USE OF OBJECTIVE MEASURES OF LONGISSIMUS QUALITY TO PREDICT TENDERNESS IN BEEF MEAT

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Abstract—**In this work, the data from two Italian cattle breeds (25 Chianina and 25 Maremmana) were used to determine whether objective physical and chemical measures performed on *longissimus thoracis* muscle aged 10 days could be used to classify meat from different animals into tenderness classes obtained by panel. The two main components of meat tenderness are summarized in the myofibrillar component and the connective tissue. Therefore, the principally objective measures tested in this work regarded these two ones and visual reflectance spectra between 360-740 nm. Univariate and multivariate regression (Partial Least Squares regression- PLS) was applied to understand the relationship between tenderness and physical- chemical properties of meat and between tenderness and reflectance spectrum on visible.**

The univariate analysis did not show good results, the best regression was with (WBSc) shear force on cooked meat (R2=0.58, RMSEP=0.88). Using the multiple linear regression (R2=0.75, RMSEP=0.80) the maximum variability was explained by WBSc followed by, soluble collagen and MFI. The validate PLS regression between objective parameters and tenderness showed the best correlation (R2=0.84, RMSEP=0.55).

The multivariate regression could explain the maximum variability and classify in an objective way the meat tenderness for both breeds.

Index Terms— **Tenderness, meat quality, sensory panel, multivariate regression.**

I. INTRODUCTION

Tenderness is one of the most important quality attributes in beef and depends on many physical, chemical and biochemical factors (Wulf, Morgan, Tatum & Smith. 1996), so is impossible define it with only one objective characteristic.

Predicting consumer acceptance associated particularly to meat tenderness is of primary importance to meat industry, but sensory evaluation is both time-consuming and expensive, while correlations between sensory evaluation and objective measures of meat tenderness from earlier work, as reviewed by (Peachey, Purchas, & Duizer, 2002), were very variable.

In particular Warner-Bratzler shear force (WBS) that explains a substantial proportion of variation in sensory assessment of beef tenderness, is an imprecise predictor of this attribute determined by trained panellists (Shackelford, Wheeler, & Koohmaraie, 1999) ranging a R2 from 0.32 to 0.94 as reviewed by (Peachey et al., 2002). However WBS has become the most common objective method for evaluating beef tenderness (Boleman, Miller, Taylor, Cross, Wheeler, Koohmaraie, et al., 1997), also if to predict the meat tenderness is impossible to not consider the miofibrillar and connective components of meat. Aim of work is to determine whether objective physical and chemical measures performed on *longissimus thoracis* muscle aged 10 days could be used to classify meat from different animals into tenderness classes obtained by trained panel.

II. MATERIALS AND METHODS

The experiment was carried out on 50 entire males from 2 Italian cattle breeds 25 Chianina (CH) and 25 Maremmana (MM). Young bulls were fed *ad libitum* with a diet composed by maize silage and proteic concentrate with appropriate minerals and vitamins supplements and slaughtered at about 18 months of age. At 24 hours after slaughter the *longissimus thoracis* muscle was removed from carcass and stored at 3±1°C until 10 days when it was subdivided in different slices, frozen at -18°C and subsequently different analysis were performed

Physical analysis

Colour parameters (lightness L^*, redness a^*, yellowness b^* following CIE$L^*a^*b^*$ System) were measured with D65 illuminant using spectrophotometer Minolta CM-2600d on ten points of the surface of slices according to Cassens, Demeyer, Eikelenboom, Honikel, Johansson, Nielsen, et al. (1995), after exposure to oxygen for 1 hour of raw meat, besides reflectance spectra between 360 and 740 nm (by steps of 10 nm) were also measured.

