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(54) **Title**: PREPARATION PROCESS OF PIECES OF WHOLE MUSCLE CURED RAW MEAT PRODUCTS

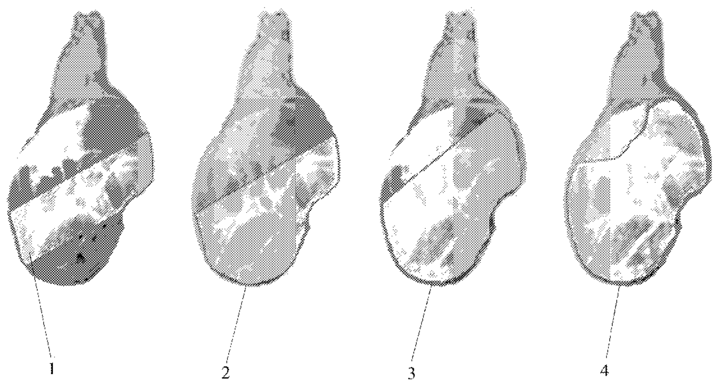

FIG.1

(57) **Abstract**: It comprises a salting stage followed by an air drying and maturation stage of said products, and it is characterized in that it includes the steps of: ai) determining a target amount of salt that each one of said pieces of meat product should have at the end of the salting stage, bi) applying salt to each one of said pieces of meat product during a salting period, to achieve the target determined in stage ai), ci) once a time t1 of said salting period has elapsed, estimating in a non-destructive fashion the amount of salt that each one of said pieces of meat product has, di) next, adjusting the salt content of each one of said pieces of meat product in accordance with the amount of salt estimated in stage ci) and continuing, if relevant, the salting until achieving said target amount of salt, and/or in that it includes the steps of: aii) determining a target weight decrease or target weight loss that each one of said pieces of meat product should have at the end of the drying and maturation stage, bii) during the drying and maturation, weighing each one of said pieces and taking measurements of the accumulated weight loss of each one of said pieces from the start of the preparation process, cii) next, covering a predetermined portion of lean surface of each one of said pieces with a predetermined amount of fat or lard, said proportion and amount of fat being determined in accordance with said accumulated weight loss and with said target weight loss, and continuing with the drying and maturation until achieving said target weight loss.

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PREPARATION PROCESS OF PIECES OF WHOLE MUSCLE CURED RAW MEAT PRODUCTS

The present invention relates to a preparation process of pieces of whole muscle cured raw meat products comprising a salting stage followed by an air drying and maturation stage of said products.

BACKGROUND OF THE INVENTION

The preparation process of whole muscle cured raw meat products, such as, for example, dry-cured hams, is a complex process that includes a salting stage wherein the whole piece is covered with salt during an approximate time of one day per kg. After the salting, the hams undergo a resting phase at low temperature (0 ºC – 5 ºC) during a few months, with the objective that the salt from the surface layers moves towards the interior of the ham. This stabilizes the product, limiting microbial development and enzymatic reactions. After the resting phase, the drying and maturation phase starts wherein the temperature is gradually increased, which facilitates the development of the texture and the aroma which characterize this type of product. During the drying and maturation phase, water is extracted from the product until achieving a target weight loss.

One of the main problems of preparing cured raw hams is the great variability in the final salt and water content of the hams of the same batch or different batches. This variability in the salt and water content produces a great variability of taste and texture of the hams marketed.

Numerous studies demonstrate that the salting and drying phase of the preparation process of cured raw hams is governed by numerous factors difficult to control on an industrial level which give rise to great variability (*Arnau, J. (2007). Factores que afectan a la salazón del jamón curado. Eurocarne, 160: 59 – 76*; *Boadas, C., Gou, P., Valero, A. and Arnau, J. (2000). "Changes in different zones of dry-cured ham during drying: Moisture and sodium chloride content". Fleischwirtschaft. International. 4: 45 – 48; Arnau, J., Guerrero, L., Casademont, G. and Gou, P. (1995). "Physical and chemical changes in different zones of normal and PSE dry cured ham during processing" Food Chemistry 52: 63 – 69).*

At present, to try to control the problems of variability in the taste and texture, emphasis is basically placed on the selection of a homogeneous raw materials in terms of weight, pH, fat content, genotype, etc., as well as in the control of the environmental conditions under which the salting and drying phases are carried out (temperature, humidity, air speed, composition of the salting salt, etc.).

Nevertheless, it has been observed that these practices are not sufficient to guarantee the obtainment of a homogeneous product in terms of taste and texture.

DESCRIPTION OF THE INVENTION

The objective of the present invention is to resolve the mentioned drawbacks, developing a preparation process of pieces of whole muscle cured raw meat products which has the advantage that it substantially reduces the variability in the taste and texture of the products obtained.

