

## **Production of dry-cured pork loin using water vapour permeable bags**

**Fuentes, A., Verdú, S., Fuentes, C., Grau, R., Barat, J.M.**

CUINA group. Department of Food Technology. Universitat Politècnica de València, Valencia, Spain

\*E-mail of the corresponding author: [anfuelo@upvnet.upv.es](mailto:anfuelo@upvnet.upv.es)

---

### ***Abstract***

*The aim of the present study was to develop an alternative method to the traditional curing process using water vapour permeable bags to obtain a dry-cured pork loin product. The dry-cured pork loins obtained by this new process showed an adequate hygienic quality and good sensory acceptance. The salting-curing process using water permeable bags requires less manipulation, reduces waste generation and allows greater control during processing. This technique could be an interesting alternative to the traditional processes, improving the hygienic quality of the products and minimizing the environmental impact.*

**Keywords:** *Dry-cured loin; Salting; Water vapour permeable bags; Physicochemical properties; Sensory.*

---

## **1. Introduction**

The meat industry innovations are focus on improving the traditional curing processes. Producers seek new methods to reduce processing times, minimise salt waste, reduce overall weight loss and/or improve the hygienic quality. In this line, a new salting process in which the exact amount of salt to be absorbed by the product is directly dosed was proposed by Fuentes et al.<sup>[1]</sup>. This controlled procedure has been applied to different fish products reducing waste and product variability. The combination of this controlled salting process and vacuum packaging was able to accelerate NaCl absorption and dehydration, and can therefore cut the total processing time without affecting physicochemical parameters and sensory traits as compared with traditional fish products. Recently, materials with high water vapour transmission rates have been investigated. The use of highly water vapour-permeable bags (WP) facilitates the control of product dehydration by managing the temperature and humidity conditions, as with the traditional methods (unpacked) and minimising the risk of microbial contamination<sup>[2]</sup>. The combination of controlled salting process with WP bags has been studied to obtain smoke-flavoured fish with similar sensory traits to smoke products obtained by traditional methods and would optimise yields, reduce waste, speed up processes, maintain the hygienic quality during processes, and facilitate transportation and distribution at the same time<sup>[3,4]</sup>. For this reason, we considered that this promising technique could be implemented in the meat sector; making necessary adjustments.

The aim of the present study was to develop an alternative method to the traditional curing process using water vapour permeable bags to obtain a dry-cured pork loin product with physicochemical, microbiological and sensory characteristics similar to traditional products.

## **2. Materials and Methods**

### **2.1. Experimental design**

Pork loin processing was carried out using a controlled salting process where the exact amount of salt, necessary for the product to reach a targeted salt concentration, was dosed. The amount of salt added to each sample was individually calculated from the initial pork loin weight and the initial meat moisture. Pork loins were covered with a thin and homogeneous layer of salt, and then, vacuum-packed in the water vapour permeable bags. Initially, the salting-drying process was carried out at 85% relative humidity (RH) and 4 °C, and these conditions were modified during the process until reaching 65% RH and 10 °C. The loins were kept in the drying chamber until a weight loss of 40% was reached. At the end of the process, the loins were analysed to determine their physicochemical parameters (moisture, salt, aw, pH, total nitrogen and non-protein nitrogen), texture, colour, microbial



counts (mesophilic bacteria, lactic acid bacteria and *Enterobacteriaceae*), and sensory profile.

## 2.2. Analytical determinations

### 2.2.1. Physicochemical analyses

During processing, weight changes in pork loin ( $\Delta M_t$ ) were calculated considering the sample weight at each time and the initial sample weight.

Moisture and lipid content were determined according to the AOAC methods<sup>[5]</sup>. The pH measurements were taken by a micropH 2001 digital pH-meter (Crison Instruments, S.A., Barcelona, Spain) with a puncture electrode (Crison 5231) at five different locations on pork loin sample. Chloride content was determined after sample homogenisation in distilled water using an automatic Sherwood Chloride Analyser Model 926 (Sherwood Scientific Ltd., Cambridge, UK). Water activity ( $a_w$ ) was measured with an Aqualab dew point hygrometer model 4TE (Decagon Devices, Inc., Washington, USA). Total nitrogen (TN) and non-protein nitrogen (NPN) was measured following the method described by Standnik and Dolatowski<sup>[6]</sup>.

