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Marco Noventa, Luigi Gallo, Enrico Sturaro, Omar Bonetti, Massimo De Marchi & Paolo Carnier

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COMMUNICATION

Relationship between raw ham cathepsin B activity and firmness of dry cured hams

Marco Noventa, Luigi Gallo, Enrico Sturaro,
Omar Bonetti, Massimo De Marchi, Paolo Carnier

Dipartimento di Scienze Animali. Università di Padova, Italy

Corresponding author: Dr. Marco Noventa. Dipartimento di Scienze Animali. Università di Padova. Viale dell'Università 16, 35020 Legnaro (PD), Italy – Tel. +39 049 8272639 – Fax: +39 049 8272669 – Email: marco.noventa@unipd.it

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ABSTRACT

This study aimed to investigate the relationship between cathepsin B activity and muscle firmness of dry cured hams. A total of 988 samples of semimembranosus muscle were collected from raw hams of heavy pigs and cathepsin B activity was determined using fluorimetric method. Raw hams were cured following San Daniele guidelines. Dry-cured hams were deboned and cross-sectioned. On the cross section firmness was measured at three muscular sites (*M. semimembranosus, semitendinosus* and *biceps femoris*) using a Hardness Meter MK2. This study did not evidence any significant relationship between cathepsin activity and firmness of dry cured hams.

Key words: Pigs, Dry cured ham, Cathepsin B activity, Firmness

Introduction

Dry-cured ham is a typical Italian meat product of high commercial value. The processing of dry-cured hams involves a long maturation period where proteolysis and lipolysis reactions take place (Toldrà *et al.*, 1992). Proteins breakdown mechanisms mostly depend on muscle lysosomial proteinases (Parolari *et al.*, 1994). Cathepsins are lysosomial proteinases that have been associated to intense protein cleavage occurring throughout ripening (Toldrà and Etherington, 1988; Toldrà *et al.*, 1992). These enzymes are active at acid pH and are able to degrade myofibrillar proteins. Cathepsins maintain 40-50% of initial activity after 8 months of curing (Toldrà and Etherington, 1988) and play an important role in biochemical processes because in dry-cured hams proteolytic activity is controlled by muscular enzymes with no microbial intervention. Some studies showed that, in raw hams, cathepsin B residual activity, proteolysis index and texture are highly correlated traits (Virgili *et al.*, 1994). However, relationships between initial activity and quality traits of end products have been scarcely investigated. This study aimed to investigate the relationship between enzymatic activity of cathepsin B in raw hams and firmness of dry cured hams.

Material and methods

This study used data from 988 (494 castrated males and 494 gilts) crossbred heavy pigs slaughtered at the same abattoir. Pigs were progeny of 49 Gorzagri C21 Large White boars and 141 crossbred Large White-derived sows. Hams were dressed after 24 h of refrigeration, pH was measured at dressing on left thighs, and samples of semimembranosus muscle were collected from all left hams for cathepsin B activity determination. Cathepsin B activity was determined two days

Table 1. Descriptive statistics of carcass weight and ham traits.

Variable		Mean	SD	CV (%)
Carcass weight	kg	136.6	13.6	9.9
pH after 45 min		6.33	0.19	3.0
pH after 24 hours		5.77	0.16	2.8
Cathepsin B activity	nmol AMC min^{-1} g^{-1}	1.36	0.31	22.8
Firmness of muscles:				
- Biceps femoris		563	80.4	14.3
- Semimembranosus		738	80.2	10.9
- Semitendinosus		586	87.8	15.0

after slaughtering using analytical procedures described by Schivazappa *et al.*, (1992) and Sturaro *et al.* (2004). Raw hams were cured following San Daniele guidelines (1996). At the end of curing, hams were deboned and cross-sectioned. Firmness of the lean fraction was measured on biceps femoris, semitendinosus and semimembranosus muscles using a Hardness Meter MK2 (Noventa *et al.*, 2004).

Statistical analysis

Measures of cathepsin activity were analysed by ANOVA (SAS user's guide, 1990) using a linear model which included the fixed effects of the slaughter group (24 groups), sex (castrated males and females), carcass weight (5 classes) and the effect of pH measured at 24 h after slaughtering (covariable). To investigate the influence of enzymatic activity on muscle firmness, data collected by Hardness Meter were analysed by ANOVA using a linear model which included the fixed effects of the slaughter group, sex, carcass weight, and cathepsin B activity (covariable).

Results and conclusions

Descriptive statistics of carcass weight and ham traits are reported in Table 1. Average carcass weight was 137 kg with moderate value of coefficient of variation. Values of pH at 45 min and 24 h after slaughtering showed limited variability and confirmed absence of PSE and DFD in the sample analysed. Cathepsin B activity exhibited an average value of 1.36 nmol AMC min^{-1} g^{-1} and a large variability (C.V. = 22.8 %).

Muscle firmness was higher in semimembranosus than in other muscular sites, and not much different between semitendinosus and biceps femoris muscles. Coefficients of variability for muscles firmness ranged from 11 to 15%. Correlations for firmness of different muscles and between cathepsin activity and firmness are reported in Table 2. Coefficients indicate a high correlation between firmness of biceps femoris and that of semitendinosus, and a moderate correlation between semimembranosus and the other muscles. Relationships between cathepsin activity and firmness were low. There was a not significant correlation between cathepsin B activity and semitendinosus firmness whereas correlations between enzymatic activity and firmness of the other muscles, albeit being significant, were small.

Results of ANOVA for muscles firmness and enzymatic activity are reported in Table 3. All

Table 2. Correlations (%) for firmness of different muscles and between firmness and cathepsin B.

	Biceps femoris	Semitendinosus	Semimembranosus
Cathepsin B activity	10.4 *	5.8 ns	20.0 ***
Biceps femoris		70.0 ***	54.8 ***
Semitendinosus			58.3 ***

**** P < .001, * P < 0.05, ns = not significant*

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Table 3. ANOVA for muscles firmness and cathepsin B activity.

Effect	F statistics			
	Cathepsin B activity	Biceps femoris	Semi-tendinosus	Semi-membranosus
Slaughter group	35.4***	9.4***	10.8***	14.0***
Sex	5.4*	ns	11.2**	ns
Carcass weight	2.1*	21.1***	16.6***	9.6***
pH at 24 h after slaughtering	13.6***	-	-	-
Cathepsin B activity nmol AMC min^{-1} g^{-1}	-	ns	ns	ns
R^2 %	47.5	27.9	28.8	29.9

**** P < 0.001, ** P < 0.01, * P < 0.05, ns = not significant*

effects included in the linear model significantly affected cathepsin activity. Effects due to the slaughter group and pH at 24 h after slaughtering were the most important sources of variation for cathepsin B activity. Coefficient of determination of the model for cathepsin activity was 47.5%. Values of R^2 for firmness were lower ranging from 27.9% (biceps femoris) to 29.9% (semimembranous). Effects due to the slaughter group and carcass weight were significant sources of variation for all muscular sites. Sex influenced firmness of semitendinosus muscle only ($P < 0.01$). Muscles firmness tended to decrease at increasing carcass weight (data not reported in table). Cathepsin B activity was not a significant source of variation for muscles firmness. Parolari *et al.* (1994) and Schivazappa *et al.* (2002) reported significant relationships between cathepsin B activity and intensity of proteolysis during curing and Virgili *et al.* (1995) postulated a significant relationship between firmness of dry cured hams and enzymatic activity. However, those studies analysed samples of limited size. In conclusion, cathepsin B activity measured in the fresh ham does not seem to be a relevant trait in relation to firmness characteristics of dry cured hams.

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