In accordance with this objective according to a first aspect, the present invention provides a preparation process of pieces of whole muscle cured raw meat products comprising a salting stage followed by an air drying and maturation stage of said products, and it is characterized in that, before the salting stage, the stage of determining in a non-destructive fashion the initial weight and the fat and protein content of each one of said pieces is carried out, and in that the salting stage includes the steps of:

ai) determining a target amount of salt that each one of said pieces of meat product should have at the end of the salting stage, said target amount of salt being determined in accordance with said initial weight and said fat and protein content,

bi) applying salt to each one of said pieces of meat product during a salting period, to achieve the target determined in stage ai),

ci) after a time *t1* of said salting period has elapsed, estimating in a non-destructive way the amount of salt that each one of said pieces of meat product has,

di) next, adjusting the amount of salt of each one of said pieces of meat product in accordance with the amount of salt determined in stage ci) and continuing, if relevant, the salting until achieving said target amount of salt,

and/or in that the air drying and maturation stage includes the steps of:

aii) determining a target weight decrease or target weight loss that each one of said pieces of meat product should have at the end of the drying and maturation stage, said decrease or weight loss being determined in accordance with said initial weight and said fat and protein content,

bii) during the drying and maturation, weighing each one of said pieces and taking measurements of the accumulated weight loss of each one of said pieces from the start of the preparation process,

cii) next, covering a predetermined portion of lean surface of each one of said pieces with a predetermined amount of fat or lard, said proportion and amount of fat being determined in accordance with the difference between said accumulated weight loss and of said target weight loss, and continuing with the drying and maturation until achieving said target weight loss.

Preferably, said pieces of raw meat product are whole muscle hams or shoulders.

The salting and drying and maturation stages of the process described enable the obtainment of very homogeneous water and salt content within the meat pieces of the same batch, or between pieces of different batches. It has also been verified that this process also enables the uniform distribution of the water and salt inside the meat pieces, which positively contributes to the uniformity in quality of the end product.

Another advantage of the process of the present invention stems from the fact that it facilitates the obtainment of products with reduced salt contents, since it enables a continuous control of salt and water content of the product that reduces the risks of alteration or growth of pathogens entailed by the reduction in salt content in the cured raw products.

Specifically with regard to the salting stage, the determination of a target amount of salt and the non-destructive estimation of the amount of salt of the meat pieces during the salting makes it possible to adjust the amount of salt of said pieces to achieve said target amount of salt. In this way, it is possible to achieve that each product satisfies the consumer's requirements.

With respect to the air drying and maturation stage, the greasing adapted to the weight loss kinetics of each one of said pieces enables a drying which contributes to the homogeneity in the salt distribution inside the pieces.

Indeed, the continuous control of the weight loss positively contributes to the uniformity of the end product obtained, since it avoids the fast dryings that lead to irregular distribution of the water and salt content and, therefore, to the obtainment of heterogeneous products from a sensory standpoint (taste and texture).

According to a second aspect, the present invention provides the use of a low-intensity X-ray inspection device, of the type that obtains images of an object projected in a single plane, to estimate in a non-destructive way the amount of salt of each piece of whole muscle raw meat product.

Surprisingly, it has been observed that it is possible to perform a non-destructive and reliable measurement of the salt content of a piece of meat product, such as, for example, a ham or ham shoulder, using a low-intensity X-ray inspection device which obtains images projected on a single plane of said pieces.

It has been verified that the overall attenuation of X-rays of a composite material can be determined as the sum of the attenuations of each one of the components.

The use of this inspection device is very suitable as it is very easy to apply on an industrial level and it is available in the market at economical prices.

This device shall preferably be used to estimate the amount of salt of said pieces from the X-ray attenuation values acquired at, at least, one emission energy of said X-rays, said attenuation values being calculated from images projected in a single plane of each one of said pieces, said estimated amount of salt being obtained by the prediction equation:

$$\textit{Amount of salt estimated (kg)} = a + bx + cy + \sum d_i z_i,$$

where:
x is the weight (kg) of the piece of meat product at the time of scanning,
y is the area (m^2) of the image of the piece of meat product,
z_i is the sum of the values of natural logarithm $\ln(I_{0i} / I_i)$ corresponding to all the pixels of the image of the meat product, where I_i is, for an emission energy i, the intensity of radiation transmitted captured by the detector after traversing the meat product, and I_{0i} is the intensity of incident radiation for the same emission energy i when it does not traverse the meat product, and
a, b, c and d_i are coefficients obtained on statistically adjusting the equation with amount of salt data and X-ray attenuation values obtained experimentally.

Going back to the process claimed, preferably, the non-destructive estimation of the salt content of each one of said pieces is carried out after a salting time *t1* of at least 3 days, since it has been verified that below this time practically no piece of meat exceeds the target amount of salt.

According to a first embodiment, in the salting stage, step di) of adjusting the amount of salt of each one of said pieces comprises the step of:

- determining, for each one of said pieces, a salting time *t2* additional to time *t1*, said additional salting time *t2* being determined from the amount of salt estimated in a non-destructive fashion in step ci) and mathematical prediction model which relates the increase in the amount of salt of each piece with the increase of the salting time at least in accordance with the fat content of each piece before salting.

This embodiment is also indicated for saltings carried out by immersing the product in brine.

It has been observed that is possible to reliably predict the additional salting time necessary to successfully adjust the amount of salt in the product to the target amount of salt. To estimate this additional time t2, mathematical prediction models can be used such as, for example, those described in the article "*Serra, X., Fulladosa, E., Gou, P., Arnau, J. (2010) " Models to predict the final salt content of dry-cured hams. 6th international conference on simulation and modelling in the food and bio-industry (Foodsim)". Summaries book, pg. 92. June 24 – 26, Bragança, Portugal."*

According to a second embodiment, in the salting stage, step di) of adjusting the amount of salt of each one of said pieces comprises the steps of:

- determining, for each one of said pieces, the additional amount of salt that must be incorporated in the product to achieve the target amount of salt established in stage ai), and

- applying said additional amount of salt to each one of said pieces of meat product.