Colour determination was directly performed on the pork loin slices. A Minolta CM-700-d photocolourimeter (Minolta, Osaka, Japan) was used, with a 10° observer and illuminant D65. Using the CIE L\*a\*b\* coordinates (where L\* is lightness, a\* deviation towards red or green, and b\* deviation towards yellow or blue), the psychophysical magnitudes of hue ( $h_{ab}^*$ ) and chroma ( $C_{ab}^*$ ) were calculated.

A texture profile analysis (TPA) was performed on the pork loin samples with a Texture Analyser TA.XT2® 174 (Stable Micro Systems, Surrey, UK) equipped with a load cell of 250 N. For this measurement, a flat-ended cylindrical plunger (7.5mm diameter) was employed. This plunger was pressed into the sample at a constant speed of 1 mm/s until it reached 50% of sample height. Samples for this analysis were obtained from middle part of each loin, which were sliced and cut to obtain parallelepiped pieces (1x1x3 cm). Force-distance curves were processed to obtain hardness, chewiness, adhesiveness, springiness, cohesiveness and resilience parameters.

### 2.2.2. Microbiological analyses

Mesophilic bacteria, *Enterobacteriaceae* and lactic acid bacteria were determined according to the methods given by the following ISO standards <sup>[7,8,9]</sup>. The results were expressed as log cfu/g.

### 2.2.3. Sensory analysis

A trained panel undertook the sensory evaluation using quantitative descriptive analysis (QDA). Tests were done with the semi-structured scales (from 0 (very low) to 10 (very

high) by which attributes such red colour intensity, color homogeneity, brightness, hardness, adhesiveness, odour and cured flavor were evaluated.

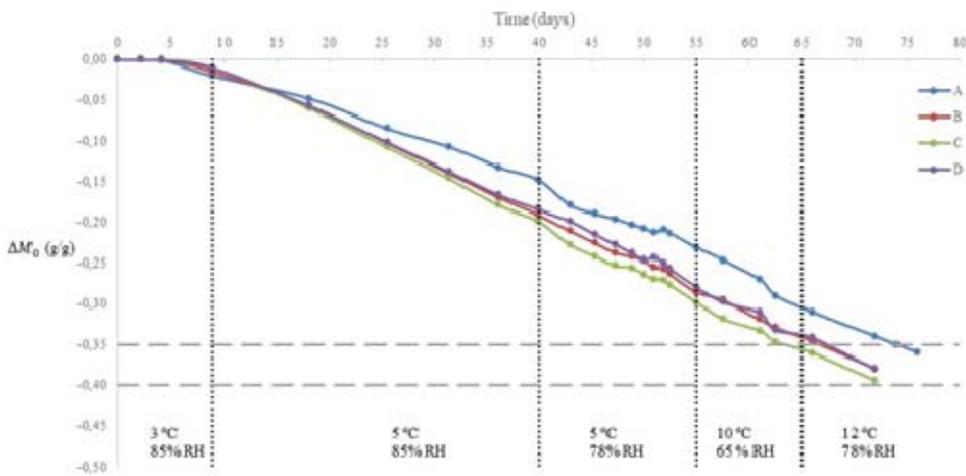
### 2.3. Estatistical analysis

One-way analysis of variance (ANOVA) was conducted to establish significant differences between samples. The least significant difference (LSD) procedure was used to test for differences between averages at the 5% significance level. Statistical treatment was performed using Statgraphics Centurion XVI (Manugistics Inc., Rockville, MD, USA).

## 3. Results and discussion

### 3.1. Changes in phisicochemical parameters

During the elaboration of the dry-cured pork loin, the loins were weighed periodically with the aim of determining the product weight loss at each sampling time and estimating the end of the drying period (Fig. 1). The salting-curing process lasted for 75 days. In this sense, considering that cured loins have usually a curing period of about 3 months, it could be established that this new process would allow to slightly reduce processing time.



*Fig. 1 Total weight changes during the salting process in pork loins obtained by using water permeable bags (average value  $\pm$  standard deviation of each batch).*

After processing, moisture of the dry-cured pork loin samples was determined. Moisture was separately measured in the central and in the outer part of the slices in order to detect crust formation during the process. Significant differences were observed between the moisture values of the central and outer parts of the loins ( $p < 0.001$ ), being these differences lower than 2% which evidences the absence of crusting in the pieces obtained by the

procedure developed in this work. Average moisture values were within the range established for commercial products.

