement and slaughterhouse visual assessment (around 0.4); for these authors the lower results could be explained because only one judge was used in each slaughterhouse and because the conditions of slaughterhouse assessment were "commercial" and not technical. Although this situation reflects exactly the present study, in which one judge was used in each of the three slaughterhouses for visual assessment, correlation between visual and instrumental assessment of carcass results quite high (0.5-0.6). Furthermore the analysis of Gaussian distributions of L^* parameter (correlation around 0.62) to discriminate marginal data that didn't have to be considered in regression analysis, determined the development of an equation of prediction characterized by a R^2 (0.7796) and accuracy (79% of carcasses correctly classified) comparable to the results obtained by Denoyelle and Berny (1999) and Hulsegge *et al.* (2001) using a pool of trained judges for visual assessment. It is unquestionable that visual assessment performed both in a commercial situation or from trained judges is liable to errors and an instrument will also be frequently handled by a human operator, thus the use of Gaussian distribution of a parameter strictly linked to visual assessment to discard part of the data, seems to be absolutely necessary before the development of an equation of prediction. Finally it has to be underlined that if for sure L^* is characterized by the best partial R^2 (0.55), the chroma, one of the two new colour coordinates introduced in the model, contributes to the total R^2 with a 0.21 partial R^2 . On the other hand hue angle wasn't reputed significant in the development of the model. Practically these results could be useful both in slaughterhouses to measure objectively the colour of veal meat, or for breeders that could modify handling, nutritional and iron administration management of their farms basing on objective results and not on subjective opinions, improving as consequence animal welfare.

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