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Improving the quality of dry-cured sausages using pork from rustic breed

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The use of pork from rustic pig breed was tested to improve the quality of dry-cured fermented sausages. The quality of a salchichón/salami-type sausage manufactured with pork from Chato Murciano breed (CM) and Early White pig (EW) (Large White × Landrace breed) was compared. CM pork improved several quality characteristics of dry-cured fermented sausage. Significant ($p \leq 0.05$) differences between mean CM and EW values were found for total lipids, ash, collagen, water activity, total acidity, CIELab colour, proteolysis, fat acidity, fatty acid profile, total viable counts, lactic acid bacteria, *Micrococacceae*, moulds and yeasts, colour, odour, flavour, fattiness and acceptance. CM mainly intensified the reddening of sausage cuts and increased monounsaturated acids in fat. Acceptance was also better for CM, although odour and flavour were only slightly improved. The production of high-quality specialities of dry-cured meat products can contribute to the sustainable production of CM and similar rustic pig breeds, maintaining the genetic diversity of pig species.

Key-words: Chato Murciano, pig, salchichón, salami, ripening, eating quality.

Introduction

Dry-cured sausages, such as salchichón, salami and others, are typical meat products of Mediterranean Europe, although their consumption has spread to many countries worldwide. Spain alone produces about 200,000 tonnes a year, which represents more than 15% of Spanish processed meat production (AICE 2009). The market is dominated by large meat companies which can produce sausage on a large scale at low cost. For this reason, some small meat industries have found it necessary to specialise by making high-quality sausages to compete in the

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market. The challenge is to apply industrial processes to traditional specialities that will ensure the survival of these small companies. It is well-known that the raw material used is a major factor involved in improving the quality of dry-cured fermented sausages, especially if short ripening is applied; thus, an alternative for improving the quality of these sausages might be to use high-quality pork from rustic pig breeds.

The Chato Murciano breed is a black rustic pig from the Region of Murcia (southeast Spain), which was on the point of extinction in the 1980s but which is now viable again after government support. The Chato Murciano, a breed well adapted to the warm dry climate of southern Spain, is raised semi-extensively and fed a balanced diet based on special feeds in which local raw materials can be included. Pigs are usually slaughtered at 18 months, when they weigh about 180 kg. These characteristics differentiate it from *recebo*-type Iberian pig, fed with feed and slaughtered at 10 months, and, especially, from early white pigs which are slaughtered at 5–6 months. Previous studies have shown that using pork from Chato Murciano provides high-quality dry-cured sausages, because of its high muscle pigmentation and considerable degree of intramuscular fat. Moreover, the carcass provides much fat with a high level of oleic acid, a good texture and fair degree of stability against oxidation (Galián et al. 2008; Martínez et al. 2008; Tejada et al. 2009; Salazar et al. 2009). However, its poor production rate and the traditional way of husbandry considerably increase the production costs of pigs, which is why the meat from Chato Murciano is probably best suited to manufacturing high quality, high value meat products, similar to those made from Iberian pigs (Peinado et al. 2004).

The processing of pork from rustic pigs will be commercially viable only if the resulting sausages reach high acceptance levels among consumers willing to pay a premium price. For this reason the quality of the sausages should be tested. The objective of this study was to determine whether Chato Murciano meat improved the quality of dry-cured fermented sausage, compared with the same product elaborated with pork from early white pig. The information obtained could be applied to the industrial transformation of other rustic European breeds, such as Negro Canario, Celta, Cinta Sinense or Nero Siciliano, thus contributing to their sustainable production and maintaining the genetic diversity of pig species and, at the same time, the viability of some local meat industries.

Materials and Methods

Experimental design

Three experimental batches of dry-cured fermented sausage (small calibre salchichón/salami) manufactured with both Chato Murciano and Early White pork were compared. CM and EW sausages were subjected to the same manufacturing process. Ripening properties, such as fermentative microflora, acidification, dehydration, the proximal composition, reddening, proteolysis, fatty acid profile, fat acidity and lipid oxidation, and eating quality were determined. Twenty-four sausage units per batch and pork type were analysed in duplicate. Three sub-batches of six sausage units were used in the physical-chemical (1 unit), microbiological (1 unit) and sensory (4 units) analyses. Average data from sub-batches were statistically analysed (N=18). The statistical model was a random design and the pork source was considered as treatment. The effect of the pork on the sausage quality was determined by ANOVA (Scheffe's test of means). Statistical calculations were carried out by the Statistix program 8.0 for Windows (Analytical Software, Tallahassee, FL, USA).

