6 :13

Distribution of Salt in Spanish Ham during the post-salting Period

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SUMMARY : The minimum period of cold storage post-salting in Spanish Iberico ham has been stablished by evaluating the salt and water content in the depth of ham during this period. This study shows a complex pattern in the water and salt distribution in the depth of ham near the hip joint. The minimum period of cold storage is stablished in 43 days for hams kept in salt for 11 days and in 87 days for hams salted during 10 days. The stabilization period is over 150 days in the area under the skin near the tibiofibular joint.

INTRODUCTION : Spanish ham is produced by dry salting and partial dehydration. Two major processes are required to obtain this product, stabilitation and aging. Stabilitation is required for room storage and even suporting a high temperature processing step in aging that gives ham its desired sensory qualities (flavor and texture).

Ham, as any other food product, depend on a few group of parameters for stabilization. These parameters are hurtles that microbes must overcome to grow and spoil food products. Each stabilized food product is the result of the sum of specific hurdles in that product that cannot be overcome by microbes (Leistner, 1977).

In Spanish ham microbial spoilage is controlled in the surface by salt rubbing in the first day of processing. However, internal spoilage is still a common fact in traditional products. The causal microbes must be anaerobic ones, due to the specific conditions of their growth, usually clostridia, with a high metabolic effect that even "inflates" the hams. Among these clostridia the *C.botulinum* species has been isolated from spoiled country hams in France (Sebald, 1970). Thus, the aim for stabilizing Spanish ham from the microbial point of view is avoiding clostridia growth.

Clostridia find favorable redox conditions inside the ham due to the activity of muscle enzymes (Brown and Emberger, 1980). The pH conditions in ham tissues are also adecuate for clostridia growth although low pH may impose some difficulties; but even with an ideal fall, pH goes to 5.4 and clostidia have a minimum pH of 4.7 (Corlett and Brown, 1980). In addition, clostridia start growing near the limph nodes (Cosnett et al., 1956) and the pH can be higher there.

The specific hurdles that may act in Spanish ham to avoid internal spoilage are cold temperatures at the begining of the process and salt concentration after the equilibration step is completed at a critical level. The critical Aw to avoid clostridia to grow is near 0.97 (Baird-Parker and Freame, 1967) and this Aw is obtained by a 5% salt concentracion (Chirife and Resnik, 1984). Cooling under 12 C avoids clostridia to outgrow (Michener and Elliot, 1964). Cooling ham as soon as pigs are slaughtered is a common practice and cold storage is mantained during the salting step and for an additional period of time post-salting. However, although all producers are in accordance with this practice there is no an uniform criterium in relation to the lenght of this post-salting period. The objective of this work has been to follow the salt distribution in ham during the post-salting period, in order to evaluate the length of this critical period of cold storage post-salting in Spanish iberico ham.

MATERIALS AND METHODS : The study has been realized on 54 hams clasified in two groups, lot A that included 27 hams under 10 Kg of initial weight (range 7.66 - 9.79 Kg) and lot B, including 27 hams over 10 Kg of initial weight (range 10.14 - 11.39 Kg). Lot A was salted in the traditional way (rubbed with salt and then buried in salt) for a total of 10 days and lot B was salted during 11 days. After the salting step, all the hams were washed using cold water, drained and then hung at 0-5 C during the whole experimental time (150 days). Three ham of each lot were taken to the laboratory fresh (0 time, before salting) and at diferent experimental times during the post-salting period (2, 25, 45, 75, 95, 110, 130 and 150 days after the salting step was completed). Each ham was analyzed taken a cilinder from the deepest area of the ham (near the hip joint; samples 1 to 8) and two more samples under the skin near the tibiofibular joint (samples 9 and 10).

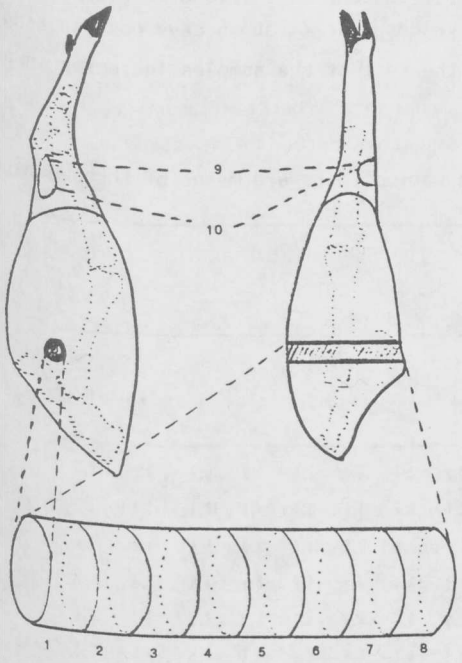

Figure 1: Experimental procedure for sampling

Figure 1 includes the experimental procedure to obtain the samples from each ham.

Samples were analyzed for moisture and chloride.

RESULTS AND DISCUSSION : During the post-salting period, water and salt in muscle present complex changes.

In Table 1 the water content in the different samples is included. It can be seen that the water content in the depth of fresh ham is quite uniform, about 70% moisture, except for sample 1, that is the fatty tissue covering ham. After salting (2 days after the salting step) the moisture content is significantly reduced only in samples 7 and 8. Part of the water contained in ham is extracted out by salt in this step.

