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Quality and sensory characteristics of Culatello dry-cured products obtained from the Italian autochthonous pig Suino Nero Lucano and from a modern crossbred pig

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Abstract. The effect of the Suino Nero Lucano (SNL) pig genotype and crossbred genotype (CG) on chemical composition, fatty acid profile, oxidative stability, and sensory characteristics of 30 Culatello samples (15 from SNL and 15 from CG pigs) was investigated. SNL pigs showed a slower growth and therefore were older and lighter at slaughter. Samples from SNL pigs showed significantly ($P < 0.001$) higher amounts of haem iron, intramuscular fat, and monounsaturated fatty acids than those from CG. The oxidative stability, evaluated by measuring the acid, peroxide and TBARS values, was significantly larger in SNL than in CG Culatello. Moreover, Culatello from SNL pigs showed the highest level of consumer preference in term of overall acceptability ($P < 0.05$), odour ($P < 0.001$), taste ($P < 0.01$), appearance ($P < 0.05$), and consistency ($P < 0.01$). The present study confirms that the SNL pig represents a useful resource both for the obtainment of products with high nutritional and sensory value and for promoting the economic development of areas where they are raised.

Additional keywords: chemical composition, cured meat, genetic type, oxidative stability.

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Introduction

Culatello is an Italian dry-cured product prepared with meat from heavy pigs, using the caudal–proximal part of the hind limb (*Semimembranosus*, *Semitendinosus* and *Biceps femoris* muscles), previously boned, skinned and defatted, and then subjected to a process of salting, stuffing, drying, and lastly ripening for a period of ~12 months. Culatello is today one of the most valuable products of Italian gastronomy and it is highly appreciated at an international level. In recent years consumer attention has been increasingly oriented towards the rediscovery of some typical traditional products obtained from an ancient autochthonous genetic type (AAGT). The Suino Nero Lucano (SNL) is an autochthonous pig breed of southern Italy (Basilicata region), included in the National Pedigree Register (http://www.anas.it/html/homew.htm, verified 15 August 2014). It is medium-sized with a bright black coat, is characterised by high rusticity, and is bred in the wild or semi-wild conditions. This breed is much appreciated for the high quality of its products linked to the local gastronomic tradition, and it represents an example of the connection among local breed, territory and typical product, both fresh and seasoned. Despite all this, SNL pig products characteristics, which have important social and economic impacts, such as dry-cured products, have not been analysed. Since the SNL pig has not undergone selection programs, like all Mediterranean pig AAGT, it is characterised by a high amount of intramuscular fat (IMF), great concentrations of haem pigments and iron, high levels of monounsaturated fatty acids (MUFA), mainly oleic acid, and low levels of polyunsaturated fatty acids (PUFA), compared with industrial genotypes (Franci *et al*. 2005; Franci and Pugliese 2007; Madonia *et al*. 2007). These characteristics are considered some of the most relevant quality aspects in the final product (Ventanas *et al*. 2005; Gandemer 2009; Fuentes *et al*. 2014). In fact, the organoleptic characteristics such as flavour, aroma, tenderness, juiciness, and the dietary characteristics of the final product are affected by IMF content and fatty acid composition of meat (Mourot and Hermier 2001; Jiménez-Colmenero *et al*. 2010). Furthermore, these last are important because of their effects on human health. For this reason, recommendations for optimal intake of total and unsaturated fatty acids (UFA) have been proposed by several scientific authorities and nutritional organisations, including the World Health Organization (2003); which recommends limiting total fat intake to not more than 30% of daily energy intake, with saturated fats no more than 10%. Many authors (Gray *et al*. 1996; Coutron-Gambotti and Gandemer 1999; Yang *et al*. 2005) reported that the lipolytic process, which leads to the release of fatty acids during product ripening, promotes lipid oxidation. Lipid oxidation of UFA is among the main causes of flavour, colour and texture deterioration (Jiménez-Colmenero *et al*. 2010). The hydroperoxides, also, have received considerable attention

due to their undesirable biological properties such as atherogenic, cytotoxic, mutagenic and carcinogenic effects (Ventanas *et al*. 2005). These are intermediate reaction products, which will react further to form the odorous aldehydes and ketones indicative of oxidative rancidity.

