EFFECT OF ISOTHERMAL COOKING AT DIFFERENT TIME ON RHEOLOGICAL PROPERTIES IN THREE DIFFERENT MUSCLES

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Background and Objectives

In Italy, generally are consumed meats obtained by crossbreeds between Italian or foreign meat breed sire and dairy or local breeds cows. These animals are bred, for most part of their live, on pasture and they show typical meat quality (Alabiso et al., 1996), however their meat quality is poorly known and studied, particularly cooked meat. Meat is cooked before to be eaten and the effect of temperature and cooking length on physical properties of meat is more interesting. Generally, the effects of cooking on meat tenderization result from the changes in connective tissue that have a tenderizing effect (Bailey and Light, 1989; Bouton et al.,1981). Moreover meat physical quality is strictly linked to breed and age of animals and result different among muscles (Lawrie, 1988).
The experiment aim is to study the qualitative characteristics of crossbred obtained by local breed of Sicily with Charolais or Marchigiana and the effect of different times of cooking with constant temperature on hardness and water loss in different muscles. The study of the mathematical functions that fit the different values of hardness and water loss allow to estimate the optimum time for cooking the meat.

Material and Methods

The trial was carried out on 16 beef of two different genotypes: 11 Charolais crossed with the genotype coming from Modicana breed (Ch*Md) and 5 Marchigiana *per* Md (Mg*Md) They were bred until 12 months on pasture and then they were fed on straw, leguminous hay (*hedysarum coronarum*) and concentrate. The animals were slaughtered at 16 months (420.26 kg of live weight average), the productive data were reported in Alabiso et al., 1996.
At dissection, 7 days after slaughtered, samples of three muscles (*caput longum tricipite brachii* - Clotb, *gluteus biceps* - Gb and *longissimus thoracis* Lt) were kept. The samples were placed in polyethylene bags and frozen at -20°C for 4 months, then they were thawed for 24 h at 4°C. After thawing, pH and thaw loss were determined. The samples were cut in 8 sub samples: the first was used to determine drip loss, colour with C illuminant (lightness, chrome and hue) using Macbet 1400 colorimeter apparatus and hardness on raw meat; the other seven were wrapped in polyethylene bags and heated in water bath at 75°C, until 30, 45, 60, 90, 120,150 and 180 minutes respectively and then are cooled in cold running water for 30 minutes . Before and after cooking, both weights were recorded to determine moisture loss. On cooked sub samples the Warner- Bratzel Shear force with Instron 1011 are recorded.
The data were analysed by analysis of variance using bifactorial model (genotypes and muscles) with interaction. Furthermore non linear regression was used to fit the water loss and hardness trends to mathematical functions ($y=a*(1-\exp(-b*x))$ for water loss and $y=a-x^{b}+c*x^{1/2}$ for hardness).

Results and Discussion

The water content of meat is economically important and affect the toughness and juiciness
The two genotypes did not show significant differences in water loss values on raw and cooked meat, but Mg*Md had less water holding capacity in the first cooking times, with 1.9% of difference between the two genotypes ($p>0.072$); this trend was present until about 1 hours of cooking. Lt muscle had higher thaw loss compared to the other muscles, while showed less water loss at different cooking times; Gb and Clotb had a similar trend in raw and cooked meat. However, the total water loss, in different moments, was similar in the three considered muscles and it showed high value (43.3%), because freezing and tawing generally cause a substantial increase in drip production over unfrozen meat (Lawrie, 1988).
The genotype Ch*Md was more tough both in raw (+14%) and cooked (+16%) meat as compared to the other one. The highest difference between the genotypes during the cooking resulted at 45 minutes was recorded.
The raw Lt was more tender if compared to the other muscles, while, it came out tough during the cooking and showed the highest valueso hardness with significant differences only for Gb during the first 45 minutes of cooking although. The high value of hardness was given by the rustic maternal breed, rearing and the excessive thaw loss. The water losses imply an increasing concentration of the structural components of the muscle and connective tissue in the shrunken meat, which may in part explain the increases in toughness (McDowell et al., 1982; Lawrie, 1988). The two genotypes were similar in the pH, while among the muscles the Clotb showed the highest value. The colour resulted slightly different between the genotypes except for the chrome where the Mg*Md showed higher value (25.98 vs 24.99). Lt muscle was lighter and had higher hue value (+7.6%, +5.1% respectively) compared to the other muscles.
The utilization of non linear equations to estimate the trends of water loss and hardness brought out a relevant muscle effect during the cooking. It is well known that different muscles have differents cooking effect as each muscle has very different structural qualities and different roles in the living animal (Barkley, 1986; Lawrie, 1988).
The non linear regression for all the considered parameters showed a high R^2 (97% in average)
The equations that fitted the water loss ($y=39.82*(1-\exp(-0.0563x))$; $y=41.40*(1-\exp(-0.0686x))$; $y=35.12*(1-\exp(-0.0413x))$ for Clotb, Gb and Lt respectively) were different particularly for the asimptotic values (Lt<Gb<Clotb), while the equation trends of the three muscles (figure1) were similar as reported by Bengtsson et al., (1976).

The hardness showed different trends, particularly for Lt compared to other muscles (figure 2). The intercept of y axis of Lt muscle showed significant differences (- 43%) and the parameter "c" was greater than 1, therefore the curve resulted convex with maximum value at 35.3 minutes, while the other muscle equations fell toward x axis ($Y=8.22-X^{0.339}+0.200X^{1/2}$; $Y=7.96-X^{0.292}+0.115\ X^{1/2}$; $Y=4.64\ -X^{0.582}\ +1.559\ X^{1/2}$). The trend noticed in isothermal cooking depends on the connective content. Several study confirmed that there is an approximate correlation between total collagen content and the mechanical properties of cooked meat (Bailey and Light, 1989).

