TEXTURE OF DOUBLE MUSCLED PIEMONTESE BEEF MEASURED BY TWO INSTRUMENTAL METHODS

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Abstract – The aim of this study was to compare the modified WBsf and TPA methods on beef during ageing and to assess correlations. At 2 and 10 days *post mortem* two steaks were taken from LTL muscle of 20 Piemontese bulls. Raw meat strips were sheared perpendicular to the fiber direction with a WBsf device or compressed perpendicular to the fiber axis with a square compression probe at 20% and 80% of sample thickness. Data were analysed by the GLM procedure and Factor analysis. The lower IY and the higher difference PF-IY at d10 in comparison with d2 certify the tenderizing effect of ageing on myofibrillar tissue. No significant differences for PF were found, because the measurements were taken on raw meat. A significantly lower force was detected at d10 for hardness at 20%, which reflects the tenderizing effect of the proteolytic enzymes on the myofibers. On the contrary, as ageing does not influence the mechanical resistance of connective tissue, no significant differences were detected for hardness at 80%. Both methods are suitable to evaluate meat texture, but the poor correlations between the WBsf and TPA parameters indicate that these tests are complementary and measure different aspects of meat texture.

Key Words – Ageing, Beef, Warner-Bratzler shear force, Texture Profile Analysis.

I. INTRODUCTION

Texture in beef, especially tenderness, is a critical factor in the consumer's perception of beef quality [1].

According to Szczesniak [2], texture is the sensory and functional manifestation of the structural, mechanical and surface properties of food detected through the senses of vision, hearing, touch and kinesthetic. This definition implies that texture is a multiparameter attribute, whose estimation involves several senses at once. Although texture examination by using a sensory panel always provides the best information, instrumental measurements are more convenient as they are more reproducible, more rapid and less expensive.

Many attempts have been made over the years to develop an accurate instrumental method to measure texture of raw or cooked meat, including computer imaging, ultrasonic and optical analysis [3].

However, the Warner-Bratzler shear force test (WBsf) and the Texture Profile Analysis test (TPA) are the most popular and widely accepted mechanical techiques. The WBsf test measures the maximum force (PF) required to shear round cross-section cores obtained from cooked steak. The TPA test, which is based on the imitation of chewing process, measures the compression force of a probe and the related textural parameters, such as hardness, cohesiveness, gumminess, springiness, adhesiveness and chewiness, of raw meat during two cycles of deformation [4].

To obtain more information from WBsf and TPA tests, some modifications to the original protocols were suggested. WBsf was performed on square cross-section raw meat cores, in order to identify the initial yield (IY), as a measure of the strength of the myofibrillar structure and to calculate the difference between PF, which is the parameter usually measured, and IY (PF-IY) as an index of the connective tissue contribution to tenderness.

TPA was performed using a modified square compression cell that avoids transversal elongation of the sample. The stress at 20% and 80% of the maximum compression would assess the myofibrillar and connective tissue strength, respectively.

The aim of this study was to compare the modified WBsf and TPA methods on beef during ageing and to assess the correlations between the values obtained from both measuring methods.

As ageing of meat is characterized by physical and chemical reactions, which produce changes in textural properties, the ageing factor was included to obtain various degree of tenderness among meat samples.

II. MATERIALS AND METHODS

Twenty double-muscled Piemontese bulls of about 20 months old, obtained from local farms located close to each other and with similar husbandry practices, were slaughtered at 645 kg average live weight. At 24 h *post mortem* the portion of *longissimus thoracis et lumborum* (LTL) between 8th thoracic and 1st lumbar vertebra was removed from the right side of each carcass and stored in a cooler at 2°C and at 80% R.U. At 2 and 10 days *post mortem* a section 6 cm thick was taken from LTL muscle and each section was divided into two 3 cm thick steaks. The first steak was used for WBsf measurement and the second for the TPA. Raw meat samples of rectangular cross section 1x1x3 cm were removed parallel to muscle fibers direction and were sheared perpendicular to the fiber direction with a V-shaped cutting Warner-Bratzler blade, or compressed perpendicular to the fiber axis with a square compression probe (1 cm^2) at 20% and 80% of sample thickness.