It has been observed that it is possible to adjust the amount of salt in the product to the target amount of salt by adding the additional amount of salt necessary to said product. This amount of salt can also be added by other methods, such as, for example, an injection of brine, or sprinkling salt over the product.

Preferably, the non-destructive estimation of the amount of salt of each piece of stage ci) is carried out by a low-intensity X-ray inspection device, said determination including the steps of:

- scanning or obtaining by said device images of each one of said pieces in a single plane,

- estimating the amount of salt of each piece from the X-ray attenuation values acquired at, at least, one emission energy, said attenuation values being calculated from said images, and said amount of salt being estimated by the prediction equation:

$$\textit{Amount of salt estimated (kg)} = a + bx + cy + \sum d_i z_i,$$

where:
x (kg) is the weight of the piece of meat product at the time of scanning,
y is the area (m^2) of the image of the piece of meat product,

z_i is the sum of the values of natural logarithm $\ln(I_{0i} / I_i)$ corresponding to all the pixels of the image of the meat product, where I_i is, for an emission energy *i*, the intensity of radiation transmitted captured by the detector after traversing the meat product, and I_{0i} is the intensity of incident radiation for the same emission energy *i* when it does not traverse the meat product, and

a, *b*, *c* and d_i are coefficients obtained on statistically adjusting the equation with amount of salt data and X-ray attenuation values obtained experimentally.

In the present invention, emission energy *i* is understood as the emission energy from the X-ray unit obtained on using a determined voltage and electric current.

As commented, it has been observed that it is possible to make a reliable estimate of the salt content of a meat product using an X-ray inspection device of the type that obtains images in a single plane, which works at one or several emission energies. This inspection is useful for estimating the overall amount of salt in a whole muscle meat piece by the prediction equation.

It has been observed that the weight of the product and the area of the image with tissues are variables that condition the degree of attenuation obtained and help to adjust the prediction of the amount of salt.

Advantageously, the X-ray emission energy is obtained by the use of a voltage between 30 kV and 90 kV and electric current between 1 mA and 1.5 mA.

Preferably, in the process claimed, the target amount of salt that each one of said pieces of meat product must have is determined in accordance with the initial weight and the estimated fat and protein content and, furthermore, in accordance with a desired salt content in the water of the lean tissue and of the fat tissue of the piece of meat product at the end of the drying stage.

The fat and protein content can be estimated or determined in a non-destructive fashion by different units currently available on the market and which give a good prediction (Autofom®, Fat-O-Meat'er®, Capteur Grass-Maigre®, Hennessy Grading Probe®, X-ray inspection etc.). These units are mainly based on the use of ultrasounds, reflectance and/or electromagnetic radiations, the attenuation of which is related to the meat composition.

It has been observed that it is very useful to estimate the target salt content in accordance with the desired salt content in the water of the lean and fat tissue, at the end of the preparation process, since it is considered that the salt is mainly dissolved in the aqueous phase of the meat, and its concentration is mainly responsible for the intensity of the salty taste of the meat product and for the product's microbiological stability.

Advantageously, if the salt content estimated in stage ci) is greater than the target amount of salt, step di) of adjusting the amount of salt of each one of said pieces includes the stage of removing or eliminating the excess salt to achieve said target amount of salt.

Preferably, said stage of removing the excess salt is carried out, in accordance with the salt content, by one of the following treatments:

- pressurized air-blowing of each one of said meat pieces, and/or

- showering with low-pressure water of each one of said meat pieces, and/or

- washing with high-pressure water of said meat pieces.

It has been observed that the pressurized air-blowing is useful for eliminating the salt incrusted on the surface of the meat pieces, it being additionally necessary to apply a low-pressure shower to eliminate the remaining crystals of salt absorbed or, additionally, a high-pressure wash to eliminate part of the already absorbed salt.

Again preferably, the determination of the accumulated weight loss of each one of said pieces is carried out during the drying and maturation, after a time *t3* of the preparation process of between 4 and 7 months.

Advantageously, in step cii) of the drying and maturation stage, the following steps are carried out:

- determining, for each one of said meat pieces, the difference between the target weight loss and said accumulated weight loss determined during the drying and maturation,

- classifying the meat pieces in groups in accordance with the difference between the target weight loss and said accumulated weight loss,

- assigning to the group with least difference between the target weight loss and the accumulated weight loss, a percentage of coverage of 95 % to 100 % of the lean surface of said meat pieces,

- assigning to the other groups a percentage of coverage comprised between 30 % and 95 % of the lean surface of said meat pieces, the coverage percentages being less for the groups with greatest differences between the target weight loss and the accumulated weight loss.

As has been commented, the application of the fat or lard adapted to the accumulated weight loss of each meat piece enables a uniform distribution of the water and also of the salt inside the piece. This uniform distribution has a positive effect on the final quality of the product obtained and on the obtainment of a homogeneous product in terms of taste and texture.

With respect to the percentage of coverage, it has been observed that it is necessary to guarantee a minimum equivalent to the surface around the coxofemoral joint and adductor muscle. This minimum approximately corresponds to 30 % of the lean surface.

Preferably, said lean surface covered with fat or lard is surface without rind or subcutaneous fat, where the product dries faster, but where the risk of cracks appearing is greater, which may damage the ham.

Advantageously, said lean surface without rind or subcutaneous fat is detected by an artificial vision system.
Advantageously, the process includes several coverings steps of fat or lard.