Fig1-Muscles water loss in isotermal cooking

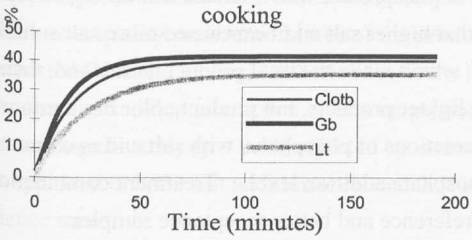
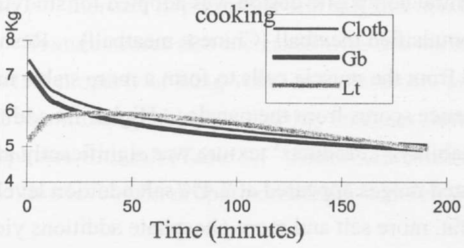


Fig2 -Muscles hardness in isotermal cooking



The effects of cooking have been summarised as producing a softening of the connective tissue by conversion of the collagen to gelatin, accompanied by a toughening of the meat fibres due to heat coagulation of the myofibrillar proteins. Therefore the meat toughness is governed by two factors: the myofibrillar structure and the connective tissue structure (cooking: shrinkage) depending on the cooking temperature and time.(Bouton et al.,1981). Usually scores of tenderness decreased with increasing cooking time (for Clotb and Gb muscles) and the soluble collagen content increased after 30 minutes cooking (Huis-Lao Guo and Ming- Tsao Chen 1996). While the different trend of Lt muscle, that has low collagen content, could be due to a rapid shrinkage followed by progressive tenderness due to the break of myofibrillar linkages wich loose their structural integrity.

Conclusion

The crossbred Mg*Md resulted better than the other genotype but the physical quality of cooked meat depend on several factors, particularly collagen content, fiber length, cooking temperature and time and rate of heat penetration at about 70°C. Infact, degradation of fibers are not only temperature dependent but also depends on the rate of heat penetration (Penfield and Meyer 1975, McDowell et al. 1982). Further study of heat effects on the denaturation of myofibrillar proteins in relation to the hardening of muscle fibbers is needed to better understand heat induced changes in tenderness of meat, particularly in rustic animal, subjected to strong thermal treatment. Anyhow, 40 minutes of cooking time are usefull to improve the quality of cooked meat at low temperature.

References

- Bailey A.J. and Light N.D.(1989). Connective tissue in meat products Ed. Elsevier Applied Science.
- Bengtsson N.E., JakobssonB. and Dagerskog M. (1976). J. Food Sci. 41:1047-1053.
- Bouton P.E., Harris P.V. and Ratcliff D. (1981). J. Food Sci. 46: 1082-1087.
- Huis-Lao Guo and Ming-Tsao Chen (1996). Proceeding of 42nd ICoMST: 164-165.
- Lawrie R (1988). Developmrnts in Meat Science-4. Ed. Elsevier Applied Science.
- McDowell M.D., Harrison D.L., Pacey C. and Stone M.B.(1982). J. Food Sci. 47:1603-1612.
- Penfield M.P. and Meyer B.H.(1975). J. Food Sci. 40:150-154.
- Alabiso M., Bonanno A., Alicata M.L. and Leto G. (1997). Tec. Agricola year 49 (1-2):21-29 .

Table 1 Phisical quality of meat

		Ch*Md	Mg*Md	Clotb	Gb	Ld	Means	root MSE
	Thaw loss	9.642	9.90	8.96b	7.99b	12.35a	9.77	3.383
% of water	30	28.17b	30.07a	29.92a	31.17a	26.28b	29.12	3.159
Loss at different	45	31.27	33.01	33.24a	33.08a	30.10b	32.14	2.751
Times (minutes)	60	32.89	34.01	35.03a	35.97a	31.03b	33.45	6.248
	90	35.81	36.47	37.35a	38.53a	32.54b	36.14	3.148
	120	37.34	37.33	37.45b	39.47a	35.08c	37.33	2.615
	150	37.30	37.27	38.14a	39.56a	34.16b	37.28	2.970
	180	38.43	38.30	39.65a	41.15a	34.29b	38.37	2.376
	0	7.47a	6.45b	8.13a	8.06a	4.68b	6.96	1.781
Hardness (kg)	30	6.06a	4.90b	6.19a	4.68b	5.57ab	5.48	0.961
at different	45	5.97a	4.65b	5.34ab	4.71b	5.87a	5.31	1.025
times (minutes)	60	6.18a	4.98b	5.79	5.17	5.77	5.58	1.096
	90	5.95	5.35	5.61	5.63	5.70	5.65	1.119
	120	6.01a	5.05b	5.49	5.63	5.47	5.53	1.204
	150	5.65a	4.77b	5.23	5.08	5.32	5.21	0.977
	180	5.32a	4.54b	5.04	4.70	5.06	4.93	1.052
pH		5.78	5.76	5.84a	5.75b	5.71b	5.77	1.178
Colour	Lightness	42.46	42.65	40.86b	41.99b	44.82a	42.55	2.008
	Chrome	24.99b	25.98a	25.13	25.29	26.05	25.48	1.581
	Hue	37.92	37.55	36.76b	37.38ab	39.06a	37.73	2.751