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INFLUENCE OF BREED ON THERMAL STABILITY OF INTRAMUSCULAR BOVINE COLLAGEN

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Background

It is widely accepted that collagen plays an important role in meat texture, because it is responsible of its basic toughness. The contribution of collagen to meat texture is a complex problem, that involves several factors, including total iminoacid content (Burjanadze, 1979, Privalov, 1982, King, 1987), age (Hill, 1966), type and amount of crosslinks (Stanton and Light, 1988), type of muscle and genetic factors (Beltrán and Boccard, 1991). In spite of this connective tissue has been less studied inside the breed effect than the miofibrilar component.

Several authors (Light, 1985) have shown that collagen quality is more important than its quantity to determine meat quality variations, and that the best correlation of collagen quality with textural variations is established by differences in the amount of heat-stable crosslinks. Thermal transition temperature is well relationed with the amount of these heat-stable crosslinks (Flandin, 1984) and it may be successfully used as a tenderness index (Judge and Mills, 1986). It seems that there is an increase in thermal stability when heat-stable crosslinks content increase. This effect has been studied by several authors (Judge and Mills, 1986, Bosselman *et al.*, 1995) but few references have been found about the influence of genetic factors into the collagen thermal stability.

Thermal transition temperature can be assessed by differential scanning calorimetry (DSC). DSC is a technique with a wide application on the study of structure and thermic properties of polymers, that allows to assess both protein thermal transition temperature (temperature at which occurs the change of its physical state) and enthalpy (amount of energy consumed during process).

Objectives

Our main aim was to study breed effects on thermal characteristics and solubility of intramuscular bovine collagen.

Material and methods

Six beef breeds, including fifteen yearlings entire males, each one, slaughtered at 450 kg live weight, were used: Asturiana de los Valles, double muscled breed (AS), Pirenaica, breed with fast growth rate (PI) and Asturiana de la Montaña (AM), Avileña-Negra Ibérica (AV), Morucha (MO) and Retinta (RE), rustic breeds. All these breeds have been described in a previous report (Campo *et al.*, 1999).

Twenty four hours after slaughtering, *m. longissimus dorsi* was removed, aged at 4° for 7 days, cut into two cm thick chops, vacuum packaged and kept at -18°C until it was analysed analysis. Determination of hidroxyproline and collagen extraction for calorimetric analysis were made as described by Bonnet and Kopp (1984). Thermal transition temperature, enthalpy and onset temperature (temperature at which starts the physical state change) have been obtained from thermograms produced using a Du Pont 2000 thermal analyzer with a DSC cell. Operating parameters were: heating rate, 5°C/min; starting temperature, 30°C; limit temperature, 120°C. Data were analysed using the SPSS (1996) package. A Duncan t-test was performed for assessing mean differences.

Results and discussion

Results are shown in Table 1. Breed effect has been significant in all the studied parameters ($p<0.001$).However, we have not found a explanation due to their productive characteristics (growth rates, precocity, live or carcass morphology, etc.) for explaining completely our results. Opposite to Young *et al.* (1994) in sheep and Berge *et al.* (1997).

Our thermal transition temperature values similars to those found by Findlay *et al.* (1986) in Charolais crosses, at 18 months of age. Our enthalpy results are lightly higher than those found by Findlay *et al.* (1986) in heifers of 18 months of age and lightly lower than those found by Kamoun *et al.* (1989) in cows at five years old. Our total collagen content values agree with those showed by Bosselman *et al.* (1995) and Berge *et al.* (1997) in animals of similar weights and nutritional levels. The collagen solubility percentage has been higher than that obtained by Kopp (1971) in animals of same characteristics. These differences could be explained by the whole action of several factors (sex, slaughter weight, type of muscle, ageing time) as was reported by Judge and Mills (1986) and Stanton and Light (1988). The highest collagen solubility found in Asturiana de los Valles and Pirenaica breeds could be due to their double muscled condition and fast growth rate respectively (Campo *et al.*, 1999).