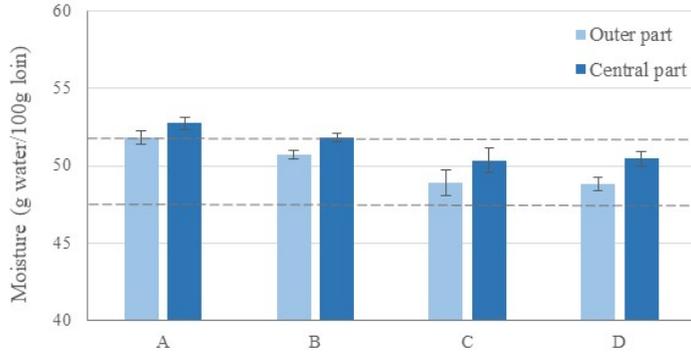


Fig. 2. Moisture values of dry-cured pork loins (mean values  $\pm$  standard deviation,  $n=3$ ). The dashed lines represent reference values.

Values of pH, salt content, and  $a_w$  in the different batches processed by the new procedure are shown in table 1.

Table 1. Physicochemical parameters in pork loins (average value  $\pm$  standard deviation,  $n=3$ ).

Parameter	A	B	C	D
pH	5.66 $\pm$ 0.02	5.78 $\pm$ 0.02	5.79 $\pm$ 0.05	5.87 $\pm$ 0.06
NaCl	4.43 $\pm$ 0.12	4.7 $\pm$ 0.2	4.59 $\pm$ 0.16	4.69 $\pm$ 0.14
$a_w$	0.9263 $\pm$ 0.0004	0.9196 $\pm$ 0.0001	0.9171 $\pm$ 0.0053	0.9198 $\pm$ 0.0015
TN	5.3 $\pm$ 0.6	5.3 $\pm$ 0.32	5.1 $\pm$ 0.5	4.7 $\pm$ 0.8
NPN	153 $\pm$ 15	199 $\pm$ 1.9	158 $\pm$ 30	196 $\pm$ 33

NaCl: salt content (g NaCl/100 g); TN: total nitrogen (mg/100 g dry matter), NPN: non-protein nitrogen (mg/100 g dry matter)

Salt content in the dry-cured products obtained in this study was similar than those reported by other authors<sup>[10,11]</sup>. The water content reduction and NaCl incorporation in the meat product as a consequence of the salting-curing process led to a  $a_w$  values reduction. No significant differences were observed regarding to total nitrogen and non-protein nitrogen among samples. During curing period, the proteolytic breakdown of meat proteins increases nonprotein nitrogen concentration in the product. These changes in proteins are an important source of flavour compounds through the involvement of amino acids and small peptides<sup>[12]</sup>. The lower NNP content could be attributed to the shorter ageing period in the present study compared with the traditional processes

Mecanical and colour parameters were similar than those reported in other studies for this type of product (data not shown). These results indicate that the new procedure do not modify texture and appearance of the dry-cured loin compared to the traditional products.

### 3.2. Microbial analyses

The counts for mesophilic, lactic acid bacteria and *Enterobacteriaceae* are shown in Table 2. Dry-cured pork loin samples, showed low levels of mesophilic bacteria and *Enterobacteriaceae* counts were below the detection limit ( $<10^2$  CFU/g).

**Table 2.** Counts of mesophilic, lactic acid bacteria and *Enterobacteriaceae* (average values  $\pm$  standard deviation, n=3)

Parameter	A	B	C	D
Mesophilic bacteria	3.9 $\pm$ 0.2	3.7 $\pm$ 0.3	4.1 $\pm$ 0.5	3.16 $\pm$ 0.12
Lactic acid bacteria	3.1 $\pm$ 0.2	3.2 $\pm$ 0.3	3.6 $\pm$ 0.5	3.05 $\pm$ 0.13
<i>Enterobacteriaceae</i>	nd	nd	nd	nd

These results indicate that the hygienic conditions employed during processing were correct, wich allow to obtained a dry-cured product with a high hygenic quality. As it can be observed, the new procedure does not affect the growth of lactic acid, whose development is considered necessary to control the proliferation of certain altering microorganisms such as coliform bacteria<sup>[13]</sup>.

A sensory analysis was carried out to check the acceptability of the new dry-cured pork loin. The tested samples were those obtained by the new technology (WP) and the commercial ones. The overall scores marked by the assessors for the sensory attributes of the samples are depicted in Fig. 3. No significant differences were recorded between samples for colour homogeneity, brightness and adhesiveness ( $p>0.05$ ). However, commercial samples had a higher intnesity regarding the colour, hardness, and cured flavour. The lower intensity of those attributes in the new products could be correlated with dry-curing time. The increase on taste active components during processins of dry-cured meat products has been reported<sup>[14]</sup>, therefore length of curing exhibit a strong correlation with the typical flavour of these type of products.

