

Preparation of Raw Hams, Comparison of Texture, Colour, Moisture and A_w

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ABSTRACT

Raw ham embodies an ancient culinary preparation, which is a way of preserving meat by salting and subsequent drying. In Chile, the demand for cured ham has been on the rise recently, which is why there has been a growing interest in taking advantage of the characteristics of naturally reared pigs and producing cured ham artisanal to give greater added value to the production. This work produced this product and evaluated its physical characteristics. The raw material was obtained from pasture-raised pigs. Five left legs salted with sodium chloride (Treatment A) and five right legs salted with a mixture of sodium chloride and potassium chloride (Treatment B) were used. The data obtained were compared with pork (control) and a commercial ham. The weight of the legs was measured weekly, obtaining a final weight loss of 6.81 ± 0.35 kg for treatment A and 6.89 ± 0.35 kg for treatment B, with a cumulative weight loss of 33.7 and 32.9% respectively. In relation to texture, colour, humidity percentage and a_w , the values tend to be different between the hams of treatment A and B. It was not significant ($p > 0.05$) between treatments.

KEYWORDS: Ham; Leg; Texture; a_w

INTRODUCTION

Raw ham embodies an ancient culinary preparation, which since time immemorial has been a way of preserving meat by salting and subsequent drying [1]. The traditional process of producing cured ham includes several stages: salting, washing-pressing, post-salting, maturing, drying and the final stage of cellaring [2,3]. Salting is one of the critical stages, as it is the phase of the process in which the curing salts are added to the surface of the ham so that once they have been distributed throughout the piece, the maturation process can take place, generating the desired appearance, texture, flavor and aroma of the product [3,4].

Ham is a whole raw jerky and anatomical parts of the pig, which corresponds to the osteomuscular parts from the hind limbs, sectioned by the ischio-pubic symphysis, consisting of the coxal bones, femur, patella, tibia, fibula and, optionally, the metatarsus and phalanges, as well as the muscle mass that surrounds it

[5,14]. Microorganisms can find true ecosystems in food, composed of intrinsic factors inherent to food, e.g., pH, a_w , and nutrients, and extrinsic factors external to it, e.g., temperature, environmental gases, and the presence of other bacteria [6,7]. In fresh meat, the a_w is 0.99 in the lean part of the muscle, with a water content of 74 to 80% [8,9]. Meanwhile, in Iberian hams, the final product has a_w values of up to 0.85 or even lower; pH values typically in the range of 5.6 to 6.5, and a salt content reaching values of around 6 to 10% NaCl [10,11]. In traditional Spanish hams, and as reported by Arnau et al. [4], these have pH values between 5.9 and 6.4 at the end of the process; the salt content is around 3% and the water activity reaches values of 0.7 to 0.72. This work aimed to evaluate and compare the physical characteristics of the raw material (pork), of raw hams processed with 100% NaCl and with a mixture of 75% NaCl and 25% KCl.

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MATERIALS AND METHODS

Sample Size and Unit of Analysis

This is a prospective technical feasibility study. The sample size was determined considering the Na concentration, as it is the most important public health parameter in this study. A minimum of 5 legs per group is necessary to detect a 10 and 8% difference in Na in ham, with 80% power and 95% confidence, for a one-tailed statistical test [29]. The pigs were reared in the province of Linares (latitude-36.1431084 and longitude-71.8260498), Chile. These animals were hybrids (Duroc with commercial line); they were raised under a mixed pasture-based and grain-finished system. The animals were kept until they reached a final live weight of 110 kg. They were then sent to a slaughterhouse and the carcasses were inspected according to Chilean law. For the test, one leg was taken from each animal used for treatment A (left) and B (right) [30,31].

The Cured Ham Production Process

Ten legs from the five slaughtered pigs were subjected to a dry-curing process based on the Ministry of Agriculture, Fisheries and Food method [14] for the production of Serrano ham using two curing treatments. The left legs (mean weight 10.28±0.46kg) were treated with 100% NaCl, while the right legs (mean weight 10.28±0.69kg) were treated with a NaCl/KCl mixture (75% and 25%).