The aim of this study was to evaluate the quality and sensory characteristics of Suino Nero Lucano (SNL) and crossbred (CG) dry-cured Culatello, in order to define whether SNL pigs can be inserted into breeding plans aimed at obtaining products with high nutritional and sensory quality. This study was conducted on dry-cured Culatello both for high consumer interest and for low manipulation that the product undergoes during technical operations of preparation at ripening.

Table 1. Proximate composition of concentrate (corn, barley and field beans, present in equal parts), grass and acorn
DM, dry matter

	Concentrate	Grass	Acorn
DM (% fresh matter)	87.2	24.37	61.05
Crude protein (% DM)	11.6	12.32	5.71
Ether extract (% DM)	2.3	2.54	6.64
Crude fibre (% DM)	3.4	23.29	3.70
Ash (% DM)	2.3	9.35	2.71
Nitrogen-free extractives (% DM)	80.4	52.49	84.24

Table 2. Growth performance and carcass traits of Suino Nero Lucano (SNL) and a modern crossbred genotype (CG)
P-value is significant at $P < 0.05$. s.e.m., standard error of mean

	Breed		s.e.m.	*P*-value
	SNL	CG		
No. of pigs	15	15	–	–
Initial age (day)	300	240	5.93	<0.001
Initial liveweight (kg)	57.2	65.3	1.72	0.016
Age at slaughter (day)	540	480	5.93	<0.001
Average daily gain (g/day)	350.8	393.3	11.75	0.070
Slaughter weight (kg)	141.4	159.7	4.26	0.029
Carcass weight[A] (kg)	107.4	126.3	3.29	0.002
Backfat thickness[B] (cm)	4.7	2.5	0.24	<0.001

[A]Including head and tail.
[B]Backfat depth over the *Longissimus* muscle.

Materials and methods

Samples

This study was carried out on 30 castrated male pigs obtained from two different pig breeds, 15 from purebred SNL pigs and 15 from commercial pig CG. The crossbreeding genotype was Landrace as sire line and Large White × Landrace as dam line. The rearing system of the two breeds was the same. SNL and CG pigs were kept on the same farm, on a surface of ~1 ha, with uniform characteristics, which was divided into two areas of equal size, each assigned to a group. The pigs were reared under a semi-extensive system. To the animals, in addition to pasture (acorns and natural grasses), a grains mixture in the form of crushed (corn, barley and field beans, present in equal parts) was administered. The amount of concentrate fed to animals was calculated according to their daily requirements of maintenance, growth plus an extra allowance for ambulation and it was equal to 70% of the estimated daily needs. The floristic composition of the pasture was determined according to the Perna *et al*. (1997) method and its results composed by *Daucus carota*, *Plantago lanceolata*, *Bromus hordeaceus*, *Dactylis glomerata*, *Phleum pretense*, and *Lolium perenne*. Proximate composition of acorns, grass and concentrate (Table 1) was carried out according to Association of Official Analytical Chemists (AOAC 2000) procedures. When the pigs attained the age at slaughter (540 days for SNL pigs and 480 days for CG pigs) and the slaughter weight (141.4 kg for SNL pigs and 159.7 kg for CG pigs), they were transported to a commercial slaughterhouse where they were kept for a minimum of 12 h before slaughter. On the day after slaughter, thighs were removed from the carcasses and sent to the trimming room. Each thigh was boned, skinned, defatted, and the portion comprising only the *Biceps femoris*, *Semitendinosus* and *Semimembranosus* muscles was retained, while other muscles were not included. The muscular mass was trimmed in standard 'pear' shape required for Culatello product (Bonazzi 2007) and it was processed according to a traditional method (Table 3). The technological parameters of SNL and CG Culatello samples during the curing process are given in Table 4. After processing, the products were cut into two pieces with each piece containing the same proportion of each of the three muscles. One piece was used for chemical analysis and the other for sensory analysis. The samples for chemical analysis were vacuum packaged and stored at −80°C until analysed, while the samples for sensory analysis were stored at 4°C until evaluation, which took place within 72 h. All analyses