In the present invention, salt is preferably understood as common salt or sodium chloride, although it can also be understood as a mixture of said sodium chloride with other types of salts or a mixture of different sodium chloride salts with another type of salts, or a mixture of said sodium chloride and other ingredients or additives, which can be used for the preparation of raw meat products with the basic purpose, in addition to contributing to taste and aroma, of stabilizing the product inhibiting the growth of pathogenic microorganisms, microbiological deterioration and increasing the shelf life of the product thanks to reduction in the water activity.

Salting is understood to mean the stage in the preparation process of whole muscle cured raw meat products during which salt is applied to the product with the purpose that the entire mass of the product (fat tissue, lean tissue, rind and bone) absorbs an amount of salt that allows said product to be stabilized.

Drying and air maturation are understood to mean the stage of the preparation process of whole muscle cured raw meat products during which a partial dehydration occurs of the product, subjecting said product, during several months, to an atmosphere of air with a controlled temperature and relative humidity to favour a series of physical, chemical and microbiological changes that largely determine the organoleptic characteristics of the end product.

Lean tissue is understood to mean the part of the meat piece composed of muscle, determined from its protein and water content.

Fat tissue is understood to be the part of the meat piece composed of adiposites determined from its fat and water content.

Protein shall be understood to mean the chemical compound of the meat whose content can be determined by multiplying the total nitrogen content by 6.25 (ISO R937 method).

Fat shall be understood to be the chemical content of the meat, whose content can be determined by extraction (ISO 1443 method).

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the aforementioned, a single figure 1 is attached wherein a practical embodiment is represented schematically and by way of non-limiting example.

Said figure 1 shows the distribution of fat applied to four hams each belonging to a different group of meat pieces obtained. The groups to which each one of said hams belongs have been obtained after being classified in accordance with a difference between the target weight loss and an accumulated weight loss determined during the drying and maturation stage.

<u>DESCRIPTION OF EXAMPLES</u>

Example 1: Preparation process of whole muscle cured raw hams. Salting stage

24 fresh hams were taken which were subdivided into two batches; one ham from each carcass was randomly assigned to each batch. All the hams were characterized before salting, determining in a non-destructive way the initial weight and the fat and protein content by conventional techniques.

The salting was carried out by common salt or sodium chloride. The first batch or control batch followed the standard process, where the hams were classified by weight into three groups: small (9 to 10.5 kg), medium (10.5 to 12 kg) and large (> 12 kg). The small ones were covered with common salt or sodium chloride (NaCl) during 11 days, the medium ones, during 12.5 days, and the large ones during 14 days.

The salting of the second batch or treatment batch followed the process claimed. Firstly, the target amount of common salt or NaCl for each ham was established in accordance with the initial fresh weight, with the estimated fat and protein content of the ham before the salting stage, and in accordance with the desired salt content in the water of the lean tissue and of the fat tissue at the end of the preparation process. The attached formula was used to determine the target amount of salt of each ham.

Formula to calculate the target amount of salt:

Target NaCl (kg) = X (kg fresh ham) · [A + B + C + D] · [E]

where,

$$A=\left[Y\left(\frac{kg\ fat}{kg\ fresh\ ham}\right)\cdot e\left(\frac{kg\ water\ in\ fat\ tissue\ at\ end\ of\ process}{kg\ fat}\right)\right]$$

$$B=\left[Z\left(\frac{kg\ protein}{kg\ fresh\ ham}\right)\cdot f\left(\frac{kg\ water\ in\ lean\ tissue\ at\ end\ of\ process}{kg\ protein}\right)\right]$$

$$C=\left[g\left(\frac{kg\ dehydrated\ rind}{kg\ fresh\ ham}\right)\cdot h\left(\frac{kg\ water\ in\ rind\ at\ end\ of\ process}{kg\ dehydrated\ rind}\right)\right]$$

$$D=\left[j\left(\frac{kg\ dehydrated\ bone}{kg\ fresh\ ham}\right)\cdot k\left(\frac{kg\ water\ in\ bone\ at\ end\ of\ process}{kg\ dehydrated\ bone}\right)\right]$$

$$E=\left[l\left(\frac{kg\ NaCl}{kg\ water\ in\ ham\ (fat.t.+lean\ t.+rind\ and\ bone)\ at\ end\ of\ process}\right)\right]$$

The target amount of salt was calculated both for the hams of the control batch and for the hams of the treatment batch using the following values for the parameters:

- $e = 0.05$
- $f = 1.4$
- $g = 0.05$
- $h = 0.35$
- $j = 0.13$
- $k = 0.05$
- $l = 0.09$

Table 1 shows the target values of the amount of salt obtained for the hams of the treatment batch.

Once the target amount of salt has been calculated, the hams of the treatment batch were covered with salt and, after four days of the salting period ($t1 = 4$), the amount of the salt that each one of the hams had was estimated in a non-destructive way. To do this, an X-ray inspection device such as that described in the description of the invention was used, which obtained images of each one of the hams in a single plane. Table 1 shows the values of the amount of salt of each one of the hams of the treatment batch after 4 days of salting.

Next, and in light of the target amount of salt established and the estimated content after 4 days of salting, the amount of salt of each one of the hams was adjusted. In this example, to adjust the amount of salt an additional salting time *t2* was determined by the attached formula which relates the increase in the amount of salt of each ham with the increase in salting time, in accordance with the fat content of the ham.

