Meat Science 80 (2008) 1074–1080

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effect of the inoculation of a starter culture and vacuum packaging during the resting stage on sensory traits of dry-cured ham

F. Sánchez-Molinero, J. Arnau *

IRTA, Finca Camps i Armet s/n, E-17121, Monells (Girona), Spain

ARTICLE INFO

Article history:
Received 4 December 2007
Received in revised form 25 April 2008
Accepted 28 April 2008

Keywords:
Dry-cured ham
Resting
Vacuum packaging
Starter culture
Flavour
Texture
Appearance

ABSTRACT

The effects of the inoculation of a mixed starter culture and vacuum packaging (during resting stage) on odour, appearance, texture and flavour of dry-cured ham were studied. After salting, half of the 36 processed hams were inoculated with a commercial starter culture containing lactic-acid bacteria, Gram-positive catalase-positive cocci and yeasts. Nine hams per group (inoculated and non-inoculated) remained vacuum-packaged during resting. External odour during the process, as well as appearance of the cut surface, texture and flavour on *semimembranosus* and *biceps femoris* of the final product were assessed.

Vacuum packaging during resting caused an increase in white film and feedstuff flavour, as well as a decrease in aged flavour, hardness, fibrousness and overall liking. The use of the starter culture brought about an increase in feedstuff flavour, a decrease in sweetness, aged flavour, nutty flavour and overall liking and, only in vacuum-packaged hams, the development of a floral flavour, but had no significant effect on texture descriptors. The starter culture studied is considered inappropriate for the production of traditional Spanish dry-cured ham regardless of the type of resting used.

1. Introduction

In dry-cured ham, cut surface appearance, texture and flavour are affected by raw material (Arnau, Gou, & Guerrero, 1994; Gou, Guerrero, & Arnau, 1995; Parolari, Virgili, & Schivazappa, 1994) and biochemical processes such as proteolysis, lipolysis, Maillard reactions and Strecker degradation (García et al., 1991; Toldrá & Flores, 1998; Ventanas et al., 1992). The role of microorganisms on texture and flavour is considered to be less important than in fermented sausages because the microbial population (mainly Gram-positive catalase-positive cocci) inside the ham is relatively low (Carrascosa, Marín, Avendaño, & Cornejo, 1988; Silla, Molina, Flores, & Silvestre, 1989). Some authors have studied the effect of starter cultures on the quality and safety of country-style dry-cured hams (Bartholomew & Blumer, 1977; Marriot, Phelps, Graham, & Shaffer, 1987), Central European hams (Liepe & Porobic, 1984; Lücke & Hechelmann, 1987; Schiefer & Schöne, 1978), Korean hams (Lee & Song, 1987) and Spanish hams (Boadas, Gou, Guardia, & Arnau, 2000; Martín, Ruiz, Núñez, Córdoba, & Asensio, 2000). Despite starter cultures not being used in traditional Spanish dry-cured ham, some authors have suggested that their use could improve some of the sensorial characteristics of the product (Martín et al., 2000; Núñez et al., 1998).

The packaging of the hams under vacuum during the salting and resting periods could have some potential economic advantages since it may save energy and reduce the space occupied by the hams in the traditional system. However, it can reduce water losses and oil drip and increase proteolysis and bacterial counts (Sánchez-Molinero & Arnau, 2008).

In a previous paper, the effect of the inoculation of a mixed starter culture and vacuum packaging during the whole resting phase on the external appearance and some microbiological and physicochemical parameters of dry-cured hams was evaluated (Sánchez-Molinero & Arnau, 2008). The aim of this study was to evaluate the effect of the inoculation of a mixed starter culture and vacuum packaging during the whole resting phase on the external odour during processing and the appearance of the cut surface and texture and flavour of the dry-cured hams at the end of the process.

2. Materials and methods

2.1. Ham processing

A total of 36 hams obtained from 18 commercial carcasses, were selected at a local slaughterhouse at 24 h *post-mortem* with the following characteristics: weight: 9.5 ± 1.0 kg; pH_{24}: 5.64 ± 0.20 in *semimembranosus* muscle; partially skinned according to the typical Spanish V shape. After 48 hours at 2–3 °C, they were thoroughly rubbed with a mixture of 35 g NaCl, 0.15 g $NaNO_2$,

* Corresponding author. Tel.: +34 972 630 052; fax: +34 972 630 373.
E-mail address: jacint.arnau@irta.es (J. Arnau).

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doi:10.1016/j.meatsci.2008.04.029

0.30 g KNO_3 and 5 g dextrose per kg of fresh ham. The hams were vacuum-packaged in plastic bags (Cryovac® BB4 L, Sealed Air) and placed in a horizontal position at 2–3 °C. After 5 d, the hams were rubbed with 30 g of salt per kg of ham, vacuum-packaged again and left in the same conditions for 16 d. Then, the hams were washed with cold water and, according to the partially balanced incomplete block design used (Table 1), half of the hams were rubbed with 0.1 g/kg of a commercial lyophilized mixed starter culture (Elce, Texel) on the lean side and the other half were not inoculated. The starter culture contained 4×10^{10} cfu of lactic-acid bacteria (*Lactobacillus sakei, Pediococcus pentosaceus*), 6×10^{10} cfu of Gram-positive catalase-positive cocci (*Staphylococcus xylosus, Staphylococcus carnosus*) and 6×10^{9} cfu of the yeast *Debaryomyces hansenii* per gram of product. Half of the inoculated hams and half of the non-inoculated ones were hung and submitted to a standard resting (STR) in a drying room with a relative humidity between 75% and 85% and a temperature of 2–3 °C for 39 d. The other hams were subjected to a resting in bag (RIB), i.e. they were vacuum-packaged in a plastic bag (Cryovac® BB4L, Sealed Air) and placed in a horizontal position for the whole resting period for the same time and temperature as before. The application of this experimental model resulted in four different treatments: C, V, S and SV (see Table 1). These treatments were balanced by pH_{24} and ham weight.