Raw materials

The pigs were reared in pig farms in the Region of Murcia, Spain, in a two-phase system, whereby the pigs were transferred to an on-growing installation after birth and weaned on the first farm. Table 1 shows the main genetic and productive characteristics of the EW and CM pigs. Unlike the EW pigs, the CM pigs were reared in a semi-extensive regime on a farm where they were fed with a special feed. Occasionally the CM pigs were fed pasture and a small quantity of figs and carobs. The carcasses were obtained from an industrial abattoir (La Cormarca, Lorca, Murcia, Spain) situated close to the farms where the pigs were reared. The abattoirs operated in accordance with existing legislation and the traceability of the meat was established from the farms to its reception in the factory.

Preparation of dry-cured sausage

The product was elaborated in accordance with specific legislation (BOE law of 4 October 1990) by a local factory (Elaborados Cárnicos de Lorca S.L, Murcia, Spain) over a period of six months. The basic recipe was meat 88.0%, additives and spices (7.5%) and water (4.5%) (all percentages were expressed as g/100 g). The lean meat and fat used came mainly from de-boned shoulders kept at 2 °C with no added backfat. The meat was minced though a 6 mm perforated mincing plate (Laska GMBH, WW1302, Nu-Meat Technology, Girona, Spain) and mixed with a commercial preparation of additives and spices in a vaccum mixer for 3 minutes (AMU102 mixer, Maquinaria Vall, Lleida, Spain). The commercial preparation (AP LQ-01-MU; Aditivos Cargill, Barcelona, Spain) was composed of sodium chloride, black and white pepper, dextrose, sucrose, dextrin and lactose, sodium nitrite, potas-

Table 1. Genetic and productive characteristics for Chato Murciano (CM) and Early White (EW) breed.

	CM	EW
Breed	Chato Murciano	Landrace × Large White
Description	Black rustic pig	Early white pig
Sex	Castrate males and females	All
Rearing	Semi-extensive	Intensive
Feeding	Ad libitum	Ad libitum
Feed raw materials (g/100 g fresh matter)		
Barley	22.4	46.2
Wheat	30.0	25.0
Maize	20.0	5.0
Soya flour	14.0	11.5
Biscuit flour	--	2.3
Maize DDGS[1]	--	3.5
Peas	10.0	--
Wheat bran	8.0	--
Lucerne	2.0	--
Pig fat	1.7	3.2
Cane molasses	1.0	1.0
Feed fatty acids (g/100 g)		
SFA[2]	30	33
MUFA[3]	40	31
PUFA[4]	30	36
Additional feeding	Grass, carob bean and fig	--
Slaughter age (months)	18	5-6
Slaughter live weight (kg)	180	100
Carcase weight (kg)	140	80

[1] DDGS = Dry residues from maize distillation, [2]SFA = Saturated fatty acids; [3]MUFA = Monounsaturated fatty acids; [4]PUFA = Polyunsaturated fatty acids.

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sium nitrate, sodium isoascorbate, sodium citrate, monosodium glutamate and Ponceau 4R red. To regulate ripening, starter cultures of *Micrococcaceae* and lactic acid bacteria composed of 25% *Staphylococcus carnosus*, 25% *Staphylococcus xylosus* and 50% *Pediococcus* (CXP Degussa Starter Iberia, Barcelona, Spain), were added. The starter cultures were defrosted and dissolved in dechlorinated water, following the revival specifications of the manufacturer, before being added to the mass at 6 10^7 CFU /g. Finally, the meat mass was allowed to stand in a cold chamber at 2–4 °C for 24 hours to facilitate the interaction of the ingredients, starter cultures and additives.