<u>Formula to determine the additional salting time *t2 (hours)*</u>

$$t2 = 251.1 + 262.1 \cdot \left(NaCl_{target} - NaCl_{4days}\right)(kg) + 0.913 \cdot Y\left(\frac{kg\ fat}{kg\ freshham}\right) - 706.6 \cdot NaCl_{4days}\ (kg)$$

Table 1 shows the additional salting time *t2* expressed in hours obtained for each one of the hams. These results made it possible to group the hams of the treatment batch in three different groups to which an additional salting time was applied to achieve the target amount of salt set.

At the end of the salting stage, the amount of salt absorbed in the hams of the control batch and the treatment batch was experimentally determined and deviations were calculated between the final amounts and the target amounts.

The results reveal that the mean error between the target amount of salt and the amount of salt absorbed in the hams of the treatment batch (0.011 kg) was approximately three and a half times less than the mean error of the hams of the control batch (0.038 kg), which confirms the process claimed reduces the variability of salt content.

On the other hand, deteriorated hams were not observed due to a deficient salt absorption. This is due to the fact that the process claimed allows adapting the time they remain in the salting pile to the salt absorption capacity of each piece and to the characteristics of the raw material.

<u>Table 1: Target amount of salt, amount of salt after 4 days of salting, amount of salt absorbed at the end of the salting</u>

<u>and additional salting time, in accordance with the weight and the estimated fat and protein content of each one of the hams of the treatment batch.</u>

Initial weight (*X*)	Fat (*Y*)	Protein (*Z*)	Target NaCl at the end of the salting	$NaCl_{4days}$	Additional time *t2*	*t2* Salting group	NaCl Absorbed at the end of the salting
kg	%	%	kg	kg	h	h	kg
10.407	11.42	17.26	0.254	0.155	178	182	0.287
10.480	7.39	18.19	0.266	0.146	186		0.271
11.026	8.65	17.97	0.278	0.153	184		0.272
10.822	8.26	18.03	0.273	0.148	187		0.294
10.505	10.92	17.39	0.258	0.132	200	206	0.272
10.892	13.57	16.84	0.261	0.131	205		0.236
15.869	20.77	15.87	0.366	0.167	204		0.365
11.342	13.55	16.90	0.273	0.133	207		0.278
12.616	10.04	17.87	0.317	0.141	207		0.299
10.284	17.00	15.98	0.237	0.101	231	232	0.230
13.113	19.03	15.90	0.302	0.121	231		0.300
12.260	21.27	15.28	0.274	0.113	233		0.267
11.947	18.64	15.83	0.274	0.109	235		0.279
12.123	20.53	15.43	0.273	0.112	233		0.265

<u>Example 2: Use of a low-intensity X-ray inspection device to estimate in a non-destructive way the amount of salt in the hams</u>.

12 pork hams were taken which had been 4 days in the salting process with NaCl. They were scanned by an X-ray inspection device (Dylog®, Italia) which obtains images of each one of the hams in a single plane. The X-ray emission energy which was used was obtained by a voltage of 50 kV and a current of 4.5 mA.

Scanning the hams made it possible to obtain a matrix of X-ray attenuation data for each ham. An experimentally developed prediction equation was applied to each one of the data matrices obtained, which related the X-ray attenuation with the amount of salt or NaCl of the ham with an adjustment error of 0.016 kg.

In the example described, the following formula was used to estimate the amount of salt or NaCl of each ham.

$$Kg\ NaCl_{4days} = 0.04775 - 0.08621 \cdot X - 6.27 \cdot Y + 0.00000145 \cdot Z$$

where,

X = Weight (kg) of the ham after 4 days of salting,
Y = Area (m^2) of the image of the piece of ham,

Z = sum of the values of ln (I_0 / I) corresponding to all the pixels of the image of the ham, where I is the intensity of radiation transmitted to an emission energy of *i* = 50 kV, captured by the detector after traversing the ham, and I_0 is the intensity of incident radiation for the same emission energy when it does not traverse the ham.

Table 2 shows the estimated values of amount of salt or NaCl absorbed for each one of the hams analysed after 4 days of salting process.

Table 2

Weight (kg) of the hams after 4 days of salting, kg	∑ln (I_0 / I) at 50 kV,	Area of the image (m^2)	Amount of NaCl after 4 days of salting, (kg NaCl)
8.7690	869497	0.0696	0.1163
10.2812	988746	0.0761	0.1184
10.3050	952165	0.0731	0.0819
10.6704	1033490	0.0825	0.1094
11.0902	1103016	0.0892	0.1322
11.1372	1067144	0.0866	0.0925
11.3266	1086471	0.0839	0.1208
11.5392	1066011	0.0799	0.0980
11.8118	1107300	0.0836	0.1109
11.8360	1114865	0.0874	0.0959
12.1470	1135351	0.0873	0.0998
12.3688	1156683	0.0905	0.0917
12.4224	1156432	0.0887	0.0980

Example 3: Preparation process of whole muscle cured raw hams: Stage of removal / elimination of excess salt.

A batch of 60 hams was prepared which was subjected to a standard salting process with NaCl by placing in salt pile (1 day / kg of initial weight of ham). At the end of the salting, the salt content of all the hams was estimated using X-ray inspection (Dylog®, Italy), half of the hams underwent a standard washing with running water (control batch) and the other half underwent an optimized process of elimination or removal of the excess salt by three types of treatment (treatment batch).

