THE INFLUENCE OF COOKING TEMPERATURE, ETHNIC GROUP AND AGEING PERIOD ON COOKING LOSSES AND TEXTURE OF BEEF

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Abstract – Steaks of *longissimus thoracis* muscle (LT) of 6 hypertrophied Piemontese (PH), 6 hypertrophied Piemontese x Friesian crossbred (PHxF) and 6 Friesian (F), were randomly assigned to 1, 3, 7 or 14 days of ageing. For each ageing period, two steaks were cooked to an end-point cooking temperature of 50 and 70°C, respectively. Cooking losses (CL) Warner-Bratzler shear force (WBsf), toughness (T) and total energy (E) were investigated.

At 50°C end-point cooking temperature, F had lower WB, T and E (P<0.01) than PH and PHxF. When meat is cooked at 70°C end-point cooking temperature, PHxF and PH showed the lowest and the highest CL, respectively (P<0.01). At d1 and d14 the lowest and the highest CL were observed (P<0.01). In comparison with d3 and d1, d14 showed a lower WB, T and E, while the same parameters resulted lower at d7 than at d1.

At 50°C, the meat toughness depended on the strength of connective tissue and allowed to detect differences due to ethnic group. On the contrary, the temperature of 70°C, inducing the collagen solubilisation, highlighted the toughness depending on myofibrillar tissue. This end-point cooking temperature allowed to observe differences in CL both among ethnic groups and ageing periods.

Key Words – End-point cooking temperature, Water holding capacity, Shear force measurements.

I. INTRODUCTION

Tenderness is the qualitative characteristic mostly affecting beef acceptability. It depends on several factors, including breed, age and sex of animals, ageing period, cooking method and end-point cooking temperature. It is widely accepted that cooking temperature influences to a large extent the tenderness of meat. Changes observed in tenderness during cooking are related to modifications occurring in intramuscular connective tissue and to muscle fibres. In fact, heat converts the collagen to insoluble gelatin that results in tenderization, but it also denatures muscle fibres that results in toughening [1]. These heat induced changes are time, temperature and end-point cooking temperature dependent. Parrish *et al.* [2] stated that the end-point temperature is a modifier of tenderness more important than marbling or maturity [3].

Therefore the aim of this study was to evaluate the effect of the end-point cooking temperature on cooking losses and texture parameters in beef from young bulls of different ethnic groups undergone to different ageing periods.

II. MATERIALS AND METHODS

Six hypertrophied Piemontese (PH), 6 hypertrophied Piemontese x Friesian crossbred (PHxF) and 6 Friesian (F), of about 18 months of age, were slaughtered at 552, 504 and 529 average live weight, respectively.

At 24 h *post mortem* the portion of *longissimus thoracis* muscle between the 11th and 13th thoracic vertebra was excised from the left right side of each animal, sliced into 8 steaks 3.5 cm thick, which were weighted and vacuum-packaged in a polyethylene bag. Steaks were randomly assigned to one of the following ageing period, 1, 3, 7 or 14 day, and stored at 2°C. For each ageing period, two steaks were heated to an internal temperature of 50 and 70°C, respectively, in a water bath at constant temperature (75°C). The cooking temperature was monitored with a thermometer placed into the geometric centre of each steak. When the fixed temperature was reached, the steaks were removed from the water bath and cooled for 15 min under tap water, then weighed to determine the cooking losses, expressed as a percentage of raw steak weight. The following day, 8 cylindrical cores 2.54 cm in diameter, taken parallel to muscle fibres, were sheared perpendicular to the longitudinal orientation of the muscle fibres [3] with a Warner-Bratzler shear device attached to an Instron Universal Testing machine (model 1011) with a 50 kg compression load cell and a crosshead speed of 100 mm/min. The parameters measured were: maximum force (WBsf, in N) required to shear the cores, toughness (T, N/cm^2) and total energy, defined as the area under the force deformation curve (E, Ncm).

The data were analysed by ANOVA GLM procedure [4], considering as factors cooking temperature, ethnic group and ageing period. As the interaction between end-point temperature and ethnic group or ageing was significant, the data were subsequently analysed separately for each end-point temperature.

III. RESULTS AND DISCUSSION

The effects of end-point cooking temperature on cooking losses (CL), shear force (WBsf), toughness (T) and total energy (E) are summarized in Table 1.

As regards the 50°C end-point cooking temperature, no differences in cooking losses among ethnic groups and in cooking losses, shear force, toughness and total energy for ageing periods were found.

The cooking losses were very low and under 8%. According to Offer *et al.* [5] water loss during meat cooking at temperature in the range of 45-60°C is mainly due to the denaturation of myosin and shrinkage transverse to fibres axis of meat.

In comparison with F group, PH and PHxF groups showed lower WBsf, T and E ($P<0.01$), with remarkable differences of about 26 N, 5 N/cm^2 and 25 Ncm, respectively.

This result is attributable to the higher collagen content of the meat of F group in comparison with the meat of double muscled animals of PH group or PHxF crossbred (data not shown).

