

Changes in meat quality characteristics of two beef muscles during ageing. II: tenderness and myofibrillar degradation

S. Failla¹, M. Juárez², F. Vincenti¹, S. Ballico¹, M. Mormile¹, S.F. González³

¹C.R.A. - PCM. Monterotondo. 00015. Rome (Italy). Email: sebastiana.failla@entecra.it.

²MERAGEM Research Group. University of Cordoba (Spain). Edif. Gregor Mendel. Campus Rabanales. 14071. Cordoba. (Spain). Email: juarez@us.es.

³Departamento de Ciencias Pecuarias, Facultad de Ciencias Veterinarias, Universidad de Concepción. Casilla 537 Chillán (Chile). Email: fgonzal@udec.cl.

Abstract

During the ageing period, meat organoleptic properties change, in particular tenderness due to proteolytic and derivative processes. The aim of this study was to evaluate the development of this qualitative parameter in beef during the first 10 days *post-mortem* in two different muscles (*longissimus thoracis* -LT and *semitendinosus* -ST) of 8 young bulls. Shear force in cooked meat was higher in ST than in LT and decreased during ageing for both muscles (from 101.9 N to 64.2 N for ST and from 89.4 N to 52.7 N for LT). However raw meat shear force showed a rapid fall at 2 days, particularly for LT muscle, successively increasing and decreasing again after 5 days to reach the minimum value the tenth day. While insoluble collagen content showed the maximum value during the second day *post mortem* (4.5 mg/g for ST and 3.2 mg/g for LT). Thanks to Partial Least Squares multivariate analysis it was possible to estimate the correlation between the first derivative deformation curves of shear force and insoluble collagen.

Introduction

Tenderness is the most important factor related to consumers' acceptability of meat, and it is known to improve during *post-mortem* storage. This improvement has been found to be influenced principally by the connective tissue and by the proteolysis of key myofibrillar proteins and other associated proteins (Koochmaraie 2006).

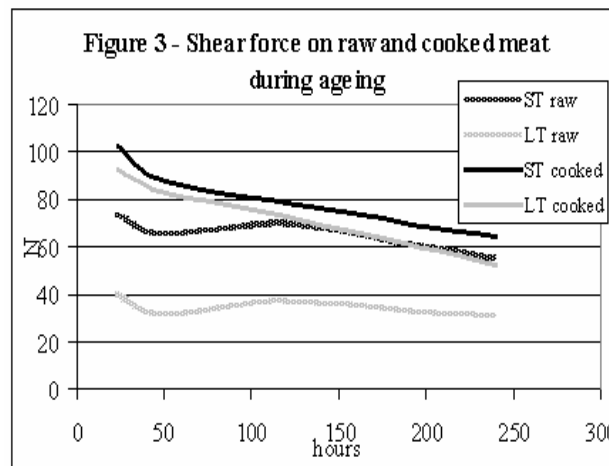
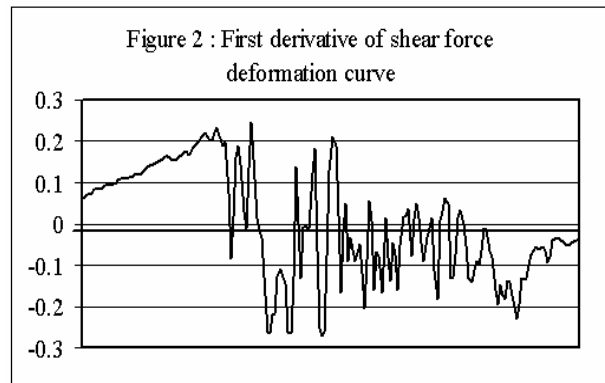
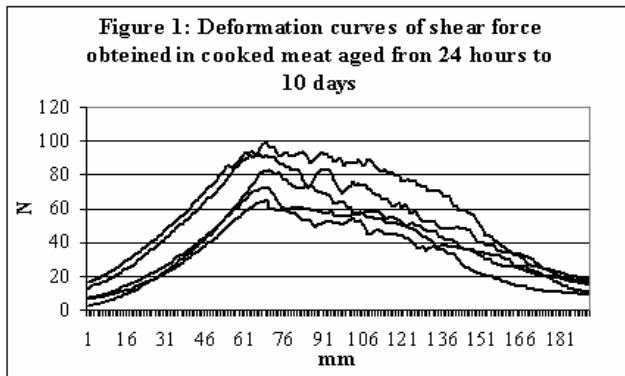
Both factors, myofibrillar degradation and connective tissue properties, have been reported to be highly influenced by the length of the ageing period (Palke, 2003) and by the studied muscle (Strandine *et al.*, 1949). Therefore the aim of the present work was to determine tenderness changes during ageing period, testing myofibrillar degradation and intramuscular connective tissue properties of two muscles (*longissimus thoracis* and *semitendinosus*) by analyzing collagen content and its thermal stability.

Materials and methods

The *longissimus thoracis* (LT) and *semitendinosus* (ST) muscles were studied in eight 18 month-old bulls. As reported by González *et al.* (2008), both muscles were removed from carcass 3 h after slaughter and subdivided in portions to analyze physiochemical characteristics at different ageing times (1, 2, 5, 8, 10 days). Total (Kolar, 1990) and insoluble collagen (Hill, 1966), expressed as percentage of total collagen, and myofibrillar fragmentation index (MFI) (Culler *et al.*, 1978) were determined on freezing meat.

