Changes in meat quality characteristics of two beef muscles during ageing. I: water holding capacity and colour

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Abstract

The aim of this study was to evaluate beef pH, water loss (before and after cooking), colour and volume, to estimate the shrinkage induced by cooking, in two muscles (*longissimus thoracis*-LT *and semitendinosus*-ST) of 8 young bulls, during an ageing period of 10 days. Drip loss in the last days of ageing increased, probably due to the low ionic strength of proteins. Cooking loss was significantly higher in ST muscle compared to LT (32.2% *vs* 29.7%). The highest value of shrinkage induced by cooking was found at 48h for both muscles and, at the same time, water loss in cooking meat was more accentuated. Meat lightness was higher at 48h, decreasing successively (from 44.7 to 40.9 for ST; from 38.0 to 37.4 for LT), while the red and yellow indices maintained a constant trend during ageing. Good correlations indices were obtained using PLS multivariate analysis between visible spectrum and drip loss data for both muscles.

Introduction

Water holding capacity measurement represents an important determination to estimate some correlated quality characteristics, such as juiciness, and to evaluate some economic aspects of meat.

In the first stage of ageing, cell shrinkage and the subsequent degradation of myofibrillar and cytoskeletal proteins lead to changes in water-binding properties and distribution (Huff-Lonergan and Lonergan, 2005). Those changes occur because water is a dipolar molecule and, in muscle cells, it is very closely bound to protein.

The majority of water in muscle is held within the structure of the muscle and muscle cells. Another portion is the immobilized water. The third fraction, the free water, can be lost by weak surface forces, or by pressing and centrifugation force. Moreover cooking induces structural changes, which decrease meat water holding capacity, and thermal shrinkage causes loss of a portion of immobilized water (Tornberg, 2005). Recently some studies have given more information on some of the major factors influencing water-holding capacity in muscle (Bertram *et al*., 2002), and on the changes that occur during ageing, underlining an increase of water holding capacity during the second day after slaughtering (Kristensen and Purslow, 2001).

The aim of this study was to evaluate beef pH, water loss (before and after cooking), colour and volume, to estimate the shrinkage induced by cooking, in two muscles (*longissimus thoracis and semitendinosus*) during an ageing period of 10 days.

Materials and methods

The *longissimus thoracis* (LT) and *semitendinosus* (ST) muscles were studied in eight 18 month-old bulls. The two muscles were removed from carcass 3 h after slaughter and subdivided in 6 slides. One of them was immediately weighed and used to drip loss bag method (Honikel, 1998), while the other ones were vacuum packed and stored at 2°C until analytical determinations were performed at different ageing: 1, 2, 5, 8 and 10 days.

Free water loss was determined by centrifugation method (Kristensen and Purslow, 2001), cooking loss was obtained in water bath at 75°C (Honikel, 1998) and pH was determined by insertion of probe. Moreover in the same samples used for cooking loss, thermal shrinkage was calculated by relative proportion of raw and cooked sample volume obtained through the immersion in water into a graduate cylinder with millimetric scale.

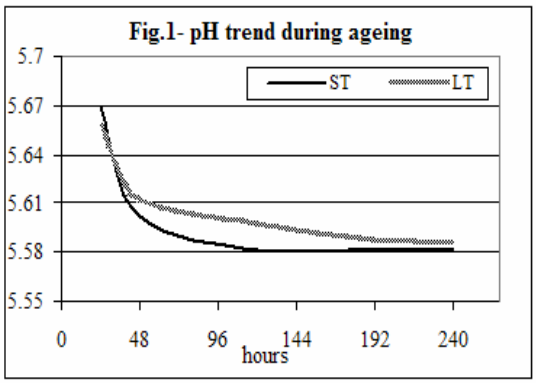
Colour indices (lightness, red and yellow), by using D65 illuminant after 1 h of oxygen exposition (Casses, *et al*.,1995), and visual reflectance spectra between 360-740 nm were determined on raw meat using reflectance spectrophotometer Minolta CM-2006d.