For WBsf measurements, raw meat was used because cooking produces confounded effects on the connective tissue and muscle fibre and, thus, profoundly changes the relative contribution of each structure to the overall tensile behavior [5].

For both the tests an Instron 5543 was used and the crosshead speed was set at 200 mm/min. From the WBsf deformation curve two parameters were considered: the initial yield (IY) and peak force (PF). Extensive studies over a number of years have establish that IY represents the initial breakage of the myofibrillar component of tenderness, while PF, the maximum force required for cutting the sample, represents the overall toughness, reflecting both myofibrillar and connective tissue. The difference between PF and IY values (PF-IY) were calculated and were considered as an index of the connective tissue contribution to Warner-Bratzler peak force values [6].

The energy (area under force deformation curve in Ncm) of PF (EPF) and IY (EIY) was also calculated from the force-distance curve.

The TPA test was performed with a square compression cell (10 x 10 mm square) which was equipped with two lateral walls to limit free strain of the sample to a direction parallel to the myofibers. The raw samples were compressed twice perpendicular to the fiber axis to 20% and 80% of their original height [7].

From the TPA curves, the following texture parameters were considered: hardness, cohesiveness, springiness, gumminess and chewiness. Hardness was expressed as maximum force required to compress the sample. Cohesiveness was calculated as the ratio between A2/A1, where A2 was the total energy required for the second compression and A1 is the total energy of the first compression. Springiness was determined as the ratio of the time duration of force input during the second compression to that during the first compression or Length2/ Length1. Gumminess was obtained by multiplying Hardness and Cohesiveness. Chewiness was defined as the product of Gumminess x Springiness.

The data were analysed using the GLM procedure of SPSS (Inc., Chicago IL). Factorial analysis, using the principal component extraction (PCA) and varimax rotation method was applied to study the relationship between WBsf and TPA texture parameters during ageing.

III. RESULTS AND DISCUSSION

The results or WBsf test are reported in table 1.

Table 1. WBsf parametres of beef at different ageing time

	Ageing time		sem
	d2	d10	
IY (N)	20.62A	16.44B	1.02
PF (N)	31.04	32.96	1.53
PF-IY (N)	10.42B	16.52A	1.26
EIY (Ncm)	12.56A	8.41B	0.75
EPF (Ncm)	17.60	15.75	0.91

A, B means in the same row with different letters differ significantly (P<0.01).

The effect of ageing period on shear force parameters was evident. In fact, the lower IY and EIY and the higher difference PF-IY at d10 in comparison with d2 certify the tenderizing effect of ageing, due to enzymatic process on myofibrillar tissue, and, therefore, its lower contribution to the overall toughness. Between d2 and d10 the decrease of IY and E-IY resulted 20% and 33%, respectively, while the increase of PF–IY was about 59%.

The results are in general agreement with that of Campo *et al.* [8], who observed an increase in tenderness associated with increased time of ageing [8]. Ruiz de Huidobro *et al.* [9] observed that shear force tended to decrease in raw meat, whereas no effect was found on cooked meat. Similarly, Campo *et al.* [8] reported that the effect of cooking on the muscle structure could influence the sensitivity of the WBsf instrument to detect myofibrillar changes during aging.

A significant decrease of EIY was also observed between d2 and d10.

Estimation of shear energy is especially important throughout ageing, because its decrease characterizes the degradation of myofibrillar proteins due to enzymatic process and consequently meat becomes softer [1].

No significant differences were observed for PF, because the measurements were carried out on raw meat and consequently the tenderizing effect of cooking on connective tissue was lacking.

The results of TPA at 20% and 80% are reported in tables 2 and 3, respectively.

