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Effect of the inclusion of chestnut in the finishing diet on volatile compounds during the manufacture of dry-cured "Lacón" from Celta pig breed

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ABSTRACT

The effect of the finishing diet on the volatile compounds throughout the manufacture of dry-cured "lacón" (a Spanish traditional meat product), from the Celta pig breed was studied. Thirty-six pigs were separated into three groups according to the type of feeding during the finish-fattening period of three months (concentrate, mixed diet and chestnut). From the pigs of each diet, four batches of dry-cured "lacón" were manufactured. From each batch, samples of fresh meat, meat after salting, after post-salting, and after 14, 28, 56 and 84 days of drying–ripening were taken. Volatiles were extracted by a purge-and-trap method and analyzed by gas chromatographic/mass spectrometry (GC/MS). Seventy-six volatile compounds were identified and quantified from dry-cured "lacón" samples in pigs finished with chestnut, eighty-two for concentrate fed pigs and eighty in pigs fed with the mixed diet. The number of identified volatile compounds increased during the manufacturing process; at 84 days of drying–ripening, in the dry-cured "lacón" samples from pigs finished with concentrate, mixed diet and chestnut, 54, 58 and 62 volatile compounds were detected, respectively. The most abundant group of flavour compounds at the end of the manufacturing process was hydrocarbons in the three feeding systems, followed by aldehydes, ketones and alcohols. Discriminant analysis selected six variables (dodecane, butadienol, pentenol, 2-pentenal, decen-3-ona and pyridine-2-methyl) and calculated two discriminating functions which allowed verification of chestnut in the finishing diet.

1. Introduction

Dry-cured "lacón" is a traditional cured meat product made in the North-west of Spain from the foreleg of the pig cut at the shoulder blade-humerus joint, following similar manufacturing processes to those used in the production of dry-cured ham. In the Galicia region this product has been awarded a Geographically Protected Identity (G.P.I.) (Official Journal of the European Communities, 2001). It has an excellent acceptance by consumers due to its sensory quality (aroma, flavour and texture), which depends on the ripening conditions (Andrés, Cava, Ventanas, Muriel, & Ruiz, 2007; Flores, Grimm, Toldrá, & Spanier, 1997; Ruiz, Ventanas, Cava, Andrés, & García, 1999) and factors that affect the raw meat characteristics, such as rearing system, mainly during the fattening period, age and pig genotype (Bermúdez, Franco, Franco, Carballo, & Lorenzo, 2012; Dirinck, Van Opstaele, & Vandendriessche, 1997; Ramírez & Cava, 2007; Sabio, Vidal-Aragón, Bernalte, & Gata, 1998; Sánchez-Peña, Luna, García-Gómez, & Aparicio, 2005). Compounds coming from feeds contribute to the final flavour of dry-cured meat products and the factor that determines "lacón" prices in the market is the fattening diet.

In dry-cured products, it has been postulated that volatile compounds arise from numerous chemical and enzymatic reactions such as lipolysis, chemical or enzymatic oxidation, proteolysis, Strecker degradation and Maillard reactions (Ordóñez, Hierro, Bruna, & de la Hoz, 1999; Ruiz, García, Muriel, Andrés, & Ventanas, 2002; Yang, Ma, Qiao, Song, & Du, 2005).

The NW of Spain is the main area of production of chestnut (*Castanea sativa* Mill.) which has been awarded a Geographically Protected Identity (G.P.I.) (Official Journal of the European Communities, 2010). Currently, the chestnuts are underutilized, a situation that contrasts with the high current price of the animal commercial compound feeds. The use of chestnuts for the feeding of the Celta pig breed in an extensive production system would allow a reduction in production costs and offer meat products of quality, having a healthier fat and with high added value.

It would be interesting to follow the changes in volatile compounds during processing of dry-cured "lacón", as a first step in the aroma research. Indeed, understanding of this aspect could help to optimize the processing time, which is empirically determined in

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industrial practice. So, the aim of this study was to evaluate the effect of the finishing diet on volatile compounds during the manufacture of dry-cured "lacón" from Celta pig breed and to explore the use of these volatile compounds as discriminating factors for the identification of the finishing diet system.

2. Materials and methods

2.1. Pigs and diets

A total of 36 Celta pigs (20 males and 16 females) were used. Piglets, which were vaccinated and deparasitised following the usual protocols, were suckled until an age of 40 days. Male piglets were castrated at two months and female piglets at three months. All pigs were reared and fattened until 16 months in an extensive regime, with a livestock density of 12 animals per hectare. After weaning, the pigs were fed a commercial compound feed. At 12 months of age, the pigs were randomly divided into three groups each comprising 12 animals: Group A was fed commercial compound feed (3 kg/animal/day) for the 4 months prior to slaughter; Group B was fed a mixed diet (commercial compound feed/chestnuts; 1.5 kg commercial compound + 2.5 kg chestnuts/animal/day) for the remaining four months, and Group C was fed a mixed diet (commercial compound feed/chestnuts) until aged 13 months, and then a diet of chestnuts only (5 kg/animal/day) in the three months prior to slaughter. The chemical composition (expressed as g/100 g) of the chestnut and commercial compound feeds used is shown in Table 1.