Table 3. Stages in the processing of Culatello, together with the relative humidity, temperature and duration of each one

Stage	Description
Salting	The thigh was boned, skinned, defatted, and the posterior muscles and inner thigh of the pig (internal and posterior crural muscles) were taken. The muscular mass formed only by *Biceps femoris*, *Semitendinosus*, and *Semimembranosus* muscles, was soaked with white wine (alcoholic degree 13% vol) and, then, it was thoroughly rubbed (~5 min per day) with the mixture of salting (~300 g/kg product per day) for 6 days and was kept at 4°C and 90% relative humidity (RH). The mixture of salting consisting of sodium chloride (82%), peppercorns (11%) and pressed garlic (7%)
Stuffing and tying	The muscular mass was brushed free to remove the mixture of salting left on the surface. Then it was stuffed into natural casing (10–15 cm in diameter) and tied with several laps of twine
Dripping and drying	The dripping was carried out for about a week at 18−20°C, while the drying lasted ~60 days at 14°C and 75% RH
Ripening	This phase occurred at a temperature of 12°C and 80% RH and lasted ~12 months. The approximate weight of Culatello product was 2 kg (~12 cm in diameter and 30 cm in height)

Table 4. Weight losses of Culatello samples from Suino Nero Lucano (SNL) and a modern crossbred genotype (CG) during curing
P-value is significant at $P < 0.05$. s.e.m., standard error of mean

	Breed		s.e.m.	*P*-value
	SNL	CG		
	Culatello weight (kg)			
Trimmed	2.65	3.98	0.14	<0.001
Ripened	1.51	2.24	0.07	<0.001
	Processing loss by period[A] *(%)*			
In salting	12.60	11.80	0.17	0.015
In dripping	10.70	9.90	0.13	0.001
In drying	12.00	15.00	0.31	<0.001
In ripening	7.64	6.89	0.09	<0.001
Total weight loss (%)	42.63	43.41	0.11	0.096

[A]Each loss is given as relative difference between initial and final weight of the period.

were performed on homogeneous and representative slices of Culatello sample that included all three muscles making up the product.

Chemical composition

Dry matter, protein, non-protein nitrogen, IMF, and sodium chloride contents of Culatello samples were determined according to AOAC (2000) methods. Haem iron content was assayed according to the method described by Hornsey (1956). All samples were analysed in duplicate.

Instrumental colour measurement

Instrumental colour (CIE L^*, a^*, b^*) was measured using a MINOLTA Chromameter CR-300 (Minolta Camera Corp., Meter Division, Ramsey, NJ, USA). The following colour coordinates were determined: lightness (L^*), redness (a^*, ± red-green) and yellowness (b^*, ± yellow-blue). Before each measurement the equipment was standardised against a white tile. The measurements were performed on slices of Culatello samples that included all three muscles making up the product. The analysis was performed in quadruplicate.

Fatty acid profile

Intramuscular lipids of the representative Culatello sample that included all three muscles making up the product, were extracted using chloroform/methanol (1 : 2), according to the Folch *et al.* (1957) method, and fatty acid methyl esters (FAME) were prepared according to the ISO (1978) method. Analysis was performed using a Varian 3400 gas chromatograph (Varian, Turin, Italy), equipped with a split-splitless injector, a TR-FAME capillary column (120 m × 0.25 mm i.d. × 0.25-μm film thickness; Thermo Fisher Scientific, Milan, Italy), a flame ionisation detector and a Galaxie Chromatography Software (Varian, Inc., Walnut Creek, CA, USA) for chromatogram acquisition and data reporting. Helium was used as carrier gas, and the injector and detector temperatures were 250°C and 260°C, respectively. The oven temperature program was 140°C for 5 min then increasing at 4°C/min up to 240°C where it was maintained for 15 min. Individual fatty acid methyl esters were identified by comparing their retention times with those of the corresponding pure standards (Sigma-Aldrich, Milan, Italy). Quantitative analysis was obtained by peak area integration using the Galaxie Chromatography Data System Version 1.9.3.2 software (Varian, Inc.) and results were expressed as percentage of the total fatty acids analysed. To evaluate the nutritional implications, both several fatty acid ratios such as UFA/SFA and PUFA n-6/PUFA ratios, and atherogenic (AI) and thrombogenic (TI) indices, were calculated. AI and TI were calculated according to the formulae suggested by Ulbricht and Southgate (1991):