Shear force was measured on raw (WBSr) and cooked meat (WBSc) according to Chrystall, Culioli, Demeyer, Honikel, Moller, Purslow, et al. (1994). Samples were cooked in a water bath at 80°C to an internal temperature of 75°C. Shear force was measured on ten samples for each animal with section 1x1 cm by a Warner Bratzler device mounted on an Instron 5543. pH values (obtained as mean of 4 determinations) with electrode penetration through meat using pHmeter Hanna Hi 98240

Total and heat soluble collagen was determined using a slight modification of the method described by Kristensen, Therkildsen, Riis, Sorensen, Oksbjerg, Purslow et al. (2002), a factor of 7.14 was used to convert hydroxyproline to total (TCol) and soluble collagen (SCol).

Myofibril Fragmentation Index (MFI) was determined at 10 days from slaughter by the procedure of Culler, Parrish, Smith & Cross (1978) using the Biuret method.

Meat samples were cooked on a pre-heated double hot-plate grill at 200ºC until it reached 75ºC of internal temperature and tasted by non trained ten sensory panellist. Panellist rated the samples on a eight-point category scale for tenderness (from very tough to very tender) (Olleta, Sañudo, Monsón, Campo, Panea, Albertí, et al., 2006).

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The variance analysis to evaluate the differences between the two breed were performed using the GLM (general least-squares models) procedure (SAS,1996).

Beside univariate and multivariate regression was applied to understand the relationship between tenderness and physical- chemical properties of meat and between tenderness and reflectance spectrum on visible.

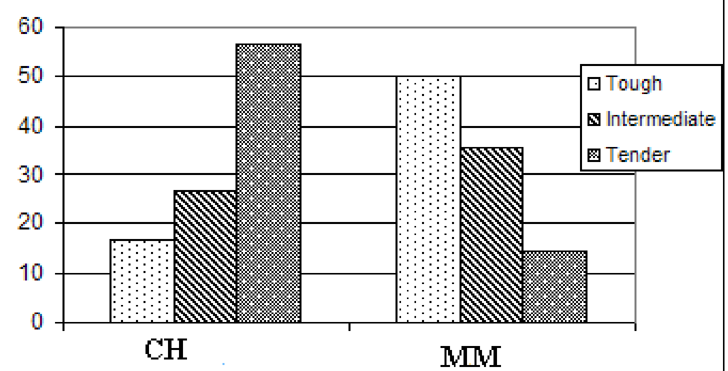
PLS (Partial Least Square regression) multivariate statistical analysis (Martens and, Martens, 1986) is used for creating calibration models for spectroscopic data. Before performing the PLS regression spectral outliers were identified and eliminated. The wavelength selection procedure consist of finding the number of variables that give the minimum value of RMSEP (root mean square error of prediction), found by cross-validation. The multivariate data analysis was performed with the Unscrambler 9.1 program (CAMO, Trondheim, Norway).

At last Multiple Linear Regression Model consisted of a stepwise search for the best combination of all chemical and physical parameters to estimate tenderness was performed.

III. RESULTS AND DISCUSSION

The two studied breeds were very different in tenderness (Fig.1) and they showed many significant differences also for the chemical and physical parameters (64.16 N vs 71.24 N, for WBSc, 3.13 vs 4.06 mg/g for total collagen and 68.21 vs 65.35 for MFI respectively in Chianina and Maremmana breed (Table1), while they were similar in colour and pH.

Fig.1- Distribution of 3 tenderness classes on the two Italian breeds



Univariate analysis did not show good results to estimate tenderness by objective measures, (Table2), the best regression was with WBS on cooked meat (R^2=0.58, RMSEP=0.88) as reported also by Peachey et al. (2002), while R^2 were lower than 0.12 for other objectives parameters. Using the multiple linear regression the maximum variability was explained by WBSc, soluble collagen and MFI (R2=0.75, RMSEP=0.80).