2.2. Handling and slaughtering

At 16 months of age, the pigs were transported to a commercial slaughterhouse (Frigolouro, Porriño, Pontevedra, Spain) located 80 km from the experimental farm, and were kept for 12 h with full access to water but not to food. The pigs were stunned electrically, exanguinated, scalded, skinned, eviscerated and chilled according to standard commercial procedures.

Table 1
Chemical and fatty acid composition of feeds consumed by studied Celta pigs.

	Diets	
	Concentrate	Chestnut
Chemical composition		
Moisture	10.5	48.1
Crude Protein [a]	17.09	8.09
Crude Fibre [a]	5.1	3.8
Fat [a]	5.4	2.5
Ash [a]	7.2	2.1
Ca [a]	0.68	0.07
P [a]	0.30	0.09
Fatty acid composition [b]		
C14:0	1.53	n.d.
C16:0	24.44	16.58
C16:1*cis*-9	2.21	0.51
C17:0	0.53	n.d.
C18:0	11.53	1.41
C18:1*cis*-9	28.61	28.92
C18:2n-6	27.72	45.04
C20:0	n.d.	0.31
C20:1	0.56	0.52
C18:3n-3	3.06	6.70

n.d. = not detected.
[a] Expressed as percentage of dry matter.
[b] Values are means expressed as percentage of total fatty acid methylesters.

2.3. Samples

A factorial design [(3 feeding groups × 4 batches × 7 sample points) = 84 Celta "lacón" samples were used].

In order to organize the work, pigs were slaughtered on four different and consecutive days. Each day, three pigs from each group were randomly chosen for slaughter. Jointing was carried out after the carcass had been refrigerated for 24 h. The six "lacón" (foreleg) pieces of the pigs from the same feeding group and slaughtered the same day constituted a batch. Therefore, four "lacón" batches for each feeding group were manufactured, and the manufacture of the different batches for each feeding group started on different days.

Batches were manufactured following the traditional procedure. The pieces were salted with coarse salt, forming piles alternating between meat and salt; pieces remained in the pile for four days (one day per kg of weight), the temperature of the salting room was in the range of 2 to 5 °C and 80 to 90% relative humidity. After the salting stage, the pieces were taken from the pile, brushed, washed to remove salt from the surface, and transferred to a post-salting chamber where they stayed for 14 days at 2 to 5 °C and 85 to 90% relative humidity. After the post-salting stage the pieces were transferred to a room at 12 °C and 74–78% relative humidity where drying–ripening took place for 84 days. The air convection in the drying room was intermittent and the air velocity around the pieces when the fan was running ranged between 0.3 and 0.6 m/s.

In each batch seven sampling times (fresh piece, after the salting, after post-salting, and after 14, 28, 56 and 84 days of drying–ripening) were established. Each sample consisted of one entire piece. However, due to the fact that seven sampling times were established and only six pieces were available per batch, the sample of the fresh piece for each batch consisted of a mix of muscle and subcutaneous fat (50:50, w/w) collected from the surface of the six fresh pieces before salting. Samples were transported to the laboratory under refrigeration (<4 °C). Once in the laboratory, the entire pieces were skinned, boned, and minced in a high-capacity mincer. The minced samples were stored in air-tight bottles at −80 °C in the dark, for no longer than four weeks, until analysis.

2.4. Analytical methods

2.4.1. Physico-chemical composition

The pH was determined in a slurry made by mixing 10 g of sample with 10 ml of distilled water in a Sorvall Omnimixer homogeneizer (Omni International, Waterbury, CT). Measurement was carried out with a pH meter micro pH 2002 (Crison Instruments, S.A., Barcelona, Spain). Moisture and fat were quantified according to ISO recommended standards 1442:1997 (ISO, 1997) and 1443:1973 (ISO, 1973), respectively.

2.4.2. Analysis of volatile compounds

Samples were ground in a domestic blender, and a 10 g sample was put into a dynamic headspace vial. The volatile compounds were extracted and concentrated in a purge and trap concentrator coupled to a cryofocusing module (Teledyne Tekmar, Mason, OH, USA).

2.4.2.1. Dynamic headspace volatile concentration. Samples were transferred into headspace vials and concentrated in a purge-and-trap concentrator (Stratum, Teledyne Tekmar, Mason, OH, USA) equipped with a cryofocusing module connected with an autosampler (Solatek 72 Multimatrix Vial Autosampler, Teledyne Tekmar, Mason, OH, USA). They were kept at 60 °C for 5 min and then flushed with helium at a flow rate of 60 mL/min for 20 min. Volatile compounds were adsorbed on a Tenax Trap (Strat trap, 30.48 cm, Agilent Technologies Spain, S.L., Madrid, Spain) and thermally