$$AI = [(4 \times C14:0) + C16:0]/[\Sigma MUFA + \Sigma PUFA\text{-}n6 + \Sigma PUFA\text{-}n3];$$

$$TI = (C14:0 + C16:0 + C18:0)/(0.5\ MUFA + 0.5\ PUFA\text{-}n6 + 3\ PUFA\text{-}n3 + PUFA\text{-}n3/PUFA\text{-}n6).$$

Lipolytic-oxidative measures

Acid value was measured on the extracted fat using the method recommended by AOAC (1984) and expressed as % oleic acid. Peroxide value was determined on cold extracted fat according to the AOAC (1995) method and expressed as meq O_2/kg fat. TBA reactive substances (TBARS) were determined using the method described by Ventanas *et al.* (2007). The standard curve was prepared using a 1,1,3,3-tetraethoxypropane solution (0.2268 g) in 3.86% perchloric acid. TBARS are expressed as mg of malondialdehyde/kg muscle.

Sensory analyses

An affective method of preference was used to evaluate consumer acceptability. The test consisted of 210 untrained consumers who had been selected based on their regular consumption of dry-cured products as well as their sex and age, attempting to represent the distribution of the population as closely as possible. In particular, we selected 113 females and 97 males between the ages of 21 and 60. The test was conducted on 3 days with one session per day. Each consumer participated in one session and tasted six samples, three SNL Culatello and three CG Culatello samples. The two Culatello types were cut into slices of ~80 cm^2, with equal thickness (0.5 mm, ~10 g), in order to have a representative sample of the three muscles making up the product, and served to the consumers in random order, at room temperature in Petri dishes coded with 3-digit numbers. The design was balanced for order and carry-over effects. Consumers were asked to evaluate the samples, visually (appearance, and colour) and then organoleptically (odour, taste, saltiness, and consistency), finally expressing a judgment on overall acceptability. The judgments were expressed individually, assigning a numerical value, on a hedonic scale, between 1 (dislike extremely) and 9 (like extremely) (Peryam and Pilgrim 1957). The consumers were isolated in individual booths to reduce collaboration, and oligomineral water and unsalted crackers were provided to between successive ham samples. All assessments were carried out in a sensory laboratory equipped according to UNI-ISO 8589 recommendations (International Organization for Standardization 1988).

Statistical analyses

Data were analysed according to the following linear model (SAS Institute 1996):

$$y_{ik} = \mu + \alpha_i + \varepsilon_{ik}$$

where y_{ijk} is the observation; μ is the overall mean; α_i is the fixed effect of the ith genetic type (W) ($i = 1, 2$); and ε_{ik} is the random error. Before setting the values, expressed in percentage terms, they were subjected to arcsine transformation. Differences between means at the 95% ($P < 0.05$) confidence level were considered statistically significant.

Results and discussion

Growth performance and carcass traits

Growth performance and carcass traits of SNL and CG pigs are reported in Table 2. SNL pigs, at the same age, showed a lower weight than CG pigs, this is due to both lower birthweight and lower average daily gain. Growth performance of the SNL pigs are in line with the findings found in other Italian (Acciaioli *et al*. 2002; Filetti *et al*. 2003; Franci *et al*. 2003) and European (Serra *et al*. 1998; Alfonso *et al*. 2005) autochthonous pigs. The lower rate of growth of SNL pigs is due to both lower nutritional level ordinarily assumed in outdoor farming conditions, and to different composition of the increase in liveweight, more fat in SNL pigs compared with CG pigs. The latter characteristic is also reflected in a higher backfat thickness in SNL pigs than CG ones ($P < 0.001$) despite a lower carcass weight.