The salchichón-type sausage was manufactured on a WF-612casing line (Handtmann Maschinenfabrik GmbH & Co., Biberach, Germany). Washed, de-salted natural cow casing was used, and each sausage was slightly curved (calibre 40–43 mm, length 30–32 cm). The raw sausages were closed by metal clips, hung with polyester thread and bathed in a solution of *Penicilium crysogenum* (Penicilium PV7, Degussa) to prevent the appearance of undesirable moulds. 100 sausage units were hung from stainless steel trolleys, measuring 1.20 (wide) × 1.20 (deep) × 1.20 m (high) to dry. Drying was carried out over 12 days in controlled atmosphere chambers at 14–18º C in a process that was divided into four stages: 1) dripping 70–75% relative humidity (RH) for 1 day; 2) drying at 85–90% RH for 4 days; 3) drying at 80–85% RH for 4 days; 4) drying at 70–75% RH for 3 days. After this time excess external microflora were brushed off in a closed chamber to prevent re-contamination. The sausages were stored at 4–10 °C and 80–85% RH until their analysis.

Physical and chemical analyses

Moisture, fat and protein (g/100 g) were estimated using an optical analyser (NIR FoodScan TM; Barcelona, Spain), with a precision of 1 g/100 g. Calculations were made using prediction models (Artificial Neural Net; Foss). The ash content (g/100 g) was analysed by gravimetry after incineration in a muffle oven (Heraeus, Madrid, Spain) (ISO 936: 1998). The collagen content was calculated using hydroxyproline values (collagen = 8 × hydroxyproline). Hydroxyproline (g/100 g) was analysed by colorimetry following acid hydrolysis of the sample and oxidation of the hydroxiproline released. The coloured compound formed was measured by spectrophotometer (Unicam UV2; Pye Unicam, Cambridge, United Kingdom) at a wavelength of 560 nm (ISO 3496, 1994).

Water activity (a_w) was measured using a water activity meter (Novasina TH200 Axair AG, Pfäffikon, Switzerland) (ISO 21807, 2004). All measurements were made at 25 °C. The pH was measured with a Crison micropH 2001 pHmeter (Crison, Barcelona, Spain) using a combined electrode Cat nº 52-22 (Ingold Electrodes, Inc. Wilmington, USA) (ISO 2917, 1999). Total acidity (lactic acid, g/100 g) was measured by titrating with NaOH using phenolphthalein as indicator. Lipid oxidation was expressed as Thiobarbituric Acid Reactive Substances (TBARS) (mg malonaldehyde / kg), as determined by Botsoglou et al. (1994), using a Unicam UV2 spectrophotometer. Colour was measured in sausage cuts using a CR-200/08 Chroma Meter II (Minolta Ltd., Milton Keynes, United Kingdom). Results were expressed as a*, b*, Lightness (L*) (CIELab units), Chroma (C*) and Hue angle (H*) (sexagesimal degrees); $C^* = (a^{*2} + b^{*2})^{1/2}$. $H^* = tg^{-1} (b^* / a^*)$.

Non-protein nitrogen (NPN) and total nitrogen (TN) were determined by Kjeldahl's method (ISO 937: 1978), using a Nº 323 digestion-distillation unit (Buchi Labortechnik AG Flawil, Switzerland) an automatic Titrino 702 SM equipped with a combined electrode of pH 6.0233.100 (Metrhom Schweiz, Zofingen, Swizerland). The non-protein-nitrogen was determined after precipitating the proteins with trichloroacetic acid. The proteolysis index was calculated as g NPN /100 g TN. The fat acidity index (mg KOH /g fat) was determined in fat extracted with chloroform-methanol using Folch's method, by titrating with KOH using phenolphthalein as indicator. The fatty acid profile (g/100 g methyl esters) was determined according to the method described by Granados (2001). Fatty acid methyl esters were analysed using an HP6890N gas chromatograph with flame ionisation detector, equipped with a 768313 autosampler (Agilent Technologies, Barcelona, Spain). The samples were injected into an HP5 capillary column (30 m length, 0.32 mm internal diameter, 0.25 µm thickness).