In summary, the processing of cured ham was conducted in four stages (salting, post-salting, drying and maturing). First, during salting, the ham was covered with salt for 1.5 days kg⁻¹ weight and stored at 3 °C [1]. Second, during post-salting, the salt receded, and the ham was washed and dried. During drying, following a sequence of gradual and progressive increase in temperature and exposure time, the ham was stored at 3 °C for 95 days. For a uniform preparation, a drying and maturation platform was used, which contained the hams hung and protected from insects, so that they could reach the required ambient temperature of 20-30 °C [32,33]. Finally, during the maturation stages, the ham was stored on racks at room temperature for 280 days.

Artisanal Production of Raw Ham

To obtain the raw material, 10 legs were selected from pigs with skin and hooves raised in the commune of Parral. The pigs used were raised under the following two months of rearing and weaning, five and a half months of grazing in sown pastures and a final period of finishing in a pen being fed only with grains. The animals were slaughtered at 9 months of age, with an average live weight of 109.2±4.1kg. After deboning, they were kept in cold chambers at 3 °C for 5 days until the start of processing.

Salting lasted for 15 days. The period of the legs in salt was calculated on the basis of the average weight of the refrigerated legs, using 1.5 days for each kg of weight [1,15]. Once the salt was applied, the legs were kept refrigerated at 3 °C during the whole salting process.

Physical Evaluations of Raw Material and Finished Product

The evaluation of weight losses during the processing steps was conducted by recording the behavior of water losses during all processing steps. During salting, an initial weighing and recording was conducted and another one at the end after the salt had been

removed. In the post-salting, drying and maturing stages, weekly weighing were carried out.

Texture evaluation was performed using a Kramer® press on the INSTRON® universal testing machine with test specimens controlled for area and thickness. Two repetitions were made for each determination for the control, treatment A and B.

The colour evaluation was carried out with 3 mm thick ham slices analysed in a Hunter Lab Color QUEST® Color QUEST® reflection spectrophotometer. Illuminant B was used at an angle of 45° and on a 2.54-centimetre diameter scope. Three replicates were made for each determination for the control, treatment A and B.

Moisture evaluation, according to AOAC Standard, was done one repetition for each determination for the control, treatment A and B.

The evaluation of water activity (a_w) was carried out on 3mm thick sliced ham samples in a tank with a Novasina aw meter at 20 °C. One repetition was made for each determination for control, treatment A and B.

Statistical Analysis

To analyse the normality condition of the data, we used the Shapiro-Wilks normality test. For descriptive statistics, we used to mean and S.D. for pH, Na and K concentration. The data do not have a normal distribution, so to analyse the difference between the medians of pH, Na and K concentration for treatments A and B, we used the Kruskal-Wallis test with a confidence level of 95%. In addition, Pearson's correlation coefficients between pH, Na and K were tested at 90% confidence level.

RESULTS

Evaluation of Weight Losses During the Processing Steps

The average initial weight of the legs of treatment A was 10.28±0.46kg and 10.28±0.69kg for treatment B. At the end of salting, the legs of treatment A lost 0.85kg and 0.89kg in treatment B, representing 8.3% and 8.7% weight loss, respectively, attributing this to the water removed by the salt. During the 95 days post-salting, the weight loss reached 1.47kg in treatment A and 1.22kg in treatment B, with a weight loss of 22.5% and 20.5% in each treatment, which represented the greatest weight loss of the three processing stages, being greater than the drying stage, where higher temperatures are reached and humidity decreases. The weight loss achieved at the end of drying and maturation reached 33.7% for treatment A and 32.9% for treatment B, giving the hams an average weight of 6.81kg and 6.89kg, respectively.

The biggest difference in weight loss between the hams of treatment A and B is found in the post-salting stage, being 2.5% higher in treatment A. Statistically, there is no significant difference in weight loss between treatments A and B, with a $p=0.05$ (Figure 1).

