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Salt uptake and water loss in hams with different water contents at the lean surface and at different salting temperatures

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ABSTRACT

The salt uptake homogeneity is crucial in assuring quality in dry-cured hams. The aim of this study was to evaluate the effect of the water contents at the lean surface before salting and of the temperature during salting on the salt uptake. Pieces of loin stored at 3 °C for 3 days before salting absorbed less salt through a surface that has been dried during storage. A group of raw hams were subjected to different pre-salting storage times (0, 3 and 6 days) and another group subjected to different set room temperatures during salting (−1.0, 0.5 and 4.0 °C). The duration of storage before salting and the temperature during salting had a negative and a positive effect on the average salt absorption, respectively. The most important effects appeared after 6 days of storage and at 4 °C. No significant differences in salt uptake homogeneity were found between storage times and between salting temperatures.

1. Introduction

In Mediterranean countries, the traditional elaboration process of dry-cured ham has three fundamental stages: dry-salting, resting and drying/ageing. During the salting stage, the amount of salt absorbed by the hams is often highly variable. The amount of salt affects the drying process (Comaposada, Gou, & Arnau, 2000; Gou, Comaposada, & Arnau, 2003) and the biochemical reactions during the whole process, e.g. proteolysis (Arnau, Guerrero, & Gou, 1997; Arnau, Guerrero, & Sárraga, 1998; Martín, Antequera, Córdoba, Timón, & Ventanas, 1998; Morales, Serra, Guerrero, & Gou, 2007) and lipolysis (Andrés, Cava, Ventanas, Thovar, & Ruiz, 2004; Andrés, Cava, Martin, Ventanas, & Ruiz, 2005), which are in part responsible for the quality of the dry-cured ham. Therefore, the variability in the salt absorption causes heterogeneous behaviour of the hams throughout the next stages of the process, hindering their control, and obtaining final products with heterogeneous sensory and nutritional characteristics which could also negatively influence the purchase decision of consumers.

There is a current tendency to reduce the salt content in dry-cured hams in line with the recommendations from the World Health Organization to reduce sodium dietary consumption (World Health Organization — WHO, 2003). However, the reduction of added salt, without a previous reduction of the variability in salt absorption, results in a higher percentage of hams showing both quality and microbial stability problems due to insufficient salt content.

Salting can be explained as a two phase process. In the first phase, NaCl is dissolved on the ham surface which results in brine formation (Raoult-Wack, 1994) but some water on the lean surface is necessary to initiate the salting process. In the second phase, the Cl^- and Na^+ ions from the brine diffuse towards the internal part of the meat (Costa-Corredor, Muñoz, Arnau, & Gou, 2010; Djevel & Gros, 1988; Fox, 1980; Sabadini, Carvalho, Sobral, Do, & Hubinger, 1998). Factors affecting these two phases are therefore expected to contribute to the salt uptake heterogeneity.

Before salting, hams are stored in cold rooms for different periods of time (from hours to several days) due to differences in transport and processing time schedules. The duration and the conditions of storage until salting may affect the water content at the lean and rind surfaces, which in turn could affect the salt uptake during salting. Moreover, the temperature and relative humidity of the salting room can also affect the hydration level of NaCl.

Temperature during salting is set below 5 °C to reduce microbiological growth, but over 0 °C to avoid freezing. Although temperature is maintained within a narrow range of values, temperature variation can also contribute to the salt uptake variability. When the temperature of the salt in the salt pile is below 0.15 °C and the water contained in the salt-water mixture is below 38.1%, the NaCl hydrates and crystals of $NaCl \cdot 2H_2O$ are formed (Hall, Sterner, & Bodnar, 1988). The formation of these crystals on the lean surface of the hams can affect salt absorption. The temperature also affects the salt diffusion in the meat matrix (Djevel & Gros, 1988; Fox, 1980; González-Méndez, Gros, & Poma, 1983). However, the above studies were focused on a higher range of temperatures (from 3 °C to 40 °C) which represent only a part of the temperatures used during the salting process. The effect of temperatures closer to the freezing point of meat (−1.5 °C) (James, Lejay, Tortosa, Aizpurua, & James, 2005), which produces the maximum reduction in bacterial growth in fresh meat, has not yet been studied.

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The aim of this study was to evaluate the effects of both the water content at the lean surface before salting and the temperature during salting on salt uptake and water loss (both on average values and standard deviations) in hams.

2. Materials and methods

Three independent studies were performed in order to evaluate the effect of both the water content at the lean surface (Experiment 1 with loins, as a model of ham, and Experiment 2 with hams) and the temperature during salting (Experiment 3 with hams) on salt uptake and water loss.

The storage times before salting applied in Experiment 2 as well as the temperatures during salting applied in Experiment 3 were set to comply with the range of values obtained in a survey carried out at 20 dry-cured ham companies of Protected Designation of Origin (PDO) Teruel (Pérez-Beriain, 2012).

