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

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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 lysosomal proteinases (Parolari et al., 1994). Cathepsins are lysosomal 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...
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 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 %).

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

| Variable          | Mean  | SD   | CV (%) |
|-------------------|-------|------|--------|
| Carcass weight    | 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 | 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

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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).

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

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

*** P < .001, * 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 R² for firmness were lower ranging from 27.9% (biceps femoris) to 29.9% (semimembranosus). 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 compositional parameters in dry-cured hams of normal and defective texture. Meat Science, 38:117-122. SAS, 1990. User's Guide: Statistics, Version 6. SAS Institute Inc., Cary, NC, USA. Schivazappa, C., Virgili, R., Parolari, G., 1992. Enzimi proteolitici nel prosciutto stagionato (II - correlazioni con i parametri fisici del muscolo fresco). Industria Conserve; 67:413-416. Schivazappa, C., Degni, M., Nanni Costa, L., Russo, V., 2002. Analysis of raw meat to predict proteolysis in Parma ham. Meat Science; 60:77-83. Sturaro, E., Gallo, L., Noventa, M., Carnier, P., 2004. Variation of cathepsin B activity in raw hams for dry curing and relationship with the firmness of dry cured hams. 39° Simposio Internazionale di Zootecnia, Meat Science and Research, Roma (Italy), 523-531. Toldra, F., Etherington, D., 1988. Examination of Cathepsins B, D, H and L activities in dry - cured hams. Meat Science, 23:1-7. Toldra, F., Arisoy, M.C., Cervero, C., Rico, E., 1992. Muscle and adipose tissue aminopeptidase activities in raw and dry-ham. Journal of Food Science, 57:816-818. Virgili, R., Schivazappa, C., Parolari, G., Rivaldi, P., 1994. Enzimi proteolitici nelle cosce destinate alla produzione di prosciutto italiano: la catepsina B. Rivista di suinicoltura; 9:61-65. Virgili, R., Parolari, G., Schivazappa, C., Soresi Bordini, C., Volta, R., 1995. Effetto della materia prima sulla proteolisi e sulla consistenza del prosciutto crudo tipico. Industria Conserve, 1995; 70:21-31.

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

| Effect                        | F statistics | Cathepsin B activity | Biceps femoris | Semitendinosus | Semimembranosus |
|-------------------------------|--------------|----------------------|----------------|----------------|-----------------|
| 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 | ns |
| R²*                           | 47.5         | 27.9                 | 28.8           | 29.9           |

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