A first treatment was applied to hams of the treatment batch with a salt content before washing of less than 1.94 % (kg NaCl/100 kg of ham), which consisted of blowing pressurized air to remove the salt incrusted on the hams' surface. The flow rate used was 32 l/s and the pressure was 6 bar.

A second type of treatment was applied to hams of the treatment batch with a salt content before washing of between 1.94 % and 2.45 %, which consisted of blowing the hams with air and, furthermore, showering them with water at

10 ºC and low pressure. The flow rate used was 6.7 l/min and the pressure was 5 bar.

Finally, a third type of treatment was applied to the hams of the treatment batch with a salt content before washing of greater than 2.45 %, which consisted of blowing the hams with air, showering them with water and, furthermore, washing them with water at 10 ºC and high pressure during 30 seconds. The flow rate used was 6.7 l/min and the pressure was 100 bar.

After the treatments, the average salt content of the hams in the control batch was 2.25 %, with a minimum of 1.19 %, a maximum of 3.31 %, and a standard deviation of 0.53 %, whilst in the treatment batch, the average salt content was 2.21 %, with a minimum of 1.36 %, a maximum of 3.02 %, and a standard deviation of 0.36 %

The results obtained reveal that the controlled elimination / removal of salt from the hams enables adjusting the total amount of salt absorbed during the salting process to achieve the target amount of salt and reduce the variability in the salt content.

Example 4: Preparation process of whole muscle cured raw hams: Drying and maturation stage.

48 hams were taken which were divided in two batches: a control batch and a treatment batch.

For each one of the 48 hams, a target weight decrease or target weight loss that each piece should have at the end of the drying and maturation stage was determined.

Said decrease or weight loss was determined, in accordance with the initial weight and the fat and protein content by the following formula.

Formula to calculate the target weight decrease or target weight loss

$$\text{Target weight loss (\%) per ham} = (\mathrm{F}+\mathrm{G}) \bullet p \bullet 100$$

$$\mathrm{F} = \mathrm{Y}\left(\frac{\text{kg fat}}{\text{kg fresh ham}}\right) \bullet \left(\mathrm{m}\left(\frac{\text{kg water in fat tissue at start of process}}{\text{kg fat}}\right) - \mathrm{e}\left(\frac{\text{kg water in fat tissue at end of process}}{\text{kg fat}}\right)\right)$$

$$\mathrm{G} = \mathrm{Z}\left(\frac{\text{kg protein}}{\text{kg fresh ham}}\right) \bullet \left(\mathrm{n}\left(\frac{\text{kg water in lean tissue at start of process}}{\text{kg protein}}\right) - f\left(\frac{\text{kg water in lean tissue at end of process}}{\text{kg protein}}\right)\right)$$

The target weight decrease or target weight loss was calculated both for the hams of the control batch and for the hams of the treatment batch using the following formula parameters:

- m = 0.20
- e = 0.05
- n = 3.00
- f = 1.40
- p = 1.2

5 months after the start of the preparation process (*t3* = 5 months), the 48 hams were weighed obtaining an average accumulated decrease or weight loss of 26.43±1.22 % for the control batch, and 26.45±1.22 %, for the treatment batch.

All hams in the control group were applied 30 g of fat throughout the surface of the lean part, whilst the hams of the treatment batch were classified in groups in accordance with the difference between the target weight loss and the accumulated weight loss calculated after 5 months of the preparation process.

In this example, two groups were established, which were assigned different percentages of fat or lard coverage. Table 3 shows the percentages of coverage and the amount of fat assigned for each of the groups.

Table 3

Groups	Difference between the target weight decrease or target weight loss after 5 months, %	Lean surface greased, %	Amount of fat to be applied kg
1	> 9	30	0.012
2	7.5 – 9	60	0.018
3	6 – 7.5	85	0.028
4	< 6	100	0.036

As has been commented in the description of the invention, the group with the least weight loss difference was assigned a coverage percentage of 100 % of the lean surface (reference 4 in figure 1), whilst the other groups were assigned a percentage of coverage between 30 % and 90 % of the lean surface (references 1 to 3 in figure 1), with the percentages of coverage being lower for the groups with greatest differences in target weight loss and accumulated weight loss.

Figure 1 shows the distribution of fat applied to the hams of the four groups mentioned. As can be seen in figure 1, the minimum surface to cover (hams of reference 1) is the surface of the ham which is around the coxofemoral joint and the *adductor* muscle. Next, the lean surface covered is that of the part of the butt (reference 2) and that of the part which is on the butt or on the *gracilis* muscle (reference 3).
At the end of the drying and maturation stage, nine months after the start of the preparation process, the average weight loss reached by the hams of the control batch and those of the treatment batch were determined, giving

results of 32.32 ± 1.65 % and 32.89 ± 1.12 %, respectively, of weight loss.

These results reveal that the adapted greasing of the hams in accordance with their weight loss kinetics enables a more homogeneous drying of the pieces of the same batch, which contributes to obtaining a more homogeneous product in terms of taste and texture.

Despite the fact that a specific embodiment of the present invention has been described and represented, it is evident that persons skilled in the art can introduce variants and modifications, or replace certain details by other technically equivalent ones, without departing from the scope of protection defined by the attached claims.