During salting, the average final weight of the hams was 9.43±0.64 for Treatment A and 9.39±0.46kg for B, with a cumulative weight loss of 8.3 and 8.7% due to salt-induced dehydration, respectively.

During post-salting, an average leg weight of 7.96±0.41 for treatment A and 8.17±0.55kg for treatment B was obtained, with a cumulative weight loss of 22.5 and 20.5% respectively.

At drying and maturation, the average leg weight was 6.81±0.35kg for Treatment A and 6.89±0.35kg for Treatment B, with a cumulative weight loss of 33.7 and 32.9% respectively.

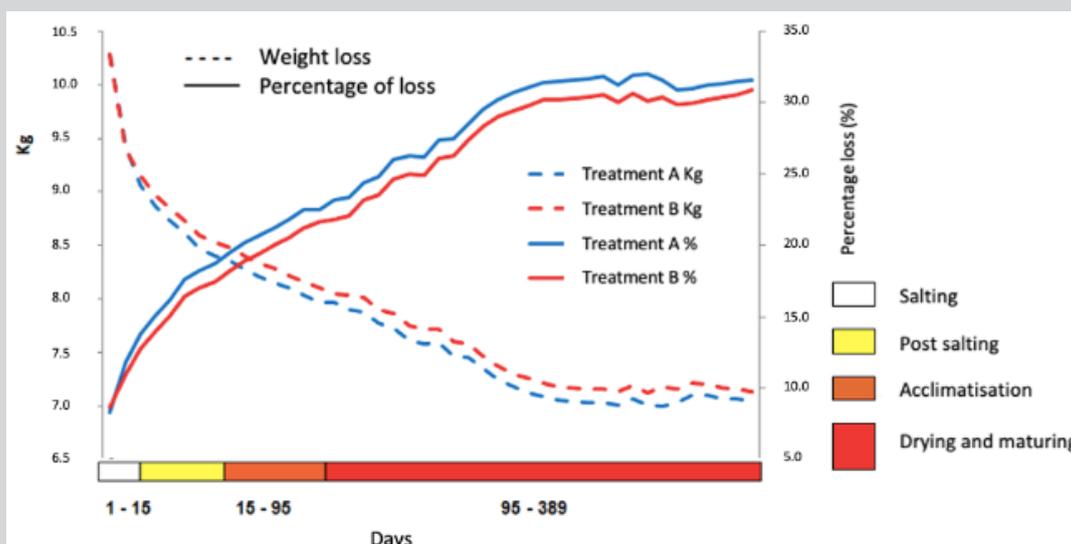


Figure 1: Weight losses and percentage of loss of raw artisanal hams from pigs at each of the processing stages.

Texture Evaluation

During the slope analysis, the interaction between treatment A and B hams and the commercial ham was not significant ($p>0.05$).

Alternatively, when relating the artisan and industrial hams to the control group, there is a marked statistical difference, where $p<0.007$, for the 3 hams (Table 1).

Table 1: Average slope and SD of artisanal hams treatment A and B, commercial ham and control (pork).

Pending (Nmm-1)	
Treatment A	311.011±111.78
Treatment B	304.841±74.202
Commercial ham	412.03±178.163
Control	152.161±49.135

There is no significant difference between treatments. This means that both NaCl and KCl produce the same texture in the finished product. The slight difference in the hams from treatment A and B is due to the lower amount of NaCl used in processing [21].

for the preservation of meat products due to its bacteriostatic effect [3,16]. The highest value in relation to the maximum point is for the commercial ham and the lowest for the control group (Table 2). Between the hams of Treatment, A and B, there is a difference that is not significant ($p=0.65$). The same occurs when comparing the hams, treatment A and B, with the commercial ham ($p=0.1$). On the other hand, when analysing the commercial ham and the control ham together, there is a difference that is significant ($p=0.028$).

Salt improves the technological suitability of meat products. In addition, it affects texture by increasing the water retention capacity, facilitates the incorporation of fat into the meat mass and is also essential for developing aroma and flavour. It is also necessary

Table 2: Average maximum* breaking point and SD of hams of treatment A, treatment B, commercial ham and control (pork).