Chemical composition and colourimetric parameter

Regarding the quality of dry-cured products from SNL pigs, to our knowledge, no information is reported in the literature. Therefore, considerations are only possible thanks to the knowledge available on the quality of dry-cured hams obtained from other pig AAGT. The qualitative characteristics (chemical composition and colourimetric parameters) of SNL and CG Culatello samples are reported in Table 5. DM and IMF contents were significantly higher in SNL samples than in CG ones ($P < 0.001$), while protein content was higher in CG samples ($P < 0.001$). These findings are in agreement with those reported by Franci *et al*. (2007) in Cinta Senese dry-cured hams, at ~14 months of ripening, compared with Large White ones. The higher IMF content detected in SNL Culatello is due to the high adipogenic potential, which is typical characteristic of autochthonous pig breeds (Franci *et al*. 2001; Gandini *et al*. 2001; Pugliese and Sirtori 2012). These results emphasise the influence of the breed on the proximate composition of dry-cured hams, as amply reported by other authors (Pugliese 2009; Jiménez-Colmenero *et al*. 2010; Fuentes *et al*. 2014). IMF content also affects the sensory traits (Fuentes *et al*. 2014), as well as the juiciness of dry-cured ham, because of the strong dehydration of the product during the ripening process (Gandemer 2002; Ventanas *et al*. 2005), and, consequently, the acceptability of the final product. No statistically significant differences ($P > 0.05$) were found between SNL and CG Culatello samples for non-protein nitrogen and NaCl content. Haem iron concentrations were higher in SNL Culatello samples than in CG ones ($P < 0.001$). Many authors (Carrapiso and García 2005; Fuentes *et al*. 2014) found higher concentrations of haem iron in dry-cured hams, at ~24 months of ripening, from Iberian pigs compared with those from reciprocal crossbred Iberian × Duroc pigs. This is mainly due to the higher concentration of oxidative fibres in muscles of autochthonous pigs compared with the same muscles of industrial genotypes (Weiler *et al*. 1995; Andrés *et al*. 2000). Moreover, the higher content in haem iron detected in SNL Culatello may also have been due to the greater age of these pigs, in agreement with the report of Mayoral *et al*. (1999) in Iberian pigs. Haem iron content affects the colour traits of meat, in particular is responsible for the characteristic red colour (Mancini and Hunt 2005). As far as the colourimetric characteristics, in this study, SNL Culatello showed values of a^* (redness) and b^* (yellowness) parameters lower than CG Culatello ones ($P < 0.001$), while no significant difference for L^* (lightness) parameter was found, even if CG Culatello was slightly brighter than SNL (Table 3). Previous studies in Iberian dry-cured products have reported higher a^* values than in products from crossbred pigs (Carrapiso and García 2005; Fuentes *et al*. 2014), due to the close relationship found between haem iron content and CIELAB data in the pig muscles (Serra *et al*. 1998; Lindahl *et al*. 2001). Our results disagree with those reported by the abovementioned authors, but they agree with those reported by Franci *et al*. (2007) who found, in Cinta Senese dry-cured hams, values of L^*, a^* and b^* lower than in Large White ones. This could be explained by several factors as the influence of breed, the pigment content, and the percentage of metmyoglobin, oxymyoglobin and myoglobin, which are the most important factors for the variation in the a^* value (Lindahl *et al*. 2001; Brewer *et al*. 2004). Lindahl *et al*. (2001) reported that the pig muscles with high metmyoglobin fraction are redder, while those with high myoglobin fraction resulted in less redness. However, other authors (Feldhusen 1994; Tam *et al*. 1998) reported a low correlation ($r = 0.11$–0.58) between redness and pigment content indicating that other factors affected the perceived redness of pig muscle. Lorenzo and Purriños (2013) in Celta dry-cured ham found that a^* values were positively related to the moisture ($r = 0.85$; $P < 0.01$) and negatively to salt content ($r = 0.95$; $P < 0.01$). The a^* value could be affected also by number

Table 5. Chemical composition and colourimetric parameters of Culatello samples from Suino Nero Lucano (SNL) and a modern crossbred genotype (CG)

P-value is significant at $P < 0.05$. Using the CIELAB colour system, the colour coordinates are represented by L^*, a^*, and b^*. DM, dry matter; IMF, intramuscular fat; NPN, non-protein nitrogen; s.e.m., standard error of mean