For example, although reference has been made in example 4 of this specification to a drying and maturation stage which includes a single greasing, it is important to highlight that it would be possible to carry out more than one greasing, recalculating, for example, the accumulated weight loss of each one of the pieces after a drying time *t3*, in accordance with the value of said weight loss, varying the percentage of surface greased or the amount of fat applied. Likewise, although reference has been made in example 2 of the present specification to the estimation of the amount of salt of the meat pieces from the X-ray attenuation values acquired at a single emission energy *i* of said X-rays, similar results, or even improved results, could be obtained by using several X-ray emission energies for the same calculation.

CLAIMS

1. Preparation process of pieces of whole muscle cured raw meat products comprising a salting stage followed by an air drying and maturation stage of said products, **characterized in that**, before the salting stage, the stage of determining in a non-destructive fashion the initial weight and the fat and protein content of each one of said pieces is carried out, and in that the salting stage includes the steps of:

   ai) determining a target amount of salt that each one of said pieces of meat product should have at the end of the salting stage, said target amount of salt being determined in accordance with said initial weight and said fat and protein content,

   bi) applying salt to each one of said pieces of meat product during a salting period, to achieve the target determined in stage ai),

   ci) once a time *t1* of said salting period has elapsed, estimating in a non-destructive fashion the amount of salt that each one of said pieces of meat product has,

   di) next, adjusting the salt content of each one of said pieces of meat product in accordance with the amount of salt estimated in stage ci) and continuing, if relevant, the salting until achieving said target amount of salt,

   and/or in that the air drying and maturation stage includes the steps of:

   aii) determining a target weight decrease or target weight loss that each one of said pieces of meat product should have at the end of the drying and maturation stage, said decrease or weight loss being determined in accordance with said initial weight and said fat and protein content,

   bii) during the drying and maturation, weighing each one of said pieces and taking measurements of the accumulated weight loss of each one of said pieces from the start of the preparation process,

   cii) next, covering a predetermined portion of lean surface of each one of said pieces with a predetermined amount of fat or lard, said proportion and amount of fat being determined in accordance with said accumulated weight loss and with said target weight loss, and continuing with the drying and maturation until achieving said target weight loss.

2. Process according to claim 1, wherein, in the salting stage, step di) of adjusting the amount of salt of each one of said pieces comprises the step of:

   - determining, for each one of said pieces, a salting time *t2* additional to time *t1*, said additional salting time *t2* being determined from the amount of salt estimated in a non-destructive way in step ci) and a mathematical prediction model which relates the increase in the amount of salt of each piece with the increase in the salting time at least in accordance with the fat content of each piece before salting.

3. Process according to any of claims 1 to 2, wherein the non-destructive estimation of the salt content of each one of said pieces is carried out after a salting time *t1* of at least 3 days.

4. Process according to claim 1, wherein, in the salting stage, step di) of adjusting the amount of salt of each one of said pieces comprises the steps of:

- determining, for each one of said pieces, the additional amount of salt that must be incorporated in the product to achieve the target amount of salt established in stage ai),

- applying said additional amount of salt to each one of said pieces of meat product.

5. Process according to any of the preceding claims, wherein, if the salt content estimated in stage ci) is greater than the target amount of salt, step di) of adjusting the amount of salt of each one of said pieces includes the stage of removing or eliminating the excess salt to achieve said target amount of salt.

6. Process according to claim 5, wherein the stage of removing the excess salt is carried out, in accordance with the salt content, by:

- pressurized air-blowing of each one of said meat pieces, and/or

- showering with low-pressure water of each one of said meat pieces, and/or

- washing with high-pressure water of said meat pieces.

7. Process according to any of claims 1 to 6, wherein the non-destructive determination of the amount of salt of each piece of stage ci) is carried out by a low-intensity X-ray inspection device, said determination including the steps of:

- scanning or obtaining by said device images of each one of said pieces projected in a single plane,

- estimating the amount of salt of each piece from the X-ray attenuation values calculated from said images acquired at, at least, one emission energy, by the prediction equation:

$$\textit{Amount of salt estimated } (kg) = a + bx + cy + \sum d_i z_i,$$

where:
x (kg) is the weight of the piece of meat product at the time of scanning,
y is the area (m^2) of the image of the piece of meat product,
z_i is the sum of the values of natural logarithm $\ln(I_{0i} / I_i)$ corresponding to all the pixels of the image of the meat product, where I_i is, for an emission energy i, the intensity of radiation transmitted captured by the detector after traversing the meat product, and I_{0i} is the intensity of incident radiation for the same emission energy i when it does not traverse the meat product, and
a, b, c and d_i are coefficients obtained on statistically adjusting the equation with amount of salt data and X-ray attenuation values obtained experimentally.

8. Process according to claim 7, wherein the X-ray emission energy is obtained by the use of a voltage between 30 kV and 90 kV and electric current between 1 mA and 1.5 mA.

9. Process according to any of the preceding claims, wherein the target amount of salt that each one of said pieces of meat product must have is further determined in accordance with a desired salt content in the water of the lean tissue and fat tissue of the piece of meat product at the end of the drying and maturation stage.

10. Process according to any of the preceding claims, wherein the determination of the accumulated weight loss of each one of said pieces is carried out during the drying and maturation, after a time *t3* of the preparation process of between 4 and 7 months.

