A comparative study on the rate and the extent of tenderness in buffalo, beef and yak: preliminary results

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Abstract

The proteolytic fragment appearance is related to the rate and extent of meat tenderness. In this study we report the results of a preliminary screening on muscle exudates and on the toughness of S*emitendinosus* (ST) muscle of different species (Buffalo - BUF, Maremmana - MM and Yak). The exudates originating from four animals for each species have been analyzed for total protein content and drip loss. The shear force data analyzed at 7d from slaughter have been correlated to the rate of proteolysis, while Magnetic Resonance Imaging (MRI) has been used to monitor the ageing from slaughter to 7d *post-mortem*. Obtained data point out a higher rate and extent of proteolysis for Yak, giving a lower toughness of its meat. MRI data point out a dark spot in the centre of BUF samples and a MM meat anomalous T_2 trend.

Introduction

The loss of proteinic fluid from meat (called drip or exudate) during ageing is an important factor to determine not only the final meat quality but also to understand the mechanism of tenderisation. It is widely studied in pig meat (Savage et al., 1990) and the structural basis of its formation has been overviewed (Offer & Knight, 1988). The appearance of proteolytic fragments in beef exudates is related to meat tenderness (Kolczak et al., 2003). Moreover, drip loss is inversely proportional to the water holding capacity of meat, which depends on the extent of *post-mortem* myofibrillar shrinkage and the correlative changes in the extracellular compartments (Renou et al., 2003). A novel approach to determine the WHC is based on MRI. (Renou et al., 2003; Ruiz-Cabrera et al., 2004; Herrero et al., 2007). This technique permits spatial resolution of water content and coupled with NMR parameters defines the state of water interaction with other molecules. The aim of this study is to analyze the biochemistry of the exudates of *Semitendinosus* muscle coming from different animal species (Buffalo, beef and Yak). Our attention has been focused on the biochemical composition of the proteinic fractions obtained from these drip samples. We have also investigated the correlations of these data with the physical ones (water holding capacity and shear force), at 7d ageing and we have monitored the conditioning of *Semitendinosus* muscles through MRI.

Materials and methods

At slaughter, ST muscles have been taken from right half carcasses of four Yak bulls (average live weight: 282.7±24.84), four (BUF) buffalo bulls (average live weight: 333.6±30.30) and four beef (MM) Maremmana bulls (average live weight: 501.7±45.49). In the centre of the muscle two slices (2.00 cm height) have been taken, vacuum-sealed and stored at 4°C. In the first one 3 cores have been sampled (2.54 cm in diameter), cut in parallel to the muscle fibres with a hand-held steel cork borer. These cores have been used to carry out the MRI analysis from 1d to 7d of cold storage. After 7d, the second slice has been used to carry out other analyses on raw and cooked meat. The analysed parameters have been: drip loss percentage (DRIP), Warner Bratzler Shear force (WBSF) and drip protein content (PC). The amount of drip has been measured as reported by Savage et al. (1990). Drip soluble protein content has been determined spectrophotometrically by Bradford's method, at different ageing time, (Bradford, 1976) using the Bio-rad assay kit and bovine IgG as standard and the total amount of protein lost (PL) has been calculated as reported by Savage et al. (1990). WBSF analysis has been performed on cooked meat (in a water-bath to a final internal temperature of 75°C). Four strips (10mmX10mmX20mm) have been cut parallel to the fibre direction, using an Instron universal testing machine (Model no. 5543, Instron Corporation, UK) fitted with a Warner-Bratzler shear attachment. MRI analysis have been recorded by using a Bruker AVANCE spectrometer (Bruker Biospin, Milan, Italy) with the ^{1}H frequency resonating at 300.13 MHz, equipped with cylindrical birdcage single-tuned nucleus (^{1}H) coil probe head with an inner diameter of 60.0 mm. Water signal has been monitored and used for the image reconstruction. Gradient-Echo (GEFI), T_1- and T_2-weighed images have been obtained with standard MRI sequences. All data have been analyzed with analysis of variance (ANOVA) using the PROC GLM procedure in SAS (SAS, 2001). Pearson correlation coefficients have been generated to describe the relationship between WBSF values and PC ones, using the PROC CORR

procedure (SAS, 2001). Prediction linear regression has been developed using the PROC REG procedure (SAS, 2001).

Results and discussion

Biochemical and physical parameters

WBSF on cooked meat is significantly lower for Yak than for the other animals. The weight of drip lost is not statistically different among the three analyzed species. MM samples show a higher DRIP value if compared to the BUF ones (P= 0.07 - table 1). Yak drip loss shows the highest PC (P≤0.05), while BUF samples show the lowest values for all the analyzed biochemical parameters (P≤0.05).

Table 1. Biochemical and physical parameters of ST muscle

	Yak	MM	BUF	Mean	RMSE
N	4	4	4	12	
WBSF (N)	44.23^{b}	56.88^{a}	63.36^{a}	54.82	10.20
DRIP (%)	6.84	7.31	4.51	6.22	1.98
PC (mg/ml)	201.53^{a}	177.18^{b}	144.83^{b}	174.51	22.20
PL (mg/100g muscle)	1324.12^{a}	1275.64^{a}	656.40^{b}	1102.05	333.33

a,b: within lines means bearing different superscripts differ significantly at P≤0.05.

