PE7.36 **Effect of cooking temperature on physical and chemical properties of some beef muscles**
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***Abstract*-The aim of this work was to evaluate how different muscles, such as *Biceps femoris* (BF), *Caput longum triceps brachii* (CL) and *Longissimus thoracis* (LD), respond to rising heating temperature (from 55° to 85°C, with step of 10° C). Meat quality attributes were determined on raw and cooked samples. The three aforesaid muscles showed different shear force trend. LD showed a hardening after cooking, ought to a high shrinkage, whilst the others became more tender at increasing temperatures. Collagen content of muscles was different (BF 5.32a; CL 4.7b; LD 3.15c, P<0.05) and this caused the peculiar LD shear force trend when compared with the others. Moreover, the collagen results implicated in changes at low/mild temperature (above 65°C) whilst, contractile system seemed more important at higher temperature.**

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***Index Terms*- Beef, Cooking, Muscle, Tenderness.**

I. INTRODUCTION

The structural changes that cooking brings about in the different proteins of the meat have been investigated by many authors [1] [2] [3]. During heating, the different meat proteins denature and they cause structural changes in meat, such as the destruction of cell membranes, the shrinkage of meat fibres, the aggregation and gel formation of myofibrillar and sarcoplasmic proteins as well as shrinkage and solubilisation of the connective tissue [4].

Many authors accept the definition of cooking as the heating of meat to a sufficiently high temperature to denature proteins proposed by Davey and Gilbert (1974) [5] and a heating treatment has been considered complete when all the samples have reached a temperature of 75 C° at the thermal centre [6]. This came out also from the recommended doneness temperature by American Meat Science Association, National Live Stock and Meat Board, 1978.

Besides, it is generally known that there are considerable differences between muscles about collagen content and structure and this may influence the level (and the temperature at which they occur) of aforesaid changes.

Owing to the usual cooking utilization of meat and meat products, it is worth studying the physical and chemical changes that occur in meat during heating. In order to carry out this task it is important to investigate connective tissues and muscular fibres and the shrinkage that may result from their denaturation. The aim of this study was to describe the effect of different heat treatments on some traits of meat quality, with particular reference to tenderness.

II. MATERIAL AND METHODS

Longissimus thoracis (LD), *Biceps femoris* (BF) and *Caput longum triceps brachii* (CL) muscles were separated from 9 Maremmana beef carcasses 8 days after slaughter. Each muscle were sub-sampled in 5 slices. Weight and volume were measured, than they were stored at -20°C separately in polietilene bags and vacuum packaged. The slices from each muscle were used to perform different physical and chemical determinations on raw meat and at 55°C, 65°C, 75°C, 85°C cooking temperature, after 5 months of storage. The slices, after thawing, were cooked without taking them out from bags and the weight before freezing was used as first weight in order to avoid considering the water loss by freezing dehydration.

The samples were cooked in water bath at the temperature of 5 degree above the experimental temperature and we removed samples when internal temperature, measured by insertion of a probe, had reached respectively 55°, 65°, 75°, 85° C. Thaw loss was obtained for each muscles on the raw meat, and cooking loss was determined as percentage of losses [7]. Moreover, in the same samples used for cooking loss, thermal shrinkage was calculated by the relative proportion of raw and cooked samples volume obtained through the immersion in water into a graduate cylinder with millimetric scale. Warner-Blatzer shear force (WBS) and resistance at maximum load on raw and cooked meat was determined in four 1 x 1cm cross section strips using an INSTRON 5543 texturometer, 50-kg compression load cell and crosshead speed of 100 mm/min were used.

Hydroxyproline was determined on 4 g of meat hydrolyzed at 110°C for 14 hours. A factor of 7.5 was utilized to convert hydroxyproline into collagen [8]. Total soluble proteins (TSP) was evaluate on 4 g of meat homogenised in 50ml of buffer, then the suspension was centrifuged and the pellet washed twice in buffer. Finally pellet was suspended in 50ml of buffer and filtrate in a nylon filter [9]. The difference between these two parameters coincide with the amount of myofibrillar proteins loss (SPL) in cooking liquid by heating. Dry matter for each sample was calculated to standardize the determination.