Correlations among measurements are shown in Table 2. Total collagen content was not significantly correlated with any thermal parameter, but it was positively correlated with insoluble collagen content ($p<0.001$) and solubility percentage ($p<0.05$), as Berge *et al.*, (1997). All calorimetric parameters have been positively correlated one of them ($p<0.001$). Also, we have found a positive correlation between solubility percentage and onset temperature ($p<0.001$) and between percentage solubility and enthalpy ($p<0.05$). However, no significant correlation have been found between solubility percentage and thermal transition temperature.

A change in crosslink characteristics occurs as the animal age increases, and this process is known as collagen maturation. This maturation is manifested by decreased solubility (Bosselman, 1995), although Berge *et al.* (1997) have shown that within a narrow range of animal age, differences in the heat stability of intramuscular collagen were not explained by differences in crosslink profile. On the other hand, Judge and Mills (1986) has reported that in females, the collagen maturation process is slow and thermal transition temperature would linearly increase with age, but the same process is faster and more variable in males.

Thus, it seems that a pool of factors should be considered to be able to explain relationships between texture and connective tissues characteristics, comprising: collagen solubilitation extension (Stanton and Light 1987), conditioning of meat (Findlay *et al.*, 1986), sarcomere length (Dutson *et al.*, 1976, Findlay *et al.*, 1984) collagen fibres diameter (Light *et al.*, 1985) presence or absence of proteoglicans that protect collagen of the enzymatic action (O'Shea *et al.*, 1974) heat-stable crosslink amount (Shimokomaki *et al.*, 1972),

production system (Koohmaraie *et al.*, 1988, Bosselman *et al.*, 1995), etc.

Conclusions

In the conditions of our experiment we could conclude that there is an important effect of breed on the collagen thermal stability. But that differences in total collagen content and its solubility are not great enough to explain in themselves collagen behaviour during thermal transition process.

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Table 1. Results of thermal transition temperature, enthalpy and collagen content parameters of six beef breeds.

Breed	AS	AM	AV	MO	PI	RE	
Onset temperature (°C)	63.32 ± 0.75 bc	63.92 ± 0.80 a	61.96±1.33 c	62.83±0.87 b	62.71±1.31 bc	63.13±1.03 ab	***
Thermal transition temperature (°C)	65.32 ± 0.61 c	66.68 ± 0.82 a	65.20±1.66 c	65.80±0.83 abc	65.69±1.56 bc	66.56±0.80 ab	***
Enthalpy (J/g)	7.98 ± 1.49 ab	8.97 ± 1.01 a	6.22±1.10 c	7.66±1.24 b	7.74±1.88 b	6.90±1.35 bc	***
Total collagen (mg/g)	3.58 ± 0.89 a	2.46 ± 0.39 d	3.14 ± 0.36 b	3.17±0.57 b	2.71±0.56 cd	2.96±0.49 bc	***
Insoluble collagen (mg/g)	1.89 ± 0.31 b	1.37 ± 0.35 c	2.25±0.24 a	2.05±0.17 ab	1.46±0.35 abc	1.90±0.52 b	***
Solubility percentage	44.45 ± 14.11 ab	44.09 ± 11.87 ab	28.13±4.24 c	36.87±6.04 ab	45.45±12.77 a	35.67±13.51 bc	***

Total and insoluble collagen content is expressed as mg/g fresh muscle. a, b,c, means in the same row with different letters are significantly different ($p<0.001$)
AS= Asturiana de los Valles; AM= Asturiana de la Montaña; AV= Avileña-Negra Ibérica; MO= Morucha; PI= Pirenaica; RE=Retinta

Table 2. Correlations between thermal transition temperature, enthalpy and collagen content.

	Onset temperature (°C)	Thermal transition Tª (°C)	Enthalpy (J/g)	Total collagen	Insoluble collagen
Thermal transition Tª (°C)	0.771 ***				
Enthalpy (J/g)	0.334 ***	0.344***			
Total collagen (mg/g)	-0.186 n.s.	-0.158 n.s.	-0.117 n.s.		
Insoluble collagen (mg/g)	-0.364 ***	-0.269 ***	-0.291 ***	0.564 ***	
Solubility percentage	0.302 ***	0.190 n.s.	0.258 **	0.183 **	-0.646 ***

Total and insoluble collagen content is expressed as mg/g fresh muscle.
**** $p<0.001$; ** $p<0.05$*