	Breed		s.e.m.	*P*-value
	SNL	CG		
No. of pigs	15	15	–	–
DM	56.61	52.21	0.83	0.001
IMF (% DM)	17.16	12.32	0.95	<0.001
Protein (% DM)	74.74	79.54	0.99	0.001
NPN (% DM)	13.35	13.19	0.60	0.402
NaCl (% DM)	5.83	5.54	0.19	0.541
Haem iron (ppm)	20.18	8.65	3.60	<0.001
L^*	36.98	40.15	2.09	0.374
a^*	17.06	20.96	1.44	0.001
b^*	14.46	18.57	0.72	0.001

and quantities of Maillard-derived compounds, which are formed by the reaction between amino acids and reducing sugars (Toldrá *et al*. 2000; Lorenzo and Purriños 2013). Depending on the type of reducing sugar or amino acid, chromophores are generated that influence positively or negatively the colourimetric characteristics of dry-cured product (Perez-Locas and Yaylayan 2010).

Fatty acid profile

The fatty acid profiles of the IMF from SNL and CG Culatello samples are reported in Table 6. C16:0, C18:0, C18:1, and C18:2 were the most abundant fatty acids in both SNL and CG Culatello, in agreement with what has been reported by other authors in dry-cured product (Fernández *et al*. 2007; Salazar *et al*. 2013; Fuentes *et al*. 2014). The breed significantly affected the fatty acid profile of Culatello ($P < 0.05$). Samples from SNL pigs showed significantly higher percentages of both saturated fatty acid (SFA) and MUFA than samples from CG pigs ($P < 0.001$), while n-3 and n-6 fatty acid percentages were higher in CG than in SNL samples ($P < 0.001$). These results are in agreement with that reported by other authors (Franci *et al*. 2005; Madonia *et al*. 2007; Jiménez-Colmenero *et al*. 2010; Salazar *et al*. 2013) in dry-cured products obtained from autochthonous and commercial genotype pigs. In SNL Culatello, higher total SFA content is due to higher proportion of C16:0, C18:0, and C22:0 acids; higher total MUFA content is due to higher contents of both C16:1 and C18:1 acids; while lower amounts of n-3 and n-6 fatty acids are due to lower percentages of both C18:2 n-6 (cis) and C18:3 n-3 acids. In this study, the long-chain n-3 fatty acids (as EPA, DPA, and DHA) were not detected. However, many authors (Hoz *et al*. 2007; Ventanas *et al*. 2007; Musella *et al*. 2009) detected long-chain n-3 fatty acids in dry-cured products obtained from pigs fed PUFA-enriched diets. The highest level of MUFA in autochthonus pigs could be the consequence of differences in *de novo* lipid synthesis and turnover (Pugliese and Sirtori 2012). Fuentes *et al*. (2014) hypothesised that the differences in the oleic acid levels, in Iberian and Duroc dry-cured hams, could be explained by the different activities of the Δ9-desaturase enzyme. To evaluate the nutritional quality of the IMF of SNL and CG Culatello samples n6/n3 ratio and AI and TI were calculated (Table 6). The value of n6/n3 ratio should not exceed 4.0 (Department of Health 1994) to avoid the prothrombotic and proagregatory state induced by a high level of n-6 PUFA (Simopoulos 1999). Overall, our samples showed an n-6/n-3 ratio well above the recommended value (18.51 and 19.73 for SNL and CG Culatello, respectively), because of the high content of C18:2 n-6. C18:2 n-6 (cis) is the precursor of C20:4 n-6, which is considered advantageous for cardiovascular health of the consumer only when present in low amounts, being antagonist of the health benefits resulting from n-3 fatty acids (Parra *et al*. 2007). The average value of the n-6/n-3 ratio detected in SNL Culatello was similar to that found by other authors (Ventanas *et al*. 2007; Pugliese 2009) in dry-cured hams, at 24 months of ripening, obtained from autochthonous pigs. AI and TI indicate the different effects that the single fatty acid might have on human health, in particular, AI assesses the risk of atherosclerosis, while TI evaluate the potential aggregation of blood platelets (Ulbricht and Southgate 1991). In this study, the breed significantly affected the AI and TI values (Table 6). SNL Culatello showed higher AI ($P < 0.01$) and TI ($P < 0.001$) values than CG Culatello, because of higher contents of both C14:0 and C16:0 acids, as well as of lower PUFA content.