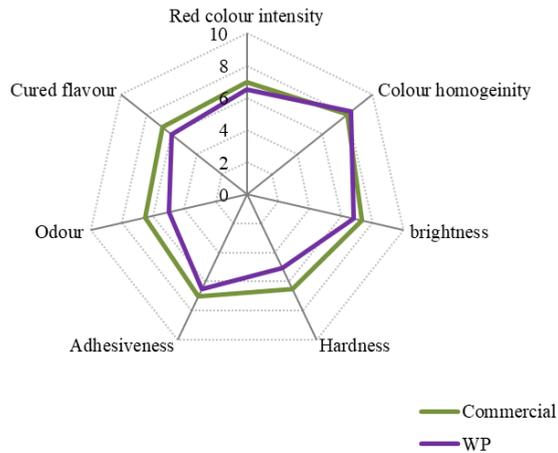


Fig. 3. Score average for the different attributes evaluated in samples of commercial dry-cured prok loin and the new product (WP).

#### 4. Conclusions

The processing conditions used and the exact dosage of the salt have been adequate to obtain a dry-cured pork loin with moisture, salt and  $a_w$  values similar to the commercial products. These conditions have allowed to obtain a product with an adequate hygienic quality and a sensory profile similar to the traditional product. This new salting-curing process using water vapor permeable bags present several advantages compared to the traditional processes such as the lower handling of the product, waste reduction and higher control of the process.

#### 5. References

- [1] Fuentes, A.; Barat, J.M.; Fernández-Segovia, I.; Serra, J.A. Study of sea bass (*Dicentrarchus labrax* L.) salting process: kinetic and thermodynamic control. *Food Control* 2008, 19 (8), 757–763.
- [2] Rizo, A.; Mañes, V.; Fuentes, A.; Fernández-Segovia, I.; Barat, J.M. Physicochemical and microbial changes during storage of smoke-flavoured salmon obtained by a new method. *Food Control* 2015, 56, 195-201.
- [3] Rizo, A.; Mañes, V.; Fuentes, A.; Fernández-Segovia, I.; Barat, J.M. A novel process for obtaining smoke-flavoured salmon using water vapour permeable bags. *Journal of Food Engineering* 2015, 149, 44-50.
- [4] Rizo, A., Fuentes, A., Fernández-Segovia, I., Barat, J.M. Smoke-flavoured cod obtained by a new method using water vapour permeable bags. *Journal of Food Engineering* 2016, 179, 19-27.

- [5] Official Methods of Analysis, Association of Official Analytical Chemists, Washington 1997
- [6] Stadnik, J.; Dolatowski, Z.J. Changes in selected parameters related to proteolysis during ageing of dry-cured pork loins inoculated with probiotics. *Food Chemistry* 2013, 139, 67-71.
- [7] ISO 15214. (1998). Horizontal method for the enumeration of mesophilic lactic acid bacteria e Colony-count technique at 30 °C. Geneva, Switzerland: International Organization for Standardization.
- [8] ISO 21528-2. (2004). Horizontal methods for the detection and enumeration of Enterobacteriaceae Part 2: Colony-count method. Geneva, Switzerland: International Organization for Standardization.
- [9] ISO 4833. (2003). Horizontal method for the enumeration of microorganisms. Colony-count technique at 30 °C. Geneva, Switzerland: International Organization for Standardization.
- [10] Ventanas, J., (2006). *El jamón ibérico*. Madrid: Ediciones Mundi-Prensa.
- [11] Aliño, M.; Grau, R.; Toldrá, F.; Blesa, E.; Pagán, M.J.; Barat, J.M. Influence of sodium replacement on physicochemical properties of dry-cured loin, *Meat Science* 2010, 83(3), 423–430
- [12] Morales, R.; Serra, X.; Guerrero, L.; Gou, P. Softness in dry-cured porcine biceps femoris muscles in relation to meat quality characteristics and processing conditions. *Meat Science* 2007, 77(4), 662–669.
- [13] Yamanaka, H.; Akimoto, M.; Sameshima, T.; Arihara, K. Itoh, M. Effects of bacterial strains on the development of the ripening flavor of cured pork loins. *Journal of Animal Science* 2005, 76: 499-506.
- [14] Flores, M.; Aristoy, M.C.; Spanier, A.M.; Toldrá, F. Non-Volatile Components Effects on Quality of “Serrano” Dry-cured Ham as Related to Processing Time. *Journal of Food Science* 1997, 62, 1235-1239.

