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# Rheological characteristics of dry cured ham of four Italian autochthonous genetic types of pig

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**SUMMARY** – The aim of this research was to evaluate rheological characteristics of dry cured ham of some Italian autochthonous genetic types (AGT) of pig. In 108 dry cured hams obtained from Calabrese (CL=29), Casertana (CT=6), Cinta senese (CS=19) and Nero Siciliano (SC=54) AGTs, rheological traits were determined on *Biceps femoris* (BF), *Semimembranosus* (Sm) and *Semitendinosus* (St) muscles using a Texturometer. Curing process was performed in Parma (64 hams) and in Morcone (Benevento) (44 hams) curing plants. Data were analysed using aging time as covariate and AGT, sex, curing plant, muscle and first order interaction as fixed factors. The results showed that AGT Casertana had higher values for hardness in comparison with SC ( $P<0.05$ ) and CL ( $P<0.05$ ). CL showed lower values for hardness and chewiness and higher values for adhesiveness. Dry cured ham obtained from Cinta senese occupied an intermediate position for all characteristics. On the other hand, no significant differences were found when two curing plants, or sex, were compared. The muscle represented a significant source of variability for all rheological characteristics: *semitendinosus* muscle showed the lowest values for hardness ( $P<0.001$ ) and chewiness ( $P<0.05$ ), while Sm muscle had the highest values and BF was characterised by a lower value for adhesiveness and springiness.

**Keywords:** Dry cured ham, rheology, pig, autochthonous genetic type.

**RESUME** – "Caractéristiques rhéologiques des jambons secs produits par quatre types génétiques italiens autochtones de porcins". Cette étude a été réalisée afin d'étudier les caractéristiques rhéologiques des jambons secs produits par les types génétiques autochtones (TGA) Calabrese (CL=29), Casertana (CT=6), Cinta senese (CS=19) et Nero Siciliano (SC=54). Les mesures rhéologiques ont été effectuées sur des échantillons des muscles *biceps femoris* (BF), *semimembranosus* (Sm) et *semitendinosus* (St) à l'aide d'un Texturometer. L'affinage a été effectué dans deux établissements différents, à Parma (64 jambons) et à Morcone (province de Benevento; 44 jambons). Les données ont été analysées avec la durée de maturation comme covariable et le TGA, le sexe, l'établissement, le muscle et leurs interactions comme facteurs fixes. Les résultats obtenus montrent que le Casertana a une valeur de dureté plus élevée ( $P<0,05$ ) que les SC et CL. Parmi les autres TGA, le Calabrese montre les valeurs de dureté et de mastication les plus faibles et la valeur d'adhérence la plus élevée. Le Cinta senese occupe une position intermédiaire pour toutes les caractéristiques. D'autre part, on n'a pas observé de différences significatives entre établissements ou sexes. Le muscle a une influence significative sur la valeur de toutes les caractéristiques rhéologiques: le muscle *semitendinosus* présente les valeurs de dureté ( $P<0,001$ ) et de mastication ( $P<0,05$ ) les plus faibles, tandis que le Sm fournit les valeurs les plus élevées. Dans le cas du muscle BF nous avons relevé la plus faible valeur d'adhérence et d'élasticité.

**Mots-clés :** Jambon sec, caractéristiques rhéologiques, porc, types génétiques autochtones.

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## Introduction

Parma ham, produced according to the official regulations, is made by traditional processes: the pork legs are first chilled and trimmed and then covered with sodium chloride without nitrates and spices. Curing occurs in a carefully controlled atmosphere over a minimum of 12 months for hams heavier than 9 kg. The traditional Italian-style dry cured ham is made in the same way (pork leg and sodium chloride), but curing process occurs for a longer time (about 18-24 months) in rooms with atmosphere not electronically controlled. Raw material is provided by genetically improved breeds for Parma ham and from autochthonous genetic types for "traditional ham". The effects of different factors (breed, sex, live weight, etc.) on ham qualitative characteristics have been previously investigated (Matassino *et al.*, 1987; Chizzolini *et al.*, 1996; Gou *et al.*, 1995; Candek-Potokar *et al.*, 2002).

This study was carried out in order to evaluate the effect of genetic type, sex, curing plant and muscle on qualitative characteristics of dry cured ham. In an earlier paper we examined colour data (Matassino *et al.*, 2003), whereas in the present one rheological characteristics were evaluated.