Table 2. TPA parameters of beef compressed to 20% of initial height at different ageing time

	Ageing time		sem
	d2	d10	
Hardness (N)	7.91A	4.89B	0.40
Cohesiveness	0.30B	0.35A	0.11
Springiness	0.51	0.52	0.020
Gumminess (N)	2.39A	1.69B	0.16
Chewiness (N)	1.11A	0.85B	0.05

A, B means in the same row with different letters differ significantly (P<0.01).

According to Lepetit and Culioli [7], the meat compression at 20% is related to myofiber strength, while the compression at 80% regards the resistance of connective tissue and the number of crosslinks between collagen molecules. Our results are in agreement with this statement. In fact, compared to d2, a significantly lower force (-38%) was detected at d10 for hardness at 20% (H20%), which reflects the tenderizing effect of the proteolytic enzymes on the myofibers.

Table 3. TPA parameters of beef compressed to 80% of initial height at different ageing time

	Ageing time		sem
	d2	d10	
Hardness (N)	17.41	15.09	1.16
Cohesiveness	0.18B	0.22A	0.007
Springiness	0.95	0.93	0.02
Gumminess (N)	3.19	3.20	0.29
Chewiness (N)	3.12	3.04	0.31

A, B means in the same row with different letters differ significantly (P<0.01)

According to Tornberg [10], myofibrils are the components that change the most during ageing. On the contrary, because ageing does not influence the mechanical resistance of connective tissue, no significant differences due to ageing were detected for hardness at 80% (H80%).

These results are in agreement with Eikelenboon *et al.* [11], who reported that connective tissue did not change during ageing.

With regard to the other parameters of TPA, in meat compressed at 20%, significant differences were found for gumminess, and chewiness which were lower at d10 than at d2.

These results probably depend on the changes in the patterns of myofibrillar degradation between 2 and 10 days.

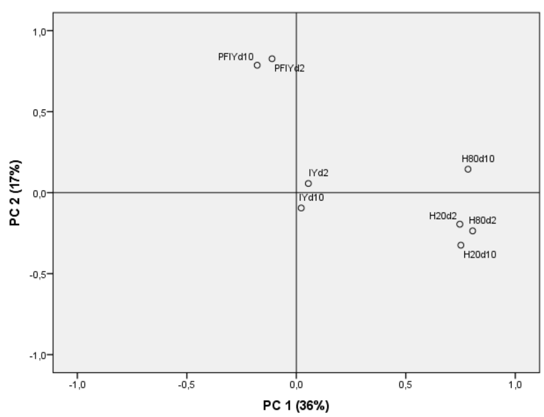
Cohesiveness at both 20% and 80%, resulted significant higher at d10 in comparison with d2.

The PCA was applied to investigate the relationship between the TPA and WBsf parameters during the ageing (Fig.1).

Four factors accounted for the 80% of the total variability. The first factor accounted 36% (PC1), the second one exhibited 17% (PC2). The PC1 was highly positively related to H20% and H80% at d2 and d10. The PC2 was highly positively related to PF-IY at d2 and d10.

Consequently it is possible to assert that the TPA differentiate the beef samples to a higher degree than did the WBsf. Since, the most significant parameters were H80% and PF-IY at d2 and d10, the connective tissue content is the most important factor which differentiate the beef samples.

Figure 1. PCA plot of texture parameters.



Poor correlations between TPA and WBsf parameters were found (r ranged from -0.002 to -0.447). Ruiz de Huidobro *et al.* [9] have tested the two methods to study the meat texture and concluded that in raw meat, TPA method is more useful than Warner Bratzler test, and when such a method is applied to cooked meat the opposite is observed.

IV. CONCLUSION

The results indicate that both WBsf and TPA are suitable to evaluate meat texture.

In fact, both methods revealed highly significant changes with ageing, even if the magnitude of their response to the ageing was different. The lack of close relationship between measurements with WB and TPA could be due to the different nature of the action involved (shear versus compression) and indicates that these tests measure different aspects of meat texture.

WBsf method is traditionally used for measuring the texture of cooked beef and it could be assumed as a valid method. In raw meat it is not possible to recommend the WBsf test as a complete substitution of TPA test. Nevertheless, it is a good complementary method to control beef quality.

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