Microbiological analyses

The study of fermentation microflora consisted of counts (log CFU /g) of total viable, lactic acid bacteria, *Micrococcaceae,* moulds and yeasts. The samples were weighed with a sterile tweezers into masticator bags and blended with 0.1 g/100 g peptone water (Oxoid Ltd. CM0087, peptone water) in a masticator (IUL Instruments, GMBH, Königswinter, Germany). The bags used for microbiological analyses were aseptically manipulated inside a microbiology cabinet (Telstar, Bio-II-A). Total Viable Counts were counted on PCA (Plate Count Agar) (Oxoid Ltd. CM0325, Basingstoke, Hampshire, United Kingdom) after incubation at 30 °C for 3 days (ISO 4833: 2003). Lactic acid bacteria were counted on MRS Agar plates (de Man, Rogosa, Sharpe) (Oxoid Ltd. CM0361) and incubated at 30 °C for 72 h in a ST 6120 culture incubator (Heraeus) (ISO 15214, 1998). *Micrococcaceae* were counted on Mannitol Salt Agar (Oxoid Ltd. CM0085) and incubated at 37ºC for 72 h. Moulds and yeasts were counted on RB (Rose-Bengal) plates with chloramphenicol (Oxoid Ltd. CM0549) after incubating at 25 °C for 5 days (ISO 21527-2, 2008).

Sensory analyses

A quantitative descriptive sensory analysis (QDA) was carried out according to ISO 4121 (2003). Sixteen panellists were selected and trained according to ISO 8586-1 (1992). Most of the panellists had previous experience in QDA applied to dry-cured fermented sausage. There were four training sessions. In the first two sessions, the main sensory descriptors of dry-cured fermented sausage, including possible off-flavours, were studied; the next two sessions were concerned with identifying, selecting and quantifying major sensory attributes. The panel evaluated dry-cured meat colour, dry-cured fermented meat odour and flavour, pepper odour and flavour, acid flavour, hardness, juiciness and fattiness on a 1 (minimum) to 5 (maximum) scale. To quantify the attributes, different sausages were evaluated by panellists according to their sensory intensity. The sensory panel was trained using these reference sausages for scoring. The reference samples used to establish the minimum values were: same sausage ripened for four days (colour, odour and flavour; pepper odour and flavour); raw-cured pork sausage (acid flavour and hardness); similar sausage made from turkey meat (juiciness); and semi-cured lean pork sausage "Fuet" (fattiness). As regards the maximum values, these referred to: similar sausage prepared with Iberian pork (colour, hardness, juiciness and fattiness); similar sausage manufactured with cured meat flavouring (odour and flavour); spicy salchichón (pepper odour and flavour); and same sausage after ripening for four days (acid flavour). Overall acceptance was also determined using a linear scale of seven points (1="dislike very much" to 7 ="like very much"). Each panellist evaluated six samples from all the batches.

Results and Discussion

Proximate composition

Table 2 shows the effects of pork (CM vs. EW) on the proximate composition of salchichón-type sausage. The total content of moisture, protein, lipid and ash was 91.3% in CM and 93.5% in EW. The addition of spices and carbohydrates, including dextrin as bulking agent, could explain these results. No statistically significant differences were observed in this respect for the mean moisture or protein content (approximate mean values of 36 and 23 g/100 g, respectively). Moisture contents of 40–50 g/100 g have been described in salchichón and salami after

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Table 2. Effects of pork, Chato Murciano (CM) vs. Early White (EW) on the proximate composition (g/100 g) of salchichón-type sausage (mean±SD).

Proximate composition	CM	EW	F	p
N=18				
Moisture	36.9±2.11	35.9±2.32	1.70	NS
Proteins	23.0±1.02	22.4±0.85	3.62	NS
Lipids	26.0±1.61	30.0±1.87	47.4	***
Ash	5.41±0.33	5.15±0.18	9.28	*
Collagen	2.64±0.24	2.08±0.40	22.5	***

SD: standard deviation; F: ANOVA F-Statistic; p: p-value.

Level of significance: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; NS $p > 0.05$.

two weeks' ripening (Sayas et al.. 1998; Lizaso et al., 1999; Hudges et al., 2002; Fernández et al., 2008). However, the lipid content was lower in CM (26 g/100 g) than in EW (30 g/100 g), perhaps due to differences in the fattiness of the raw material used and/or the optical properties of lean meat. Fitting a meat mixture formula by NIR probe may lead to deviations when the optical properties of the meat vary as a function of muscle pigmentation and fat. Differences in fat may affect the drying speed and some sensory properties of sausages, especially small-calibre and lean varieties. However, the degree of dehydration was similar in CM and EW after 12 days of drying. The mean ash content was slightly higher in CM (5.4 g/100 g) than in EW (5.1 g/100 g). The combined contribution of spices, additives and salt was slightly greater in CM (14 g/100 g) than in EW (12 g/100 g), which might partly explain the differences in ash content observed.

