Colour variation during ageing in Piemontese beef

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Abstract— **The aim of this study was to determine the effect of three ageing periods on colour of m. *longissimus thoracis* from 26 Piemontese young bulls.**

At d2, d7 and d10 *post mortem*, colour parameters (L*, a*, b*) and reflectance spectra (R, %) were measured using a Minolta 600D spectrophotometer. From CIEL*a*b* values and reflectance curve, Chroma, Hue, a*/b* ratio, colour, Chroma and Hue differences, Mb, OMb and MetMb percentages and 630/580 nm ratio were calculated.

Data were analysed by GLM repeated measures procedure, with day of ageing as fixed effect.

Lightness played a minimal role in meat discoloration. At d10 Chroma decreased (P<0.01) while Hue and a*/b* ratio showed the highest and the lowest values respectively (P<0.01). The Chroma and Hue colour differences were higher between d7 and d10 in comparison to d2 and d7. Mb percentage decreased over time (P<0.01), OMb percentage did not change during the first 7 days, while a significant decrease was observed at d10. The percentage of MetMb increased throughout the ageing period with a more marked increase at d10 (P<0.01). The 630/580 nm ratio showed a significant decreasing trend from d2 to d10.

The overall results indicate that the largest colour variation occurs between d7 and d10. As previous studies indicated that the largest variation of tenderness in Piemontese young bulls occurs between d2 and d7, the best compromise between tenderness improvement and colour worsening is an ageing period of seven days.

Keywords— **meat colour, ageing length, Piemontese young bulls.**

I. INTRODUCTION

Ageing of meat is a prerequisite for the development of tenderness, the most important palatability trait of meat quality. It is generally accepted that degradation of myofibrillar proteins and structure disruption by endogenous proteases, the calpain system, are responsible for tenderness improvement.

Whether increasing storage length will be profitable for tenderness, it will have a negative effect on colour, which is the greatest visual characteristic taken into account by consumers when purchasing meat.

Meat colour mainly depends on the concentration of its pigment myoglobin, as well as on the chemical state of myoglobin pigments. In the absence of oxygen the predominant pigment is myoglobin (Mb) which has a dull, purple-red colour. On exposure to air it is oxygenated to form oxymyoglobin (OMb) which has a bright red colour that consumers find attractive. As time progresses both myoglobin and oxymioglobin oxidize to metmyoglobin (MetMb), which has a dull, brown colour that consumers associate with a loss of quality.

For this reason to prevent meat discoloration, the ageing period is sometime shortened and beef is sold at retail as early as 3-4 days after slaughter.

As in a previous study on Piemontese breed, Destefanis [1] found the highest and significant improvement in tenderness from three days to seven days and further gradual improvement, even if less notable, up to fifteen days *post mortem*, it is necessary to find out the best compromise between tenderness and this adverse time effect on beef colour.

Therefore the aim of this study is to determine the effect of three ageing periods on colour of m. *longissimus thoracis* from hypertrophied Piemontese young bulls.

II. MATERIALS AND METHODS

Samples of *longissimus thoracis* (LT) of 26 hypertrophied Piemontese young bulls were purchased at retail 24h *post mortem* and refrigerated at 3°C. The animals aged about 20 months and had an average live weight of 639 kg.

At 2 days *post mortem* after a blooming period of 45 min, colour parameters (Lightness L*, redness a*, yellowness b*, according to CIEL*a*b* colour space

model), and reflectance spectra (R, %) were measured using a Minolta 600D spectrophotometer, with a 11 mm aperture, a D65 illuminant and 10° standard angle observer [2]. Three random readings at different locations on the meat surface were taken and averaged. Chroma (C*), a measure of colour saturation, was calculated as $(a^{*2}+b^{*2})^{1/2}$ and Hue (H*), i.e. the colour angle, as $\tan^{-1}$ b*/a*.

In addition, a*/b* ratio was calculated since it is generally considered as an indicator of myoglobin oxidation or surface discoloration. The colour CIEL*a*b* difference (ΔE*), the Chroma difference (ΔC*), and the Hue difference (ΔH*) were calculated by the following equations:

$\Delta E_{ab}^{*}=(\Delta L^{*2}+\Delta a^{*2}+\Delta b^{*2})^{1/2}$;

$\Delta C_{ab}^{*}=(a_1^{*2}+b_1^{*2})^{1/2} - (a_2^{*2}+b_2^{*2})^{1/2}$;

$\Delta H_{ab}^{*}=(\Delta E_{ab}^{*2}-\Delta L^{*2}-\Delta C_{ab}^{*2})^{1/2}$ [3].

Total colour change (ΔE*), the Chroma (ΔC*) and the Hue differences (ΔH*) express the magnitude of difference between d7 vs d2 and d10 vs d7.

The relative contents of Mb, OMb and MetMb were calculated from the reflectance curve according to Kryzwicki [4]. As the Minolta 600D spectrophotometer measure reflectance between 400 nm and 730 nm at 10 nm intervals, the reflectance values at wavelengths not given by the instrument (473, 525, and 572) were calculated using linear interpolation.