For each ageing time a slide of fresh meat was used to perform shear force on raw meat. Another one was cooked in plastic bag, immersed in a water bath at 80°C until it reached an internal temperature of 75°C and cooled in fresh water for one hour to obtain shear force in cooked meat (Christall *et al.*, 1994). Warner-Brätzler shear force (WBS) on raw and cooked meat was determined in four 1 x 1cm cross section strips using an INSTRON 5543 texturometer. A 50-kg compression load cell and a crosshead speed of 100 mm/min were used. Force-deformation curves from the Warner-Brätzler shear device were obtained on cooked meat by steps of 0.5 mm.

From the curves only 85 central data were analyzed (Figure 1) and transformed in first derivative, calculated with the Savitzky-Golay derivative function (Figure 2), to accentuate the curve oscillations depending of variability in myofibrillar structure.



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 Pearson coefficient correlation was performed among the data.

First derivative data of deformation curve 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 insoluble collagen. This multivariate 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 chemiometric program (Unscrambler 9.1, CAMO, Trondheim, Norway).

Results and discussions

WBS force in cooked meat (Figure 3) was higher in ST than in LT ($P=0.04$) and decreased regularly during ageing for both muscles (from 101.9 N to 64.2 N for ST, and from 89.4 N to 52.7 N for LT $P=0.0002$), while raw meat WBS force showed a rapid fall at 2 days, particularly for LT muscle, successively increasing and decreasing again after 5 days to reach the minimum value the tenth day.

This trend inversion probably is due to major swelling of fibres at this time as reported by Gonzalez *et al.* (2008) in the same experiment or by Kristensen and Purslow (2001). Crossing section for swelling fibres contained a minor number of cells and more intracellular water that produced a minor resistance at shear, while in cooked meat the quantity of water inside the cells is more uniform because cooking loss.

Total collagen (Table 1) was higher in ST than LT (Strandine *et al.*, 1949), while insoluble collagen percentage increased significantly for ST during the first two days, and successively decreased showing the maximum value during the second day *post mortem* (4.5 mg/g for ST and 3.2 mg/g for LT). Similar trend was observed in thermal shrinkage as reported in González *et al.*, (2008).

Table 1. Total collagen and percentage of insoluble collagen of two different muscles during ageing

Musc	Total collagen mg/g	Insoluble collagen %					Sig
		1d	2d	5d	8d	10d	
ST	5.95.45±0.64	72.3±3.33 ab	74.7±2.58 a	71.1±3.61 ab	69.4±5.14 b	67.5±3.19 b	**
LT	4.04.46±0.49	76.0±7.30	79.1±8.82	76.1±7.92	71.9±8.30	71.6±7.35	ns
Sign.	***	ns	*	ns	ns	ns	

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

Table 2. MFI of two different muscles during ageing

Muscles	1d	2d	5d	8d	10d	Sig
ST	43.4±8.02 e	55.5±6.49 d	70.9±6.08 c	83.1±11.98 b	103.0±19.58 a	***
LT	33.3±4.87 e	51.7±4.57 d	73.7±5.68 c	91.8±10.35 b	111.5±17.76 a	***
Sign.	ns	ns	ns	ns	ns	

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

The MFI index (Table 2) increased during aging times from 43.4 to 103.0 for ST and 33.3 to 111.5 for LT.

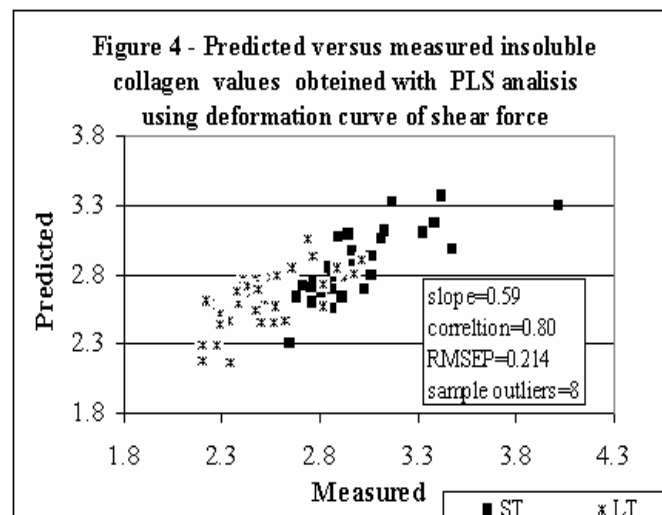
Correlation index (Table 3) was significant for all the parameters considered with exception of MFI and insoluble collagen. In fact, both parameters, even if they are correlated with meat tenderness, belong to different phenomena. The first one increases with myofibrillar degradation, while the second is linked to structural composition of meat.

Table 3. Pearson correlation coefficient among parameters

	pH	WBS raw	WBS coked	MFI	Insoluble collagen
pH	-				
WBS raw	Ns	-			
WBS coked	0.55 ***	0.40***	-		
MFI	-0.57 ***	-0.24 *	-0.77 ***	-	
Insoluble collagen	Ns	0.72 ***	0.50 ***	ns	-

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

The PLS analysis (Figure 4) evidenced a good RMSEP (0.214) and slope for predicted and measured data (0.59) between first derivative of force-deformation curve and insoluble collagen, probably because the oscillation in the curve depends on the structural characteristic of myofibrils and on the presence of quantity and solubility of collagen.



Conclusions

Tenderisation during ageing derives from structural protein and myofibrillar degradation. During ageing, the oscillations in the deformation curve of shear force increased and using PLS analysis good information about insoluble collagen quantity was obtained.

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