The collagen content was clearly higher in CM (2.6 g/100 g) than in EW (2.1 g/100 g), although both figures may be considered normal for pork dry-cured sausage (González et al. 2009). The fact that muscle connective tissue increases with age in pigs (Fang et al. 1999) would explain the higher collagen content of the CM meat. The connective tissue contributes negatively to the chewiness of dry cured sausage, since the drying process does not gelatinise the native collagen. Both types of salchichón-type sausage contained less than 4.8 g collagen /100 g dry matter, which is the maximum permitted value (Spanish Regulation 10/4/1990. 1990), which means that raw materials used did not have a high connective tissue.

Drying-ripening

Table 3 shows the effects of pork (CM vs. EW) on the drying-ripening of salchichón-type sausage. The a_w was very slightly higher in CM (0.90) than in EW (0.89), perhaps as a result of the fat content. As in the case of the moisture content, the a_w was below the range (0.90–0.94) described for salchichón and salami after two weeks of ripening (Lizaso et al. 1999, Roig et al. 1999, Hudghes et al. 2002, Fernández et al. 2008). The a_w modulates the ripening of dry-cured fermented sausage, especially microbiological activity. All factors being the same, small calibre sausages dry faster since the internal migration of water tends to slow down the drying rate, so that the a_w falls rapidly.

The type of meat hardly affected acidification. The mean pH was similar for CM (4.76) and EW (4.71), both values considered normal, if slightly acidic, for sausage fermented with starter cultures. Values of pH 5.0–5.4 have been cited for salchichón and salami ripened for two weeks (Sayas et al. 1998, Hudghes et al. 2002, Roig et al. 1999, Casaburi et al. 2008, Fernández et al. 2008). Mean lactic acid values were lower in CM (0.6 g/100 g) than in EW (0.7 g/100 g), while a figure of 0.8 g lactic acid /100 g has been mentioned for a similar salchichón-

Table 3. Effects of pork, Chato Murciano (CM) vs. Early White (EW) on the drying-ripening parameters of salchichón-type sausage.

Drying-ripening	CM	EW	F	*p*
N=18	M±SD	M±SD		
a_w	0.90±0.01	0.89±0.02	6.50	*
pH	4.76±0.22	4.72±0.05	0.47	NS
Total acidity (g lactic acid / 100 g)	0.62±0.09	0.73±0.13	9.79	**
L* Lightness (CIE units)	47.0±2.40	53.2±3.04	46.7	***
a* Redness (CIE units)	16.0±1.62	14.7±1.78	5.81	*
b* Yellowness (CIE units)	3.63±0.89	5.72±0.82	54.1	***
C* Chroma (CIE units)	16.5±1.69	15.7±1.91	1.40	NS
º Hue (CIE units)	12.7±2.65	21.3±1.64	137.3	***
Proteolysis (g NPN / 100 TN)	11.3±1.49	13.1±1.84	11.12	**
Fat acidity (mg KOH / g fat)	7.03±1.50	12.0±1.50	97.9	***
TBARS (g MDA / kg)	n. d.	n. d.		

SD: standard deviation; F: ANOVA F-Statistic; *p*: *p*-value; CIE: Commission Internationale de I'Ecleirage; NPN: Non Protein Nitrogen; TN; Total Nitrogen; TBARS: Thiobarbituric Acid Reactive Substances, MDA: Malonyldialdehyde. Level of significance: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; NS $p > 0.05$.

type sausages (Sayas et al. 1998, Fernández et al. 2008). It is unlikely that the pH of the meat used can affect the final pH of a dry-cured sausage that undergoes such intense acidification in such a short time. CM meat has a pH of 5.6 (Galián et al. 2008), a normal pH for pork. The meat mass has a pH value of 6.5 before fermentation, which falls as a result of fermentation of the added sugars by lactic acid bacteria.