All data were subjected to variance analysis [10] to evaluate muscle and temperature effects, using a bifactorial model with interaction. On the same data we performed a PCA analysis using a chemometric program [11].

III. RESULTS AND DISCUSSION

Cooking losses and shrinkage

As we expected the statistical analysis showed a significant difference in cooking loss with temperature ($P<0.05$) due to a decreased amount of bound water by heating. This confirms what found in previous works on cooked meat [12] (Tab.1) and it might be due to muscle fibres and collagen shrinkage, [13]. No important differences came out for distinct muscles.

Similar effect resulted about shrinkage percentage as the more muscular fiber shrank the more water poured out. Among muscles, LD showed the highest shrinkage percentage in comparison with other muscles.

Warner Blatzer and resistence

No significant differences emerged from WBS analysis neither for the three muscles nor for the different cooking temperatures. The only significance appeared to be between raw and cooked meat (Tab.1). Nevertheless, there was a strong interaction between muscle and temperature. LD raw muscle seems to be the most tender muscle and the toughest at 75°C and 85°C ($P<0.05$) (Fig. 1). On the other, hand BF and CL showed a decreasing toughness during heating, from raw to cooked. The above agrees with founds of others [13], confirming that high collagen muscles shows a tenderization for mild heating temperatures, whereas the same effect was not observed for the low collagen content muscles. The same authors argued that the lower WBS value for the last typology muscles is at about 55°C of cooking temperature. In our study LD showed the same trend even if there are no significant differences between treatments, except for the highest temperature (85°C), and nor among the three muscles.

The resistance, which depends on the muscle structure, showed a lower value for LD muscle. For all the muscles (Fig. 2) resistance increased with cooking temperature until 65°C, then fall down probably because of a higher collagen solubilization.

Collagen content and soluble proteins

LD has the lowest collagen content. During cooking the amount of total collagen decreased, showing two steps. The first during the initial cooking stage (until 55°C) and the second when internal temperature has reached 85°C. At 85°C of internal core temperature it showed the maximum WBS value and the minimum total collagen content, suggesting that the critical stage in toughening for this kind of muscle could be related to the myofibrillar component. This might be

confirmed by the analysis of total and myofibrillar soluble proteins (table 2). As we expected, in fact, total soluble proteins did not change, while protein loss increased significantly when cooked, pointing to their remarkable denaturation and so that of the contractile system, particularly at high temperature. Thereby we agree with a previous work [14]. Not similar outcome resulted for CL and BF muscles, maybe due to their higher collagen content.

Furthermore, PCA analysis showed soluble protein loss, shrinkage percentage and cooking loss to be the most of variance explaining factors. The two principal components explained overall 93% of variance (Fig. 3). The graphic confirms that for high temperature, myofibril effect is prevalent (Fig. 4). PCA analysis denoted a clear differentiation between mild and high temperature cooked groups.

IV. CONCLUSION

Cooking is a method used to solubilise collagen and improve tenderness, but at 65°C endpoint temperature it seems to be completely solubilised and the following changes occurring above 65 °C are muscle protein structural part dependant. In particular this effect is evident for a low collagen content muscle (*i.e. Longissimus thoracis)*. A mild cooking temperature allows to rich the best tenderization. At high temperature, toughening is mostly related to myofibrillar component and its denaturation and shrinkage.

Tab. 1: Means of some physical parameters for different muscles

	Shrinkage %	*Cooking Loss %*	*WBS Kg*	**Resistance mm**
		Muscle		
BF	26.02b	25.69	5.23	16.53a
CL	25.61b	24.68	5.64	16.02a
LD	28.35a	26.21	5.38	14.38b
		Temperature		
raw	-	8.28e*	7.22a	15.52a
55°C	16.71d	20.77d	4.54b	18.43b
65°C	24.78c	27.94c	4.84b	14.10b
75°C	29.34b	32.50b	5.24b	15.4b
85°C	35.81a	38.14a	5.24b	14.75b
Means	26.66	25.53	5.42	15.65
RMSE	3.276	3.635	1.589	2.831