2.1. Experiment 1. Effect of water content at the surface of loins on salt uptake and water loss.

Four pork loins from different animals were obtained from a commercial slaughterhouse at 24 h *post-mortem*. Each loin was longitudinally divided into six pieces of 50 mm length, forming three pairs of adjacent pieces (Fig. 1). Two pieces of 20 mm length from each loin were also obtained to determine the basal NaCl content (0.25 ± 0.01%). For each pair of pieces, the area of the adjacent surfaces was calculated by averaging the two surface areas estimated using Image-Pro® Plus software (2008 ©Media Cybernetics). One piece from each pair was completely wrapped with 3 layers of a food grade PVC film (polyvinyl chloride, 9 µm thick, water-vapour transmission rate 200 g/m^2/24 h at 38 °C and 90% RH (ASTM, 1995); Macopal, S.L., Lliçà de Vall, Spain) (control, C); while the other piece was also wrapped except for the adjacent surface (surface-dried, D), where most of the water loss was expected to occur. The loin pieces were stored together at 3–5 °C, 60–70% relative humidity and constant ventilation for 3 days. In order to stress differences in surface water content between C and D loin pieces, a ventilation of 3 m/s during storage was applied. Thereafter, the adjacent surfaces of C loin pieces were unwrapped and the water content at the adjacent surfaces of C and D loin pieces were determined by means of Near Infrared Spectroscopy (NIR) (Collell, Gou, Arnau, & Comaposada, 2011). All the loin pieces were dry-salted through their adjacent surfaces by contact with dry salt (4.7 ± 0.17% moisture) in a cold room at 3–5 °C and 80–90% relative humidity. Groups of three pairs of loin pieces were salted for 1, 2, 4 and 7 days. At the end of salting, the loin pieces were individually minced to determine their salt and water contents. The weight of the loin pieces was recorded when fresh, after 3 days of storage (just before salting) and after salting.

Salt uptake (M_s, kg NaCl/m^2) was calculated with Eq. (1):

$$M_s = \frac{\left(S \times W_{as} - S_b \times W_f\right)/100}{A} \quad (1)$$

where, S (%) is the NaCl content after salting, S_b is the basal NaCl content (0.25%), W (kg) is the loin piece weight when fresh (f) or after salting (as) and A (m^2) is the area of adjacent surface.

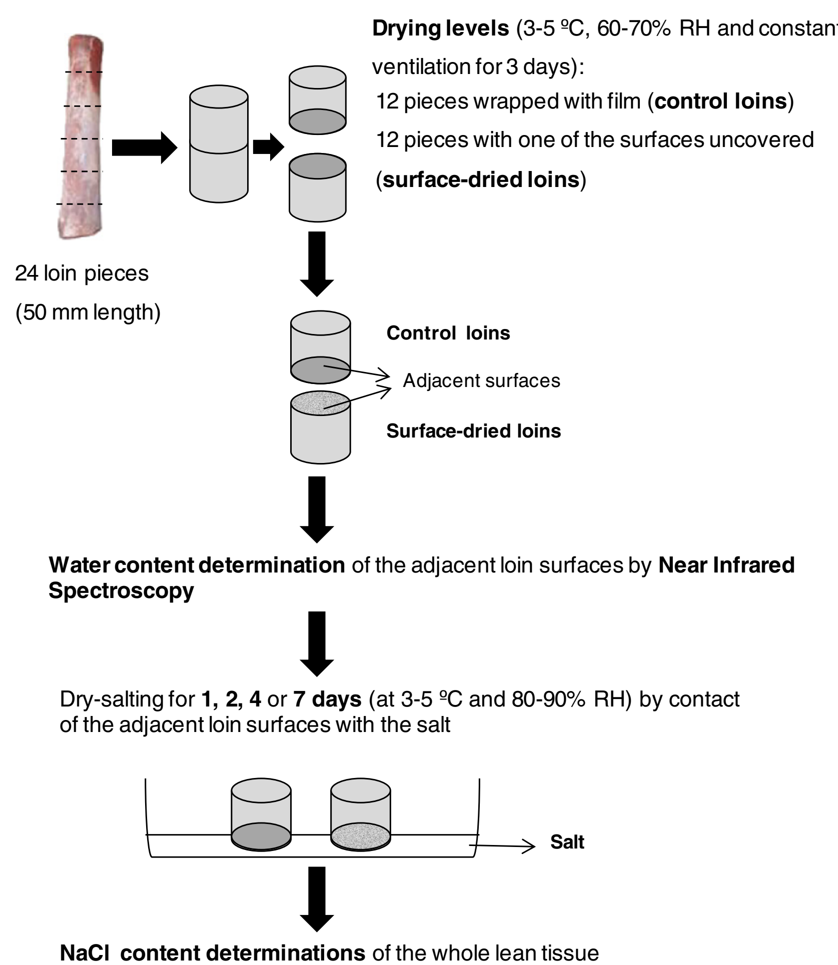

Fig. 1. Experimental design for Experiment 1.