Table 6. Fatty acid profile, fatty acid ratios and nutritional indices of intramuscular fat of Culatello samples from Suino Nero Lucano (SNL) and a modern crossbred genotype (CG)

Atherogenic index (AI) = [(4 × C14:0) + C16:0]/[ΣMUFA + ΣPUFA-n6 + ΣPUFA-n3]; thrombogenic index (TI) = (C14:0 + C16:0 + C18:0)/(0.5 MUFA + 0.5 PUFA-n6 + 3 PUFA-n3 + PUFA-n3/PUFA-n6); results are expressed as percent of total fatty acids. *P*-value is significant at $P < 0.05$. MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; s.e.m., standard error of mean; SFA, saturated fatty acids

	Breed		s.e.m.	*P*-value
	SNL	CG		
No. of pigs	15	15	–	–
C14:0	1.75	1.87	0.03	0.089
C16:0	28.41	26.19	0.43	<0.001
C16:1	3.70	3.09	0.14	0.010
C17:0	0.34	0.36	0.01	0.493
C17:1	0.27	0.30	0.01	0.216
C18:0	14.94	12.46	0.59	0.028
C18:1 n-9 (trans) + C18:1 n-11 (trans)	0.73	0.25	0.09	<0.001
C18:1 n-9 (cis)	36.67	33.08	0.74	0.002
C18:1 n-11 (cis)	4.28	3.34	0.18	<0.001
C18:2 n-6 (cis)	6.46	15.74	1.78	<0.001
C18:3 n-3	0.37	0.84	0.09	<0.001
C20:0	0.19	0.16	0.01	0.125
C20:1 n-9	1.01	0.93	0.06	0.234
C20:3 n-6	0.31	0.69	0.07	<0.001
C20:4 n-6	0.08	0.14	0.01	0.001
C22:0	0.58	0.46	0.02	0.002
SFA	46.09	41.62	0.46	<0.001
UFA	53.91	58.38	0.45	0.001
MUFA	46.66	40.98	0.51	<0.001
PUFA	7.24	17.40	0.39	<0.001
UFA/SFA	1.17	1.40	0.02	0.001
n-6	6.85	16.57	0.37	<0.001
n-3	0.37	0.84	0.02	<0.001
n-6/n-3	18.51	19.73	0.21	0.254
AI	0.66	0.58	0.01	0.002
TI	1.62	1.30	0.03	0.001

Lipolytic-oxidative parameters

In the present study, lipid hydrolysis and primary and secondary lipid oxidation were evaluated by measuring the acid, peroxide and TBARS values, respectively (Table 7). Statistical analysis showed a significant effect ($P < 0.001$) of the breed on lipolytic-oxidative measures. Acid value was higher in CG than in SNL Culatello (15.67% and 11.19% oleic acid, respectively). This could be due to different lipase enzyme activity, which remain active throughout the curing process (Motilva *et al*. 1993). Rosell and Toldrá (1998) reported lower lipolytic activities in *Biceps femoris* muscle of the Iberian pig breed than in that of white pig crossbreed. Peroxide value was significantly ($P < 0.001$) higher in CG than in SNL Culatello (42.40 and 25.65 meq O_2/kg fat, respectively). The higher peroxide value in CG Culatello is due to

Table 7. Lipolytic and oxidative parameters of Culatello samples from Suino Nero Lucano (SNL) and a modern crossbred genotype (CG)
P-value is significant at $P < 0.05$. s.e.m., standard error of mean

	Breed		s.e.m.	*P*-value
	SNL	CG		
No. of pigs	15	15	–	–
Acid value[A]	11.19	15.67	0.85	0.001
Peroxide value[B]	25.65	42.40	3.35	<0.001
TBARS[C]	0.32	0.62	0.01	0.007

[A]% oleic acid.
[B]meq O_2/kg fat.
[C]mg MDA/kg muscle.