## Material and methods

The research was carried out on 108 cured hams obtained from four autochthonous genetic types (AGT): Calabrese (CL=29), Casertana (CT=6), Cinta senese (CS=19) and Nero Siciliano (SC=54). Pigs were fed on a commercial diet and reared in multiple boxes at the experimental farm of ConSDABI (Circello, BN). The dissection of carcasses was made after 72 hours of refrigeration at about 4 °C. Hams were then prepared by an expert: right ham was sent to the "Stazione Sperimentale per l'Industria e le Conserve" of Parma (64 hams), whereas left ham was cured in a plant in Benevento province (44 hams), according to the Italian style method. At the end of the curing period (750±94 days) hams were boned and two/three samples of each ham were used for investigation. The rheological traits were determined on *Biceps femoris* (Bf), *Semitendinosus* (St) and *Semimembranosus* (Sm) muscles using Texturometer (Zenken, Tokio). Data were analysed by GLM procedure (SAS, 1997) using curing period as covariate and AGT, sex, plant of curing, muscle and their first order interactions as fixed factors (Matassino *et al.*, 1984). Mean values of factors that interact were estimated according to Zullo *et al.* (2003) and the significance of the differences among the estimated means was tested using Student's *t* test.

## Results and discussion

The analysis of variance showed that genetic type interacts with sex in all parameters, except hardness, and with curing plant in adhesiveness and chewiness. Castrated males, in comparison to entire females, provided dry cured hams characterized by high values of adhesiveness in Nero Siciliano AGT ( $P<0.05$ ) and low value in Casertana ( $P<0.01$ ), whereas Cinta senese hams were characterised by a higher value of chewiness ( $P<0.01$ ) (Table 1).

Table 1. Rheological traits (mean ± std error) of dry cured hams and difference (\*) between sex

Sex type	Hardness (kg)	Cohesiveness (TU) <sup>††</sup>	Springiness (cm)	Adhesiveness (TU) <sup>†</sup>	Chewiness (TU) <sup>†</sup>
Castrated males					
CL	1.261 ± 0.05	0.519 ± 0.01	13.43 ± 0.10	15.92 ± 1.02	857.51 ± 43.65
CT	1.723 ± 0.25	0.509 ± 0.04	13.58 ± 0.51	5.36 ± 4.97 <sup>B</sup>	1226.30 ± 213.18
CS	1.487 ± 0.05	0.555 ± 0.01	13.65 ± 0.11	15.31 ± 1.10	1138.13 ± 47.26 <sup>A</sup>
SC	1.368 ± 0.04	0.536 ± 0.01	13.55 ± 0.08	17.70 ± 0.82 <sup>a</sup>	996.69 ± 35.17
Entire females					
CL	1.320 ± 0.06	0.535 ± 0.01	13.73 ± 0.12	17.26 ± 1.61	976.54 ± 49.77
CT	1.625 ± 0.11	0.546 ± 0.02	12.94 ± 0.24	17.43 ± 2.30 <sup>A</sup>	1174.07 ± 98.56
CS	1.245 ± 0.08	0.507 ± 0.01	13.13 ± 0.17	15.14 ± 1.67	855.55 ± 71.31 <sup>B</sup>
SC	1.344 ± 0.04	0.518 ± 0.01	13.73 ± 0.08	15.22 ± 0.81 <sup>b</sup>	974.69 ± 34.66

<sup>†</sup> Means in the same column with different superscripts are significantly different (a, b:  $P<0.05$ ; A, B:  $P<0.01$ ).

<sup>††</sup> TU= Texturometer Units.

Among the considered genetic types, Casertana showed significant higher values of hardness respect to SC (23%,  $P<0.05$ ) and CL (30%,  $P<0.05$ ) (Table 2). The lowest values of hardness and chewiness and the highest value of adhesiveness were observed in Calabrese. Dry cured hams produced from the Cinta senese occupied intermediate position for almost all rheological traits. Although during the sensory evaluation the global score obtained by ham of crosses CS x Large White (LW) was higher than Large White (Bozzi *et al.*, 1996) the authors suggest the utilization of Cinta senese only for limited crosses due to poor technological yield. Also Pugliese *et al.* (1996) observed positive characteristics in meat of CS x LW, as pH 45 and water holding capacity, respect to LW.