As peak absorption of light occurs at wavelengths of 630 nm and 580 nm for oxymyoglobin and metmyoglobin respectively [5], the ratio of reflectance of light at these two wavelengths (OMb/MetMb) can be used to measure the rate of conversion of oxymyoglobin to metmyoglobin in meat during ageing. The colour measurements were repeated on the same samples on day 7 and 10 *post mortem*.

Data were analysed by GLM repeated measures procedure of SPSS software [6], with day of ageing as fixed effect.

III. RESULTS AND DISCUSSION

The results are reported in table 1. Ageing time strongly affects all the considered parameters. A significant increase of L* occurred between d2 and d7 ($P<0.01$), with no significant subsequent changes. Therefore, Lightness appears to play a minimal role in meat discoloration. Redness showed at d10 a lower value in comparison with d7 and d2 ($P<0.01$). The decrease in redness is due to a higher oxidation of myoglobin and indicates a decrease in colour acceptability [7].

A lower yellowness was observed at d10 compared to d7 ($P<0.05$). As a consequence a weaker meat colour was observed at d10 since Chroma showed a lower value ($P<0.01$). Chroma has been described as a good index to characterize of colour changes, because its value decreases as brown colour appears [8] [9].

According to Renerre [8], the Hue increased with storage length ($P<0.01$). The increasing rate of Hue was different in relation to the day considered. The increase was 5% between d2 and d7, but the largest variation was observed between d7 and d10 (+19%).

A higher Hue angle value at d10 means that the colour shift from red to yellowish.

The a*/b* ratio was lower at d7 compared to d2 and at d10 compared to d7 ($P<0.01$). The most important decreasing rate (-24%) was observed between d7 and d10.

As reported by Strange et al. [10] a low a*/b* value indicates a high concentration of MetMb, and, therefore, a higher pigment oxidation as a consequence of storage length. Colour differences can be seen by naked eye. Colour variation between the d2 and d7 were lower ($\Delta E^* \sim 5$) than between the d7 and d10 ($\Delta E^* \sim 7$). Compared with little change in ΔL*, relatively large fluctuations especially in Δa* and Δb* suggest that meat generally lost redness and yellowness as ageing increase.

From d7 to d2 the ΔC* (0.78) and ΔH* (1.08) were relatively stable, while from d10 to d7 the meat colour shifted towards higher negative value of ΔC* (-5.48) and positive of ΔH* (3.00).

In relation to the chemical state of myoglobin, Mb content decreased over time. In particular, the percentage of Mb showed the lowest value at d7 and the highest at d2 ($P<0.01$). OMb percentage did not change during the first 7 days, while a decrease was observed at d10 ($P<0.01$). The relative percentage of MetMb increased throughout the ageing period ($P<0.01$) with a more marked change at d10.

Compared to d10, at d7 meat showed higher values of OMb redness and yellowness, while at d10 was

observed a higher MetMb concentration and a lower redness and yellowness.

Considering the shelf life of meat, Renerre and Mazuel [9] pointed out that a value of 20% of MetMb is a criterion of rejection of meat by consumers. In this respect beef of Piemontese young bulls reached this level after about seven days.

Finally, the 630/580 nm ratio showed a significant decreasing trend from d2 to d10 ($P<0.01$). The highest 630/580 value, observed at d2, indicate a low percentage of MetMb and very little discoloration. As greater amounts of MetMb accumulates on the meat surface, ratio between reflectance values decrease. The greater discoloration rate was observed at d10 in comparison to d7 (-42%). Morissey et al. [11] found that, when the 630/580 nm ratio fell down below 3.5, consumers perceive that colour of lamb topside is more brown than red and therefore unacceptable.

Table 1: Effect of ageing on colour parameters and myoglobin forms at the surface of m. *longissimus thoracis* of Piemontese young bulls.

	Storage Day		
	2	7	10
Lightness (L*)	40.21 A	42.15 B	41.90 B
Redness (a*)	18.70 B	18.76 B	12.74 A
Yellowness (b*)	15.61 ab	16.69 b	14.78 a
Chroma	24.37 B	25.15 B	19.67 A
Hue angle	39.81 A	41.81 B	49.91 C
a*/b*	1.20 C	1.13 B	0.86 A
Mb	0.21 C	0.08 A	0.10 B
OMb	0.64 B	0.65 B	0.48 A
MetMb	0.16 A	0.27 B	0.43 C
630/580 nm	5.30 C	4.05 B	2.34 A

a, b: $P \leq 0.05$
A, B: $P \leq 0.01$

IV. CONCLUSION

On the basis of these results it is possible to highlight that the most important colour variations occurs between d7 and d10 of ageing. As we found that the largest variation of tenderness in Piemontese young bulls occurred between d2 and d7 of ageing the best compromise between tenderness improvement and colour discoloration is an ageing period of about seven days.

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