The meat type clearly affected the characteristic red colour of the cured meat. Significant differences ($p < 0.01$) were observed between CM and EW for all mean CIELab values, except Chroma. Mean L* was considerably lower in CM (47 CIE units) than in EW (53 CIE units). Particularly pronounced was the difference in Hue angle between CM (12.7 CIE units) and EW (21.3 CIE units). Curing pigmentation was more intense in CM than EW, even though the colour was reinforced with added Ponceau Red. The addition of red colorants is common practice to improve the colour of dry-cured sausages made with pig meat, especially when pale meat is used. The CM meat was clearly redder and more pigmented than the EW meat, so that a redder colour was to be expected in the cured product because of the formation of nitrosomyoglobin. This, together with the lower fat content, would explain the lower L* in CM, since fat reflects light more than lean meat. Sayas et al. (1998) found CIELab coordinates of 48 (L*), 12 (a*) and 6 (b*) CIE units in a similar dry-cured sausage manufactured with meat from EW pigs with no added colorant and after two weeks of ripening.

The meat type also affected the intensity of proteolysis that took place. The corresponding index was lower in CM (11 g NPN / 100 g TN) than in EW (13 g / 100 g), although both are within the range (9–17 g / 100 g) cited for salchichón and salami after 2 weeks' ripening (Lizaso et al., 1999; Hudges et al. 2002). Proteolysis and related reactions generate peptides, nucleotides and free amino acids, contributing to the flavour and other attributes of dry-cured meat. Two factors may attenuate the proteolysis that takes place in the salchichón-type sausage tested: the short ripening time and intense acidification that slows down protease activity in the meat. Regardless of the proteolytic activity of the starter cultures, the intensity of muscle protease

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activity may vary with the pig breed, especially in early breeds (Soriano and García, 2003). This may help explain the slight differences in proteolysis observed between the CM and EW.

Fat acidity was lower in CM (7 mg KOH /g fat) than in EW (12 mg KOH / g fat). Fat acidity of 10 mg KOH / g fat was mentioned by Lisazo et al. (1999) for salchichón ripened for two weeks. Fat acidity increased during ripening due to the fatty acids generated by the hydrolysis of triglycerides and phospholipids. Lipolysis in fermented pork products depends on factors such as salt concentration, temperature, pH, fat composition and the starter cultures added. PUFAs show a slight greater tendency to be released before other fatty acids (Sorensen, 1997), which might explain the results obtained. The free acids are degraded by oxidation to form peroxides and secondary compounds such as aldehydes and ketones, among others. However, no appreciable levels of TBARS were noted in CM or EW. This may seem surprising at first, even for a dry-cured sausage manufactured in vacuum and subjected to a short drying-ripening process, except that the addition *quantum satis* of ascorbate or citrate could have inhibited the formation of carbonyl compounds. When the oxidation of the experimental samples was speeded up, they showed TBARS values.

Fatty acid Profile

Table 4 shows the effects of using CM or EW pork on the main fatty acids of salchichón-type sausage. As can be seen, the respective fatty acid profiles differed considerably. CM showed higher levels of MUFA (48 g/100 g) than EW (44 g/100 g), especially oleic acid. In turn, the PUFA content was lower in CM (14 g / 100 g) than in EW (16 g/100 g). The mean SFA content was also lower in CM (34 g/100 g) than in EW (39 g/100 g). The SFA/UFA ratios were 0.56 and 0.65 respectively in CM and EW. Tejada et al. (2009) also found different SFA-MUFA-PUFA ratios in dry-cured loin manufactured with CM meat (35-49-16 g/100 g) and EW meat (36-43-21 g/100 g). Moretti et al (2004) obtained similar results when comparing commercial salami with one manufactured using Nero Siciliano meat.

The fatty acid profile affects crucial properties of dry-cured fat, such as its susceptibility to oxidation, its texture and impregnation capacity. An excess of PUFA leads to soft, oxidisable fats, which lowers acceptance and makes slicing more difficult. The profile of pork meat fatty acids depends much on the diet since there is no ruminal fermentation of lipids. Compared with EW pigs, CM pigs provide fat with a high level of MUFA, fatty acids characterized by their good technological and sensory properties for drying-curing. However the PUFA content, both CM and EW showed values slightly higher than the 14 g/100 g recommended for meat products (Fisher et al. 2006). The differences in the fatty acid profiles would have been mainly due to the raw materials used in the feed. Furthermore, oleic acid is the major fatty acid in pig adipose tissue and its content increases with age. However, MUFAs did not exceed 50 g/100 g, as observed in other rustic breeds, such as Iberian (Daza et al. 2007), Celta (Franco et al. 2006), Nero Siciliano (Moretti et al., 2004) and Cinta Senese (Franci et al. 2005). Spanish legislation rules that Iberian dry-cured fat must have more than 51 g/100 g of oleic acid when pigs are fed acorns and feed (*recebo*) (Spanish Regulation APA/3795/2006). Chato Murciano does not reach this high level of oleic acid, although it would be possible to modify the fatty acid profile of dry-cured sausages by changing the pigs' diet (Rubio et al. 2008).