After the resting period, the hams submitted to a RIB were taken out of the bags and hung in a drying chamber together with the rest of the hams. The drying conditions (temperatures and relative humidity) are shown in Table 2. The hams were placed in such a way that the two hams from the same carcass were always hung with the lean surfaces facing each other 5 cm apart.

The mean weight losses at 21, 60, 120 and 310 d were 3.7%, 14.2%, 23.4% and 36.6% for hams with a standard resting and 3.8%, 3.9%, 19.4% and 33.7% for hams with a RIB (Sánchez-Molinero & Arnau, 2008).

2.2. Sensory analysis

Quantitative descriptive analyses (Stone, Sidel, Oliver, Woolsey, & Singleton, 1974) were carried out to assess the odour of the ham (during processing) and the appearance, texture and flavour (in the finished product). The panel consisted of six selected and trained assessors (ASTM, 1981; ISO 8586-1:1993), with a minimum of 10-years experience in the evaluation of the descriptors used for dry-cured ham evaluation. Each type of sensory analysis (odour, appearance, texture and flavour) was undertaken in nine sessions and a complete block design was used (Steel & Torrie, 1983), where each taster assessed all the treatments in each session. Samples were coded with three random numbers and were presented to the assessors by pairs balancing the first order and carry over effects according to MacFie, Bratchell, Greenhoff, and Vallis (1989). The judges used a 0–10 non-structured scale, i.e. 0 for absence of the descriptor and 10 for maximum intensity (Amerine, Pangborn, & Roessler, 1965). The mean of the six panellists for each muscle and ham was used for data analysis.

2.2.1. Odour assessments during processing

Odour assessments were performed on the external part of the whole ham at 120 d, 210 d and 310 d of processing using the following descriptors: yeast odour (odour associated with fermenting yeasts), fatty odour (typical odour developed in the external fat of dry-cured ham during ageing), fruity odour (odour associated with different fruits), winery odour (odour similar to a wine cellar), matured odour (set of pleasant nuances characteristic of dry-cured meat products not described by the other odour attributes).

2.2.2. Sensory analyses in final product

2.2.2.1. Sampling procedure. Hams were deboned and transversal cuts were made at A (level of coxofemoral joint) and B point to obtain the 4.5-cm-thick piece AB and the parts 1 and 2 (Fig. 1). The visual assessments were performed on AB. Then, the parts of *semimembranosus* and *biceps femoris* muscles were removed, vacuum-packaged and kept under refrigeration (3 ± 1 °C) for white film evaluation. *Biceps femoris* and *semimembranosus* muscles from part 1 (Fig 1) were excised, vacuum-packaged and kept under refrigeration until the flavour and texture analyses.

2.2.2.2. Visual assessments of the final product. Just after doing the transversal cut at A the hollow extent (extension of the cavities formed as a result of the separation between muscles around the

Table 1
Experimental design

Treatment	Starter application	Type of resting[a]	Hams assigned to each treatment[b]
C	No	STR	1l 2r 3l 4r 5l 6r 7l 8r 9l
S	Yes	STR	1r 2l 3r 10l 11r 12l 13r 14l 15r
V	No	RIB	4l 5r 6l 10r 11l 12r 16l 17r 18l
SV	Yes	RIB	7r 8l 9r 13l 14r 15l 16r 17l 18r

[a] STR: standard resting; RIB: resting in bag.
[b] Hams with the same number come from the same carcass. l = left ham; r = right ham.

Table 2
Drying conditions

Duration (d)	Temperature (°C)	Relative humidity (%)
30	14–16	70–80
75	16–18	70–80
45	20–22	70–80
30	23–25	60–70
40	23–25	55–65
30	25–27	45–55

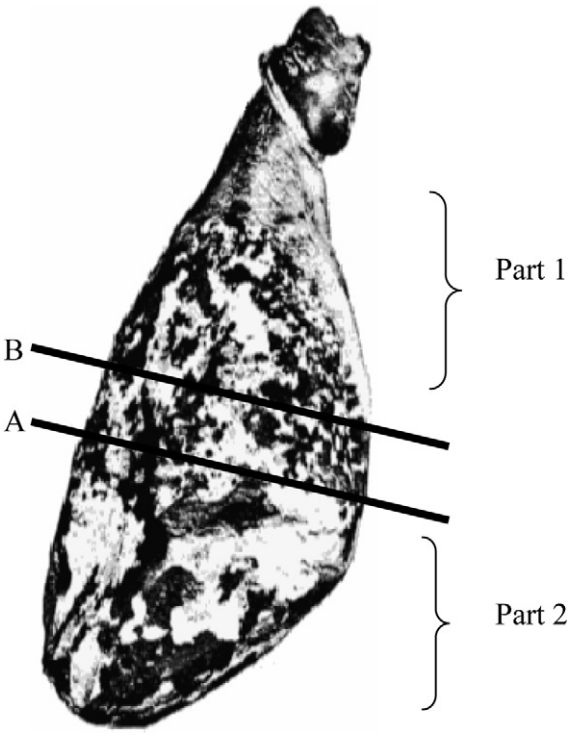

Fig. 1. Sampling zones.