The validate PLS between spectrum data on visible and tenderness showed the best correlation coefficients (R2=0.84, RMSEC=0.55), also if it was necessary eliminate 5 data outliers from data set. The estimate regression coefficients reported in Figure 3 showed that the wavelength around 500 nm and 610 nm absorbed maximum variability. Also if the visible spectrum did not discriminate the two different breeds it was capable to discriminate the different tenderness type of meat.

The measured and predicted data (Fig.3) showed different trends for the three statistical model, the best slope (Table 2) was reported in PLS analysis (0.68). However the predicted data differed from measured data principally in intermediate tenderness samples and principally for Maremmana breed.

Table1 -*Physical and chemical analysis of longissimus thoracis muscle in two Italian breeds*

	CH	MM	RMSE	Sign.
pH	5.52	5.54	0.045	ns
WBSr N	42.53	55.16	6.190	***
WBSc N	64.16	71.24	10.66	**
*L**	45.19	44.92	4.35	ns
*a**	15.37	15.84	3.15	ns
*b**	14.92	15.17	2.17	ns
TCol mg/g	3.13	4.06	0.432	***
SCol %	21.16	20.96	3.00	ns
MFI	68.21	65.35	4.88	*

*Significant differences was expressed as ns: non significant, * ($P < 0.05$), ** ($P < 0.01$), *** ($P < 0.001$)*

Table2 –*Univariate, MLR and PLS analyses*

	Univariate	MLR	PLS
N outliers	0	0	8
Parameters	WBSc	WBSc, ML, S80, TCol, MFI, pH, WBSr	VIS Spectrum 360-740 nm
RMSEP	0.88	0.80	0.55
Correlation index	0.58	0.75	0.84
Slope	0.42	0.63	0.68

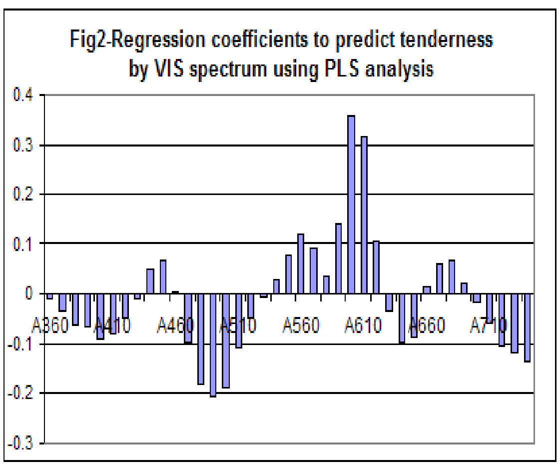


Fig2-Regression coefficients to predict tenderness by VIS spectrum using PLS analysis

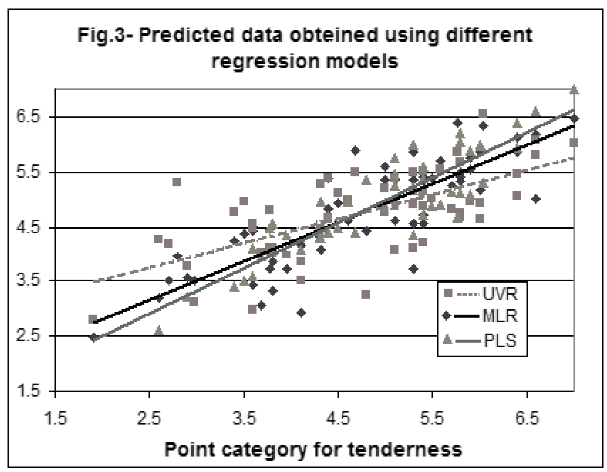


Fig.3- Predicted data obteined using different regression models

IV. CONCLUSION

The attributes evaluated by a descriptive texture profile panel may not reflect completely what is measured by shear force, while this study showed the potentiality of visible spectrum analysis for predict meat tenderness, and samples were successfully segregate from their respective class of sensory test both Maremmana and Chianina breeds. Therefore, evaluating meat tenderness could be possible with a non destructive and economical method.

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