Fermentative microflora

Table 5 depicts the effect of pork (CM *vs* EW) on the main groups of fermentative microflora in the salchichón-type sausage. Statistically significant ($p < 0.001$) differences are evident in the mean counts of the four groups studied. CM showed higher counts of TVC (8.9 log CFU /g) and LAB (8.8 log CFU /g) than EW (8.4 and 8.3, log CFU /g, respectively, but lower counts of *Micrococcaceae* (6.9 log CFU /g) compared with EW (7.3 log CFU /g). The mean counts of moulds and yeasts were

Table 4. Effects of pork, Chato Murciano (CM) vs. Early White (EW) on the fatty acid composition (g / 100 g methyl esters) of salchichón-type sausage (mean±SD).

Fatty Acids	CM	EW	F	p
N=18				
C10:0	0.12±0.04	0.13±0.04	0.19	NS
C12:0	0.11±0.09	0.07±0.07	1.47	NS
C14:0	1.23±0.13	1.34±0.17	4.09	NS
C16:0	22.8±1.08	23.7±0.43	11.4	**
C16:1	3.03±0.29	2.17±0.08	142.8	***
C17:0	0.15±0.17	0.27±0.20	4.03	NS
C18:0	10.6±0.69	13.3±0.36	216.8	***
C18:1	45.1±0.94	41.6±0.68	162.3	***
C18:2	8.79±1.36	11.7±0.47	74.7	***
C18:3	4.81±0.64	3.88±0.11	37.2	***
C20:0	0.00±0.00	0.03±0.11	1.00	NS
C20:4	0.29±0.20	0.16±0.18	4.35	*
∑SFA[2]	34.7±1.99	38.9±0.84	71.1	***
∑UFA[3]	62.3±2.17	59.6±1.11	22.8	***
∑MUFA[4]	48.2±0.81	43.8±0.74	294.7	***
∑PUFA[5]	14.0±1.65	15.8±0.48	17.8	***
∑n.i. FA[6]	2.93±1.68	1.57±0.82	9.61	**

SD: standard deviation; F: ANOVA F-Statistic; p: p-value; [2]SFA = Saturated fatty acids; [3]UFA = ; [4]MUFA = Monounsaturated fatty acids; [5]PUFA = Polyunsaturated fatty acids; [6]n.i. FA: no identified Fatty Acids.

Level of significance: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; NS $p > 0.05$.

Table 5. Effects of pork, Chato Murciano (CM) vs. Early White (EW) on the fermentative groups (log CFU / g) of salchichón-type sausage (mean±SD).

Fermentative groups	CM	EW	F	p
N=18				
Total Viable Counts	8.92±0.24	8.38±0.24	45.8	***
Lactic Acid bacteria	8.80±0.32	8.26±0.21	39.2	***
Micrococacceae	6.88±0.50	7.30±0.32	9.09	**
Moulds and Yeasts	4.98±0.45	6.22±0.30	93.3	***

SD: standard deviation; F: ANOVA F-Statistic; p: p-value.

Level of significance: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; NS $p > 0.05$.

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Table 6. Effects of pork, Chato Murciano (CM) vs. Early White (EW) on the sensory attributes and acceptance (arbitrary units) of salchichón-type sausage (mean±SD).