In accordance with the statement of Møller [6], the shear force deformation curve clearly showed the lacking effect of 50°C end-point temperature on connective tissue component. As the collagen does not solubilise, the cooking effect is minimized and, consequently, the peak force (maximum force) can be related to connective tissue component of toughness. According to Christensen *et al.* [7], the changes of meat toughness at temperatures below 60°C correspond to changes in mechanical properties of the perimysial connective tissue.

Since the increase of meat tenderness during the ageing depends on the modifications of the myofibrillar tissue rather than that of connective tissue, no significant differences in shear force were observed in aged meat.

On the contrary, when the meat was cooked to an end-point temperature of 70°C, significant differences in cooking losses among ethnic groups ($P<0.01$) and in cooking losses ($P<0.05$), shear force ($P<0.01$), toughness ($P<0.01$) and total energy ($P<0.01$) for ageing period were observed.

The increase of temperature is the principal determinant of the weight loss during the cooking. Obuz *et al.* [8] reported an increase of cooking losses with the increasing of end-point temperature from 40 to 80°C in *longissimus* muscle cooked in a water bath. In fact, the cooking losses were about 3 fold higher in meat cooked at 70°C than at 50°C. The increase of cooking loss can be attributed to the denaturation of actin (66-73°C) and to the shrinkage parallel to the axis fibre of meat [5].

As regard ethnic group, PHxF and PH groups showed the lowest and the highest cooking losses, respectively. Nevertheless, in a previous work Destefanis *et al.* [6] did not find significant difference in cooking losses of *longissimus thoracis* muscle from PH, PHxF and F animals.

The 70°C end-point cooking temperature did not affect shear force measurements of the three ethnic groups. This result is in agreement with that of Campo *et al*. [10] who found no significant differences between breeds in WB shear force of meat cooked at 70°C.

Palka [11] reported that about 50% of collagen is solubilised at around 70°C and that the shear force variation above 60°C mainly involves the myofibrillar toughness. Consequently, according to Møller [6], when the meat is cooked to an internal temperature of 70°C the maximum peak is related to myofibrillar tissue. In fact, at 70°C the collagen network solubilises during cooking and, therefore, reduces its contribution to the shear force.

Møller [6] reported that the contribution of muscle fibres to Warner-Bratzler tenderness measurements increased as the end-point temperature of beef increased from 60°C to 80°C, while the contribution of connective tissue decreased. Therefore, the changes in muscle fibres due to cooking had a toughening effect, whereas the changes in connective tissue had a tenderizing effect.

At d1 and d14 the lowest and the highest cooking losses were observed ($P<0.05$). According to Bruce *et al*. [12], the increase in cooking losses during the ageing is probably due to protein degradation.

In comparison with d3 and d1, the LT muscle cooked at 70°C and aged for 14 days showed a lower shear force, toughness and total energy, while the same parameters resulted lower at d7 than at d1. On the whole, throughout the ageing (from d1 to d14) the shear force decreased of 32% and the major decrease was observed between d3 and d7 (-13%). A similar trend was observed for toughness and total energy values, which decreased of 32% and 22% from day 1 to day 14 of ageing.

As previously outlined, the toughness of meat cooked at 70°C cannot depend on connective tissue component, but rather is attributable to the weakening of myofibrillar proteins by endogenous protease during the ageing [12].

IV. CONCLUSION

The end-point cooking temperature influenced the cooking losses and texture parameters of meat.

Unlike 50°C, the temperature of 70°C allowed to observe differences in cooking losses both among ethnic groups and ageing periods. These latter are presumably due to myofibrillar protein degradation during the ageing.

Because of the absence of collagen solubilisation at 50°C, the meat toughness depended on the strength of connective tissue and, therefore, this cooking temperature allowed to detect differences due to ethnic group of the animals.

On the contrary, the temperature of 70°C, inducing the collagen solubilisation, highlighted the toughness depending on myofibrillar tissue and its enzymatic degradation during the ageing.

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Table 1 Effect of end-point cooking temperature, ethnic group and ageing period on cooking losses, Warner-Bratzler shear force, Toughness and Total energy of LT muscle.

	Ethnic groups			Ageing period (days)			
	PH	PHxF	F	1	3	7	14
Cooking temperature 50°C							
Cooking losses (%)	7.61	6.94	7.82	7.17	7.97	7.34	7.34
WBsf (N)	89.14^{A}	89.40^{A}	115.20^{B}	100.20	96.74	99.77	94.94
Toughness (N/cm^2)	17.59^{A}	17.64^{A}	22.74^{B}	19.78	19.02	19.69	18.74
Total energy (Ncm)	146.45^{A}	147.18^{A}	172.20^{B}	162.82	161.31	150.77	146.20
Cooking temperature 70°C							
Cooking losses (%)	24.00^{B}	19.86^{A}	21.86^{AB}	20.23^{a}	20.94^{ab}	22.78^{ab}	23.68^{b}
WBsf (N)	87.54	89.10	96.56	109.00^{C}	96.98^{BC}	84.01^{AB}	74.26^{A}
Toughness (N/cm^2)	17.28	17.58	19.06	21.51^{C}	19.14^{BC}	16.58^{AB}	14.66^{A}
Total energy (Ncm)	165.13	158.96	162.56	180.76^{C}	170.66^{BC}	155.06^{AB}	142.38^{A}

Least square means; A, B: P<0.01; a, b: P<0.05.