Maximum Breaking Point (N)	
Treatment A	841,107±206,073
Treatment B	757,213±208,928
Commercial ham	1512,53±352,129
Control	667,87±191,486

Colour Assessment

The CIE L a b (CIELAB) is the colour model commonly used to describe all colours that can be perceived by the human eye. It was developed specifically for this purpose by the Commission Internationale d’Eclairage (International Commission on Illumination), which is why it is abbreviated CIE. The three parameters in the model represent the colour luminosity (L, L=0

yields black and L=100 indicates white), its position between red and green (negative values of a indicate green while positive values of a indicate red) and its position between yellow and blue (negative values of b indicate blue and positive values of b indicate yellow).

The behaviour of the different hams analysed in this study, once the production process is finished, is shown (Figure 2). It is clearly seen in the graph that the hams of Treatment A, Treatment B, and

Commercial ham have the same tendency, unlike the control group, where their trajectory is modified in the blue line. This colour

change in the control is associated with the fact that there is still an instability of the pigments in the muscle (Table 3).

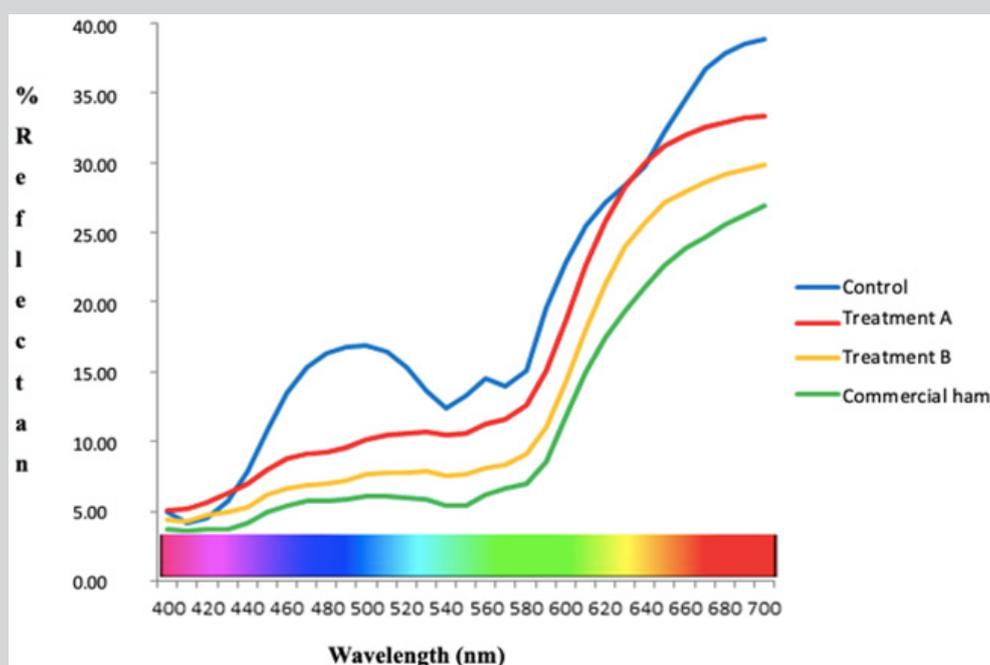


Figure 2: Percentage of hams from treatment A, treatment B, commercial ham and control (pork).

Table 3: Mean colour and SD of hams from treatment A, treatment B, commercial ham and control (pork). (CIELAB).

	L*	a*	b*
Treatment A	37.64±4.118	17.53±1.419	14.26±2.344
Treatment B	43.02±1.956	16.2±1.579	16.1±1.307
Commercial ham	33.57±3.057	17.86±2.619	12.62±3.587
Control	47.71±4.086	9.51±0.827	14.7±0.517

Evaluation of Moisture Content

The average moisture value expressed as a percentage of hams from treatment A was 42.65±4.31%, 40.35±4.02% for treatment B, 38.21±0.43% for the commercial ham and 68.08±1.61% for the control.