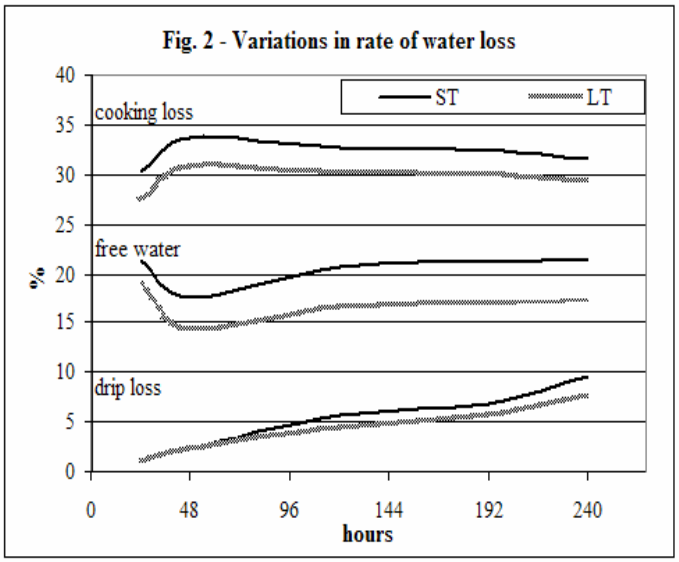
All data were subjected to variance analysis (GLM procedure of SAS package), using a bifactorial model with interaction, to evaluate muscle and ageing-time effects. Moreover correlation analysis among the data and single wavelength of visible spectra was performed.

Spectral data points were processed using Partial Least Square regression (PLS) multivariate data analysis with the purpose of developing calibration models for predicting the reference information from the water holding capacity traits. The wavelength selection procedure consisted of finding the number of variables that give the minimum value of RMSEP (root mean square error of prediction), found by cross-validation. Before performing the PLS regression, spectral outliers were identified and eliminated. The multivariate data analysis was performed with a chemometric program (Unscrambler 9.1,CAMO, Trondheim, Norway).

Results and discussions

The initial pH (Figure 1) on ST fell faster than on LT, although both reached the same value after 5 days (5.58). The trends of different water loss portions are shown in Figure 2.





Drip loss increased during ageing with an elevation in the last period for both muscles (+2,85% for ST and + 1.89% for LT respect to 8 days value) probably due to accentuated proteolysis, with consequently reduction of ionic stretch, after 8 ageing days (Huff-Lonergan and Lonergan, 2005).

The amount of free water lost by centrifuge showed a significantly increase in water holding capacity at 48 h for both muscles as reported in Kristensen and Purslow (2001). The higher quantity of liquid held at 48 h was removed during cooking. Therefore both muscles lost significantly more water at this time. ST muscle showed higher water loss than LT during ageing. In fact, ST muscles showed lower pH value, what was negatively correlated with water loss. The thermal shrinkage (Figure3) increased in the central period of ageing for ST, while remained constant in LT muscle. Cooking loss was significantly higher in ST muscle compared to LT (32.2% *vs* 29.7% *P*= 0.0053 as average for all times).

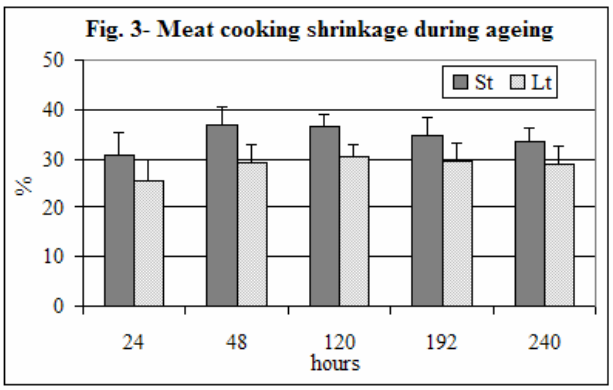


Table 1. Lightness of two different muscles during ageing

Muscle	1d	2d	5d	8d	10d	Sig.
ST	41.9±2.28^{b}	44.7±1.27^{a}	41.3±1.68^{b}	41.0±2.46^{b}	40.9±3.12^{b}	*
LT	38.0±1.81	38.1±1.99	37.4±1.16	37.9±2.00	37.4±1.36	ns
Sig.	***	***	***	**	***	

Sig: Significant differences. ns = *P*>0.05; * = *P*<0.05; ** = *P*<0.01; *** = *P*<0.001.

Meat lightness was higher at 2 days and decreased progressively (from 44.7 to 40.9 for ST; from 38.0 to 37.4 for LT), while the red and yellow indices maintained a constant trend during ageing.