11. Process according to any of the preceding claims, wherein, in step cii) of the drying and maturation stage, the following steps are carried out:

- determining, for each one of said meat pieces, the difference between the target weight loss and an accumulated weight loss determined during the drying and maturation,

- classifying the meat pieces in groups in accordance with the difference between the target weight loss and the accumulated weight loss,

- assigning to the group with least difference between the target weight loss and the accumulated weight loss, a percentage of coverage of 95 % to 100 % of the lean surface of said meat pieces,

- assigning to the other groups a percentage of coverage comprised between 30 % and the 95 % of the lean surface of said meat pieces, the percentages of coverage being less for the groups with greatest differences between the target weight loss and the accumulated weight loss.

12. Process according to any of the preceding claims, wherein said lean surface covered with fat or lard is surface without rind or subcutaneous fat.

13. Process according to claim 12, wherein said lean surface without rind or subcutaneous fat is detected by an artificial vision system.

14. Process according to any of the preceding claims, wherein said pieces of whole muscle meat products are hams or shoulders.

15. Use of a low-intensity X-ray inspection device, of the type that obtains projected images of an object in a single plane, to estimate in a non-destructive fashion the amount of salt of a piece of whole muscle raw meat product.

16. Use according to claim 15, to estimate the amount of salt of said pieces from the X-ray attenuation values acquired at, at least, one emission energy, said attenuation values being calculated from images projected in a single plane of each one of said pieces and said amount of salt being obtained by the prediction equation:

$$\text{Amount of salt estimated } (kg) = a + bx + cy \sum d_i z_i,$$

where:

x (kg) is the weight of the piece of meat product at the time of scanning,

y is the area (m^2) of the image of the piece of meat product,

z_i is the sum of the values of natural logarithm ln (I_{0i} / I_i) corresponding to all the pixels of the image of the meat product, where I_i is, for an emission energy i, the intensity of radiation transmitted captured by the detector after traversing the meat product, and I_{0i} is the intensity of incident radiation for the same emission energy i when it does not traverse the meat product, and

a, b, c and d_i are coefficients obtained on statistically adjusting the equation with amount of salt data and X-ray attenuation values obtained experimentally.

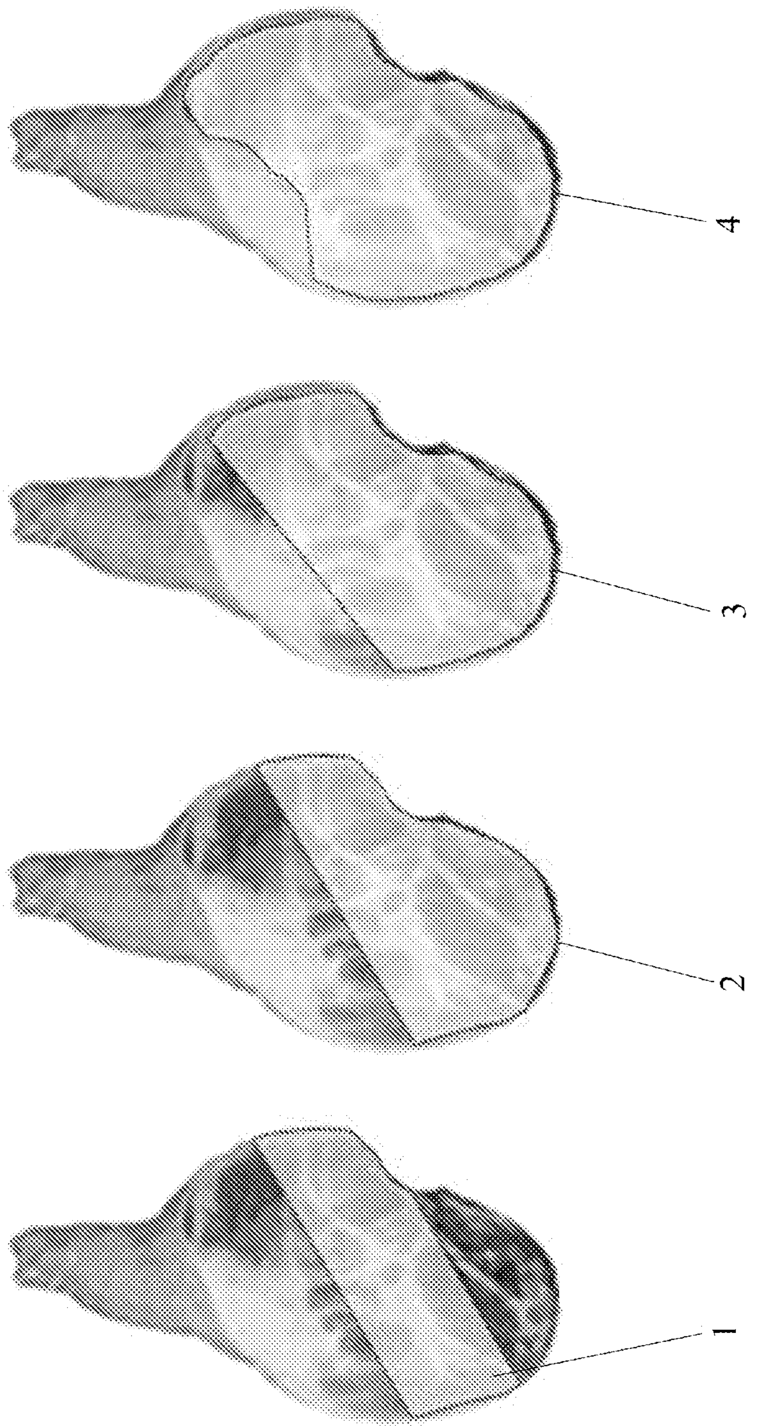

FIG.1