Table 2. Mean value ( $\pm$ std error) and comparison (\*) between levels of principal factors

Factor	Hardness (kg)	Cohesiveness (TU) <sup>††</sup>	Springiness (cm)	Adhesiveness (TU) <sup>†</sup>	Chewiness (TU) <sup>†</sup>
Genetic Type					
Calabrese	1.291 $\pm$ 0.04 <sup>b</sup>	0.527 $\pm$ 0.01	13.54 $\pm$ 0.08	16.59 $\pm$ 0.77	917.02 $\pm$ 33.07
Casertana	1.674 $\pm$ 1.53 <sup>a</sup>	0.528 $\pm$ 0.02	13.26 $\pm$ 0.32	11.40 $\pm$ 3.09	1200.19 $\pm$ 99.41
Cinta senese	1.366 $\pm$ 0.05 <sup>ab</sup>	0.528 $\pm$ 0.01	13.39 $\pm$ 0.10	15.23 $\pm$ 0.99	996.84 $\pm$ 42.54
Nero Siciliano	1.356 $\pm$ 1.41 <sup>b</sup>	0.527 $\pm$ 0.01	13.64 $\pm$ 0.06	16.46 $\pm$ 0.58	985.46 $\pm$ 25.02
Curing plant					
Parma	1.415 $\pm$ 0.06	0.525 $\pm$ 0.01	13.50 $\pm$ 0.13	15.85 $\pm$ 1.24	1024.48 $\pm$ 53.30
Benevento	1.428 $\pm$ 0.04	0.530 $\pm$ 0.01	13.42 $\pm$ 0.09	13.99 $\pm$ 0.86	1025.28 $\pm$ 36.77
Sex					
Males	1.460 $\pm$ 0.06	0.528 $\pm$ 0.01	13.53 $\pm$ 0.13	13.57 $\pm$ 1.29 <sup>b</sup>	1054.54 $\pm$ 55.22
Females	1.383 $\pm$ 0.04	0.527 $\pm$ 0.01	13.38 $\pm$ 0.08	16.26 $\pm$ 0.79 <sup>a</sup>	995.21 $\pm$ 34.03
Muscle					
Bf	1.488 $\pm$ 0.05 <sup>A</sup>	0.520 $\pm$ 0.01	13.17 $\pm$ 0.11 <sup>B</sup>	9.21 $\pm$ 1.11 <sup>C</sup>	1037.79 $\pm$ 47.51 <sup>a</sup>
Sm	1.527 $\pm$ 0.06 <sup>A</sup>	0.522 $\pm$ 0.01	13.64 $\pm$ 0.12 <sup>A</sup>	19.15 $\pm$ 1.12 <sup>A</sup>	1107.49 $\pm$ 48.13 <sup>A</sup>
St	1.250 $\pm$ 0.05 <sup>B</sup>	0.540 $\pm$ 0.01	13.56 $\pm$ 0.11 <sup>A</sup>	13.39 $\pm$ 1.11 <sup>B</sup>	929.36 $\pm$ 47.63 <sup>Bb</sup>

<sup>†</sup> Means in the same column with different superscripts are significantly different (a,b: P<0.05; A,B,C: P<0.01).

<sup>††</sup> TU= Texturometer Units.

Other studies carried out on Casertana (Colatruglio *et al.*, 1994; Zullo *et al.*, 2003) and on Calabrese, Casertana and Siciliano (Cappuccio *et al.*, 2000; Palazzo *et al.*, 2000) in order to verify their use as a cross-breeding genetic type for production of pork for fresh consumption and/or processing, provided a good suggestion of these genetic types for pork and salami production.

The curing plant and sex factors have not produced significant differences even if hams obtained from Cinta senese and Nero Siciliano cured in Parma plant reached higher values of adhesiveness and chewiness (P<0.05) than hams cured in Benevento plant. On the other hand, Zullo *et al.* (2000) observed in Salami Napoli different responses of AGT to ripening conditions, obtaining a better sensory score in salami cured in Benevento area than in salami cured at the Experimental Station of Angri. It is important to outline that in products obtained in Angri the mean rate of fungal colonization was extraordinarily high (5-fold greater) (Marziano *et al.*, 2000).

Muscle was a significant source of variation for all rheological characteristics. *Semitendinosus* showed low value of hardness (P<0.001) and chewiness (P<0.05), while Sm had both higher values (Table 2). BF muscle was characterized by low adhesiveness and springiness.

## Conclusions

The undertaken study indicates that Calabrese pig provides a dry cured ham with the best rheological traits, among the considered genetic types. However taking also into account colour characteristics: L\*, a\* and hue (Matassino *et al.*, 2003), the value of the "empirical index", obtained assigning to each characteristic a score of 100 when its value was considered to be the best (for example the highest value of a\*, the lowest of hardness, etc.), was 93 for Calabrese, 91 for Cinta senese and 88 for Siciliano and Casertana.

The curing plant did not produce significant differences in texture of ham, even if hams of Cinta senese and Nero Siciliano cured in Benevento showed a lower value of chewiness, in comparison to hams cured in Parma, and this indicates a better response of AGT to curing conditions for making the "italian style" dry cured ham.

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