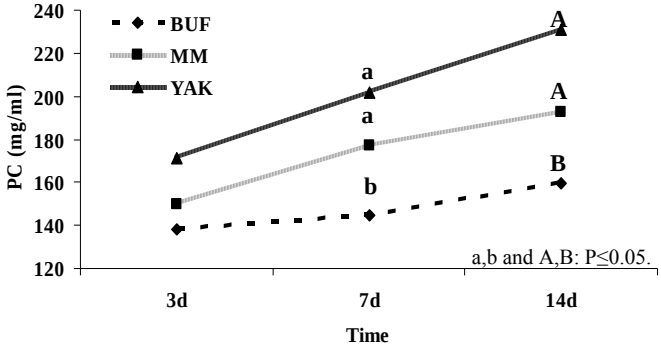
Obtained data point out that Yak samples show a higher extent and a higher rate of proteolysis (Figure 1), yielding a meat more tender than the other ones. These results are in agreement with the Pearson correlation coefficient (-0.742: P=0.0058 - table 2); in fact, increasing PC value we observe a significant reduction of WBSF value in all three different animals. We also observe a high and significant Pearson correlation coefficient between DRIP and PL (table 2). These results are in agreement with those by Savage et al. (1990) that find a correlation between DRIP and PL values on *Longissimus Thoracis* muscle of pigs.

Table 2. Pearson correlation coefficient

	WBSF	DRIP	PC	PL
WBSF	1			
DRIP	-0.029	1		
PC	**-0.742** *	0.263	1	
PL	-0.373	0.890 ***	**0.656** *	1

*= P≤0.05; **= P≤0.001; ***= P≤0.0001

Figure 1. PC trend during ageing time.



Furthermore the interaction between WBSF and PC is showed by a regression, with a significant coefficient of determination R^2=0.55; P≤0.001.

Magnetic Resonance Imaging Analysis of ST muscles

Magnetic Resonance Imaging has been used to monitor the water mobility during ageing. GEFI images, where the intensity of the signal is directly proportional only to the water content, have revealed that samples do not lose large amount of water. Figure 2 shows a darker region in the centre of BUF sample, which is not observed in Yak and MM samples.

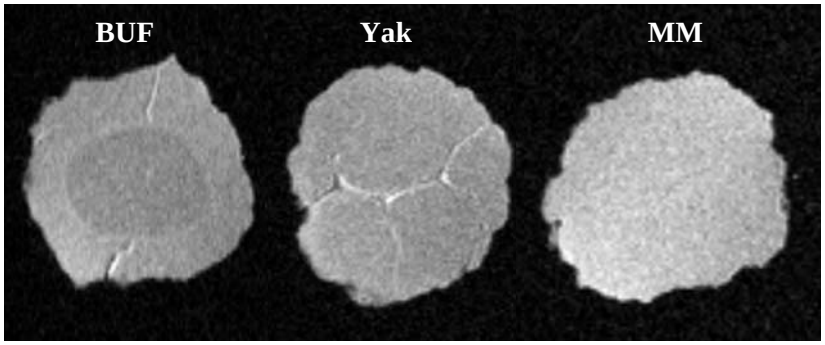


Figure 2. T_1-weighed images revealed after 6-7d of cold storage.

Such dark spot may be related to a more fibrous tissue, which slows down the longitudinal relaxation time. Figure 3 shows T2 trend during ageing. T_2 is related to the local mobility of the water molecules, both inter- and intra-cellular, so that low values indicate a tissue where the water is strongly bound to the substrate, while larger values characterize tissues where molecules can move faster. For MM, we observe a decrease of the T_2 already after 30h, which remains constant till 3d ageing and finally reaches the 80% of the initial value. For BUF and Yak T_2s do not change: a slight increase and decrease is found, but the variations are not significant.

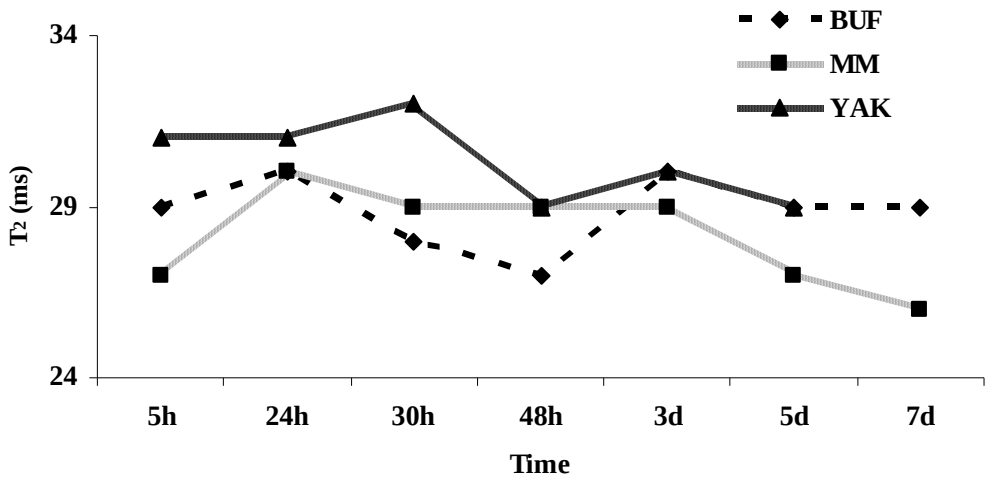


Figure 3. Local transverse relaxation time (T2).

The results indicate that Yak and BUF meat remain almost unchanged during ageing, while the opposite is found for MM.

Conclusions

This study demonstrates that there are significant differences about the most important physical parameter of meat quality (WBSF) among the three different species. Yak meat appears to be more tender, while the beef one shows an intermediate behaviour even if it drips more than the other ones. We show a significant relationship between WBSF and PC, which can be considered a good indicator of meat ageing as it represents a rapid and non-invasive detection method for tenderness assessment. MRI data, according to drip loss value, show that the MM meat has completely different water mobility. These results point out the importance of this technique for understanding the mechanisms of *post-mortem* water exudation

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