*Thaw loss
Different letters means P<0.05

Tab. 2: Means of some chemical parameters for different muscles

	Total Collagen mg/g	*Total Soluble Proteins mg/g*	**Soluble Proteins Loss mg/g**
		Muscle	
BF	5.32a	49.75	37.36a
CL	4.7b	47.35	33.63b
LD	3.15c	47.38	36.00ab
		Temperature	
raw	5.38a	54.90	26.60d
55°C	4.44b	52.49	32.74c
65°C	4.09c	52.27	37.48b
75°C	4.00c	53.15	39.92ab
85°C	4.03c	53.18	41.57a
Means	4.40	53.2	35.66
RMSE	0.947	6.237	6.089

Different letters means P<0.05

Fig. 1: Shear Force trend of muscles at different cooking temperature

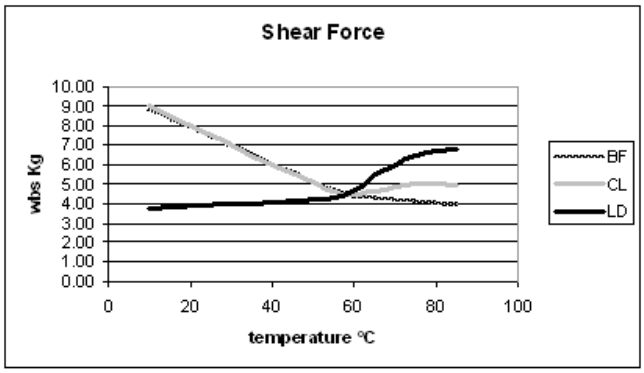


Fig. 2: Resistance trend of muscles at different cooking temperature

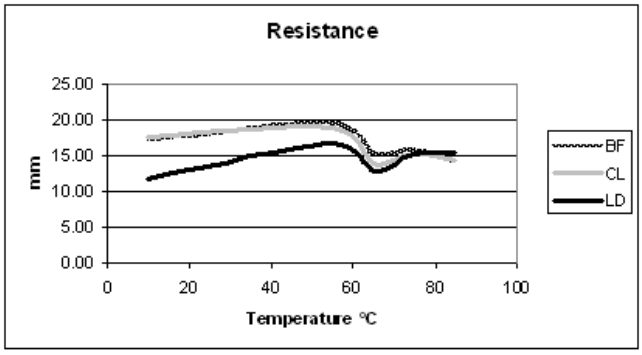


Fig. 3: PCA analysis plot of scores at different cooking temperatures

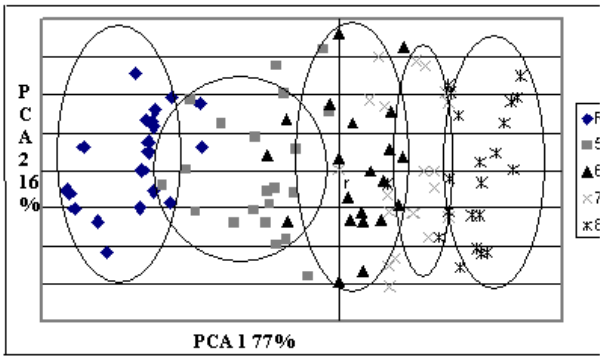
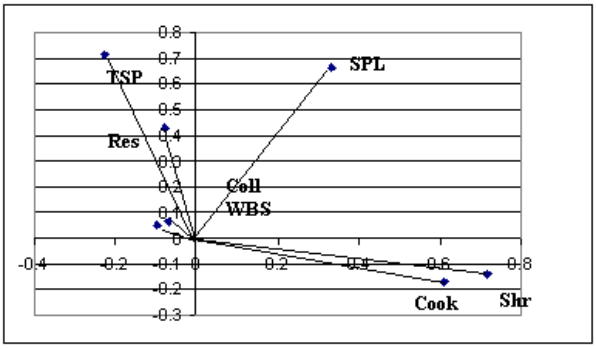


Fig. 4: PCA analysis plot of loading



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