There is no difference ($p=0.5$) between the humidity values for the hams. Regarding the control group, it is observed that it is higher between 18 and 20% compared to the hams.

Evaluation of Water Activity (a_w)

The a_w value of Treatment A was 0.723±0.0379, Treatment B was 0.6866±0.0357, Commercial Ham was 0.725±0.0095 and the control group was 0.9206±0.0117. In addition, we can see that the ham from treatment B has a slightly lower a_w than the hams from treatment A and commercial ham. The control group had the highest value compared with the hams analysed. There was no significant difference between treatments.

DISCUSSION

When comparing the processing stages, there was a sharp decrease in weight during salting, in contrast to post-salting and drying, and maturing, where an 8% decrease in weight was generated in a shorter time. In the subsequent stages after salting, the decrease in weight became more gradual and the slope of the curve in the graph did not become steep. In the acclimatization

phase, belonging to post-salting (orange in the graph, Figure 1), the hams begin to progressively leave the refrigeration temperatures at which they were during post-salting. However, in this phase, the weight loss curve maintained its trend, with a slight increase in weights associated with the uptake of ambient humidity because in artisanal processing the temperature, speed and humidity of the air are not controlled, so that the weight variation becomes dependent on the storage conditions of the hams. The weight loss results of this study coincide with those defined by the Spanish Ministry of Agriculture, Fisheries and Food [14] for the production of Serrano ham, with the processing period being higher than the established minimum of 210 days, and the weight loss is similar to established 33%.

Texture is a physical test that is directly related to the tenderness of the meat when it is consumed; this is a characteristic directly related to the muscle structure, that is, to the myofibrillar protein, which form an integral part of the structure of the muscle fibre and collagen [17,18].

The modulus of elasticity is the ratio of the increase in stress to the corresponding change in unit strain. If the stress is tension or compression, the modulus is called Young's modulus and has the same value for tension as for compression [19].

Meat colour can vary from the deep red purple of freshly cut beef to the light grey of discoloured pork. Fortunately, the meat colour can be controlled if the factors influencing it are understood.

The colour of fresh and cured meat depends on myoglobin, but they are considerably different from each other in terms of how they are formed and their overall stability [12,20].

According to Armenteros [21], the moisture values of hams are within the expected range, because of water losses due to dehydration during the different stages of the production process. The decrease in moisture content during the salting stage is due to the osmotic effect produced by the salt covering the surface of the ham [3,22,23]. The losses that occur at this stage of the process are 3 to 7%; if the salt absorbed is taken into account, the total amount of water lost is between 6 and 10% [24]. Hams from treatment A lost 8.3% and those from treatment B 8.7%.

The water activity parameter (a_w) is defined as the ratio of the water vapour pressure of a food to the vapor pressure of pure water. The values reached by this parameter can range from 0 to 1, its value being indicative of the strength with which water is retained in the feed. The smaller the value of a_w , the less free water is available in the food and the more strongly the water is retained in the food [25,26].

Salt is one of the most widely used food additives as a preservative over the centuries. It has also been used for its properties in enhancing the flavour of food [13]. Salt has also been used, especially in the meat industry, to improve water adsorption. Although salt does not have direct antimicrobial action, its ability as a water activity (a_w) reducing agent in food reduces or even interrupts vital microbial processes.

A high salt concentration generates changes in cell metabolism, due to the osmotic effect, generating an effect in different concentrations on different classes of microorganisms [3,26,27]. One of the main objectives of the process of obtaining cured ham is the microbiological stabilization of the meat, which is achieved fundamentally by decreasing the water activity [3,24].

The average initial weight of the legs of treatment A was 10.28±0.46kg and 10.28±0.69kg for treatment B, because of the dehydration of the artisanal raw hams, reaching an average weight of 6.81kg for treatment A and 6.89kg for treatment B. In the finished product, the total loss of water during the process was 33.7% and 32.9% respectively.

There was no significant difference ($p>0.05$) in texture, colour, a_w and moisture percentage between hams from treatments A and B.

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