Sensory attributes	CM	EW	F	p
N=18				
Colour	4.30±0.29	2.96±0.46	108.6	***
Odour	3.34±0.21	3.00±0.37	11.2	**
Pepper odour	2.63±0.23	2.55±0.30	0.93	NS
Flavour	3.20±0.16	2.88±0.22	23.3	***
Pepper flavour	2.71±0.18	2.51±0.24	8.10	**
Acid flavour	3.28±0.38	3.08±0.23	3.61	NS
Hardness	3.24±0.22	3.14±0.25	1.65	NS
Juiciness	2.90±0.19	2.93±0.17	0.28	NS
Fattiness	2.65±0.19	2.85±0.27	6.70	*
Acceptance	4.82±0.20	4.22±0.29	51.2	***

SD: standard deviation; F: ANOVA F-Statistic; p: p-value.

Level of significance: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$; NS $p > 0.05$

Scales: (1-5) for sensory attributes; (1-7) for acceptance.

considerably lower in CM (5.0 log CFU /g) than in EW (6.2 log CFU /g). LAB are the predominant Group in fermented dry-cured sausages followed by *Micrococcaceae* and the moulds and yeasts. The corresponding counts made after 2 weeks' ripening in salami and salchichón manufactured with starter cultures were in the following ranges: 7–9 log CFU /g for BAL; 4–7 log CFU /g for *Micrococcaceae;* and 2–3 log CFU /g for moulds and yeasts (Roig et al. 1999, Lizaso et al. 1999, Casaburi et al. 2008, Fernández et al. 2008).

The above counts suggest that the salchichón-type sausage tested still had an abundant fermentative microflora and intense activity after 2 weeks of ripening, since large populations of *Micrococcaceae* and lactic acid bacteria still existed, which would also explain the low pH observed. Meat fermentation by starter cultures contributes to the colour, aroma, taste and firmness, favours drying and reddening, and, above all, ensures the microbiological quality of the dry-cured sausage. It is common practice to add LAB and other starter cultures to guarantee good fermentation in this type of sausage. The high yeast and mould counts would be the result of adding casing mould to prevent toxigenic moulds from developing, although they were in the minority. It is unlikely that the meat type would influence the fermentative microflora of a fermented sausage, unless problems of microbiological contamination existed. It is more likely that the differences in the microflora observed as a function of meat type were due to differences in the application of the starter cultures.

Sensory quality

The effects of pork (CM vs. EW) on the sensory quality of salchichón-type sausage are shown in Table 5. This sausage presented an intense red-violet colour, a mild flavour of fermented-ripened meat with a slight predominance of acid over pepper flavour, good slicing texture, and medium fattiness and juiciness. Some substantial sensory differences between CM and EW were cleared. The typical dry-cured meat colour was markedly higher in CM (4.3) than EW (3.0), which agreed with the CIELab scores. The CM colour score was close to the maximum reference value of a similar Iberian sausage. The odour and flavour of fermented-cured meat were more intense in CM (3.3 and 3.2) than in EW (3.0 and 2.9). The mean pepper odour value was similar in both CM (2.6) and EW (2.5), although the pepper flavour was slightly stronger in CM (2.7 compared with the 2.5 of EW). There was no significant ($p > 0.05$) difference in mean acidity between CM (3.3) and EW (3.1). As regards texture, the mean scores for hardness and juiciness were similar in both products, with scores of around 3.0. The mean fattiness score in CM were lower than in EW (2.6 and 2.8, respectively). Finally, CM was better accepted than EW. Using a hedonic scale of 7 points, CM was scored with 4.8 points ("I like it a lot") and EW was scored with 4.2 ("I neither like nor dislike it"). This suggests that using CM meat results in high quality dry-cured sausage, although the degree of acceptance evaluated by a trained panel may be biased and a wider, consumer-based survey would be necessary to corroborate these views. In such a survey, Martínez-Cachá et al. (2009) found higher acceptance for CM dry-cured products (ham and loin) compared with similar products containing EW meat.

Conclusions

The results confirm that CM pork can be used to manufacture a high quality dry-cured fermented sausage, although there is still room for improvement as regards to sensory quality. CM meat improved some quality characteristics compared with EW meat. CM especially improved the colour and fatty acid profile, acceptance was greater although aroma and flavour were only slightly improved. CM meat also provides greater opportunity to eliminate or, at least, reduce the amounts of chemical additives used, such as colorants, taste enhancers and antioxidants, which are increasingly questioned by consumers. The production of high-quality "speciality" dry-cured meat products can contribute to the sustainable production of CM and similar rustic pig breeds, thus helping to maintain the genetic diversity of pig species.

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