Table 8. Effect of genetic type on the sensory acceptability of Culatello samples from Suino Nero Lucano (SNL) and a modern crossbred genotype (CG) by 210 untrained consumers
Each attribute was evaluated on a hedonic scale from 1 (dislike extremely) to 9 (like extremely). *P*-value is significant at $P < 0.05$. s.e.m., standard error of mean

Descriptor	Breed		s.e.m.	*P*-value
	SNL	CG		
No. of pigs	15	15		
Overall acceptability	6.68	6.12	0.15	0.043
Colour	5.01	6.35	0.14	0.001
Odour	5.57	4.72	0.17	0.001
Saltiness	6.37	6.31	0.13	0.183
Taste	6.61	5.87	0.15	0.008
Appearance	6.32	5.96	0.15	0.032
Consistency	6.12	5.56	0.16	0.006

higher PUFA content, which is known to be more susceptible to oxidation during dry-cured processing than MUFA or SFA (Gandemer 2002; Hoz *et al*. 2007; Musella *et al*. 2009). The extent of oxidative rancidity in Culatello samples was determined by TBARS test. As for peroxide value, TBARS value was significantly ($P < 0.01$) higher in CG Culatello (Table 7). The higher oxidative stability of the SNL Culatello could be explained by both lower levels of PUFA and higher antioxidant enzymes activity. In fact, many authors (Renerre *et al*. 1996; Lee *et al*. 1997) reported that muscles with higher oxidative fibres showed higher antioxidant enzymes activity, which could potentially delay the onset of oxidative rancidity in stored meat (Mei *et al*. 1994; Pradhan *et al*. 2000). Moreover, Hernández *et al*. (2004) in Iberian pigs found a more intense activity of catalase and superoxide dismutase than in industrial genotypes. From the present results, Culatello from SNL pigs showed a larger oxidative stability, and this may have an impact on the consumer preference.

Sensory analyses

To investigate the degree of acceptance of the two different Culatello types, a preference test was carried out: overall acceptability, colour, odour, saltiness, taste, appearance, and consistency descriptors were assessed and the results (mean scores and standard error values) are shown in Table 8. Significantly higher scores for the acceptability of odour, taste, appearance and overall acceptability were shown for the SNL samples but the acceptability of saltiness was similar for both groups. Colour was more acceptable for samples from the CG group, probably because meat products obtained from autochthonous pigs showed a darker muscle colour (Franci *et al*. 2007), in agreement with our instrumental results for redness. Consequently, this valuation can be explained by habit of consumers to use meat products of bright red colour, typical characteristic of products obtained from commercial genotype pigs. Fat content of dry-cured hams affects the consumer preference, since the higher the fat content, the greater the acceptability of cured hams (Jiménez-Colmenero *et al*. 2010), but what most affects the acceptability of dry-cured product are the IMF content, fatty acid composition and oxidative stability (Ruiz-Carrascal *et al*. 2000; Gandemer 2009). Gandemer (2002) reported that dry-cured hams with high IMF content have a more intense fat aroma because intramuscular triacylglycerols are good solvents of most aromatic compounds, which will be trapped in the dry-cured ham (Salazar *et al*. 2013). Other authors (Hoz *et al*. 2007; Santos *et al*. 2008; Musella *et al*. 2009) reported that meat products with low oxidative stability and higher PUFA content, in particular n-3 PUFA content, showed the least acceptance for odour, taste, and overall acceptability. High concentration of oleic acid in the IMF of dry-cured hams, a typical characteristic of autochthonous pig breeds, is linked to a high fluidity of the fat in the surface of the lean, which influences the appearance of the product (Ruiz-Carrascal *et al*. 2000). Moreover, in various Iberian dry-cured products, high concentrations of oleic acid have been related to pleasant aroma notes (Ruiz *et al*. 2002; Ventanas *et al*. 2007).

Conclusions

In summary, Culatello obtained from SNL pigs showed a superior quality than Culatello from CG in terms of haem iron, IMF and MUFA content, oxidative stability, and consumer preference. The present study confirms that SNL pigs, like other autochthonous pig breeds, represents a resource both for the obtainment of products with high nutritional and sensory value and for promoting the economic development of areas where they are raised.

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