Correlation analysis of data confirmed that parameters such as pH, cooking loss, water holding capacity and lightness are an expression of the same phenomenon (Denoyelle and Lebihan, 2003), resulting particularly in a high Pearson correlation coefficient between pH and drip loss (-0.572; $P<0.001$).

Some portions of reflectance showed high correlations (Figure 4): with drip loss in particular after 580nm and with shrinkage for all spectrum data with exception to Soret peak around 420 nm. The PLS analysis (Figure 5) evidenced an optimal RMSEP (1.55) between spectrum data and drip loss, as reported by Brøndum *et al*., (2000). The model, in fact, showed a good slope for predicted and measured data (0.68), erasing 8 outlier data only. A multivariate model was proposed in Figure 6, in which the coefficients of regression were plotted. The spectrum zones that absorbed maximum variability were between 480nm and 500nm and between 580 and 600 nm.

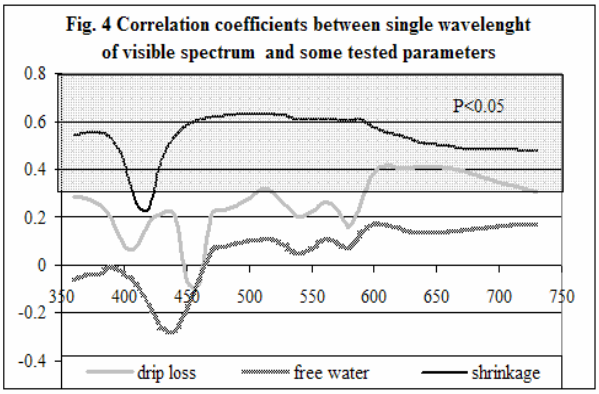


Fig. 4 Correlation coefficients between single wavelenght of visible spectrum and some tested parameters

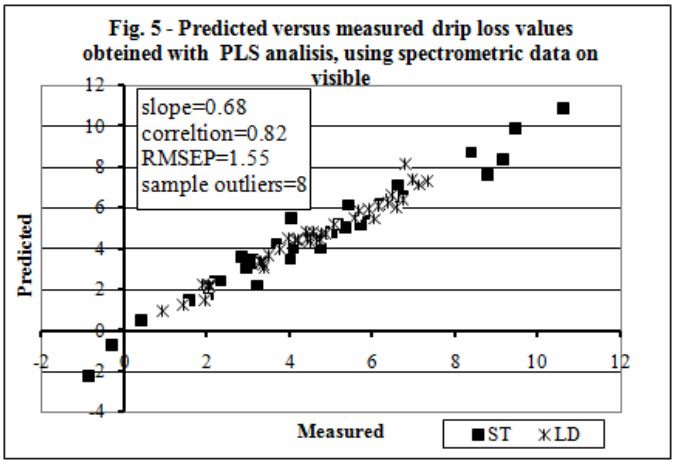


Fig. 5 - Predicted versus measured drip loss values obteined with PLS analisis, using spectrometric data on visible

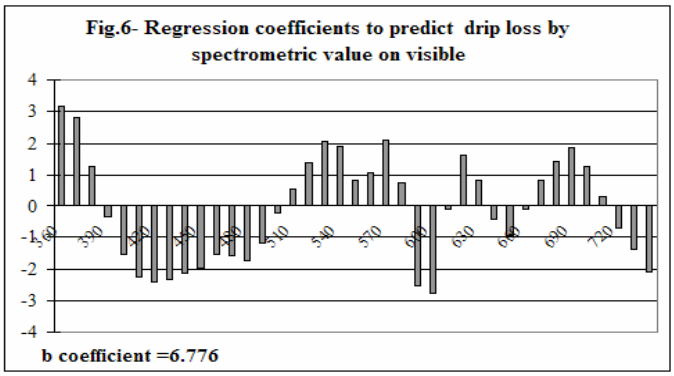


Fig.6- Regression coefficients to predict drip loss by spectrometric value on visible

Conclusions

Ageing-time and muscle effects were evident in drip, cooking and free water loss, especially 48 h after slaughter, when the water holding capacity was more accentuated. This valuation is important because the fibres result more swelling and all the physicochemical determinations obtained at this time are high-amount-of-water depending. Finally, visible reflectance provided significant predictions of water holding capacity.

References

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