During the rest of the period, water content is reduced in a complex way in these sample and in the other ones. Thus, water content keeps 42 - 44 % at 75 days and for the rest of the post-salting period in sample 8 in both experimental lots. Changes in water content are also quite significant in samples 6 and 7 and less significant in sample 5 during post-salting storage. There is almost no changes in water content in samples 2, 3, 4, 9 and 10 during the whole studied period. These findings indicate that water is lost to the air during post-salting storage in ham specially through the lean surface (sample 8). Also from these results it is possible to deduct that the drying process is more significant than water difussion during the first 75 days and from there on the predominant change is water difussion to the surface.

Table 1: Percent of moisture in Spanish ham in the post-salting period (data are means from 3 hams each)

	LOT A										LOT B									
days	SAMPLE										SAMPLE									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
0	16.8	69.2	71.6	70.9	73.9	71.7	71.1	68.8	77.1	74.3	17.9	64.7	69.0	69.6	71.5	71.9	70.2	71.0	72.2	70.5
2	15.1	70.9	70.7	66.0	71.7	71.4	65.9	59.0	72.1	70.6	13.7	69.1	67.5	69.4	68.5	65.6	62.2	60.2	67.3	67.3
25	14.3	71.9	72.2	71.8	70.3	72.5	67.7	56.0	70.6	70.4	16.8	70.0	74.0	69.9	70.9	68.8	68.4	57.1	71.3	71.5
45	5.1	67.3	69.7	64.8	62.3	64.3	61.5	49.2	67.1	69.2	7.6	67.2	69.3	68.9	65.9	66.0	61.4	47.8	68.3	69.5
75	8.3	67.9	67.4	65.4	66.4	66.6	62.0	43.1	66.3	65.7	11.7	70.6	69.7	69.3	67.3	64.8	61.8	44.3	67.8	66.0
95	7.9	68.1	69.6	67.4	68.8	64.8	62.2	44.0	65.2	65.2	11.9	64.4	69.7	65.6	66.6	63.8	58.2	42.7	64.7	63.9
110	12.0	70.4	67.3	67.7'	67.0	65.0	59.4	43.2	64.8	66.1	8.6	63.7	63.6	64.7	66.2	64.5	59.9	43.8	62.9	64.4
130	12.1	67.3	67.2	65.7	66.6	64.6	60.5	49.6	66.6	67.3	13.8	68.4	68.7	69.8	68.7	66.2	59.4	44.2	65.9	67.3
150	7.4	64.7	68.7	64.0	64.8	64.6	60.4	44.1	66.5	65.9	7.3	63.3	63.5	64.7	61.0	60.5	58.3	42.3	64.4	63.6

Salt content in the different studied samples during the 150 days of post-salting is included in table 2. It is possible to check that chloride content in fresh ham is low (near 0.2%) and quite uniform in the depth of ham. Just after the salting step (2 days) there is a high salt content in sample 8 in both lots, higher in lot B. Then onward salt content is reduced in this sample 8 to values near 4% at 45 days post-salting, keeping this values for the rest of the studied period. Salt values in the rest of the samples increases in a complex

Table 2: Percent of salt in Spanish ham during the post-salting period (data are means of three hams each)

	LOT A										LOT B									
	SAMPLE										SAMPLE									
days	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
0	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.2	0.3	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.3
2	0.2	1.1	0.7	0.5	0.4	1.0	3.4	7.5	0.7	0.7	2.3	1.9	0.8	0.7	1.6	3.0	4.8	10.4	1.4	1.1
25	0.5	1.5	1.3	1.3	2.4	3.9	4.7	5.8	1.8	1.6	0.5	1.8	1.7	1.9	3.9	4.6	5.9	6.4	1.8	1.6
45	0.3	1.6	1.6	1.9	3.2	4.4	5.2	4.4	1.6	1.5	0.5	1.4	1.6	2.1	4.2	5.0	5.6	4.8	1.9	1.8
75	0.1	2.0	2.3	2.8	4.1	4.6	4.8	4.2	2.0	1.7	0.5	2.4	2.9	3.3	4.1	4.9	5.4	4.3	2.3	2.6
95	0.7	3.1	3.2	4.0	4.9	5.0	5.2	4.0	2.1	1.9	0.2	3.6	4.1	4.7	5.5	5.9	5.8	4.5	2.9	3.0
110	0.5	3.6	3.7	4.3	4.9	5.0	4.6	3.9	2.6	2.9	1.2	4.0	4.3	4.7	5.4	5.6	5.3	4.1	2.9	3.1
130	0.7	3.9	4.3	4.5	5.1	5.2	5.2	4.0	3.0	2.9	1.0	4.4	4.6	4.7	5.6	5.8	5.5	4.2	3.1	3.2
150	0.7	4.3	4.3	4.5	5.3	5.3	4.9	3.9	2.7	3.0	0.7	4.8	4.9	5.2	5.6	5.5	5.3	4.0	2.8	3.2

way in the other samples during the post-salting period. As the result, it is possible to detect that salt content in all samples is similar near the end of the studied period, or even there is a higher salt content in samples 2 to 7 than in sample 8 (the one with the starting higher salt content). From these results it is possible to deduct that there is a difussion of salt to the inside of ham starting in the lean surface.

The salt concentration in the water of ham is showed in figures 2 and 3 during the different studied times. From these figures it is possible to stablish the complex nature of the diffussion of salt. There is a tendency to equilibrate salt concentration toward the end of the studied period. The complex nature of the difussion-drying processes shows a similar pattern in both lots, but with an important practical difference: the critical stabilization time.

From these results it is possible to stablish a best fitting line for salt content versus time for each sample.

The corresponding equations and the calculate period required for each sample to reach the critical concentration of 5 % salt in the water phase is shown in table 3. The calculate period for storage bellow 12 C of ham depend significantly from the salting step. As the critical area for internal spoilage is located between samples 4 and 5,

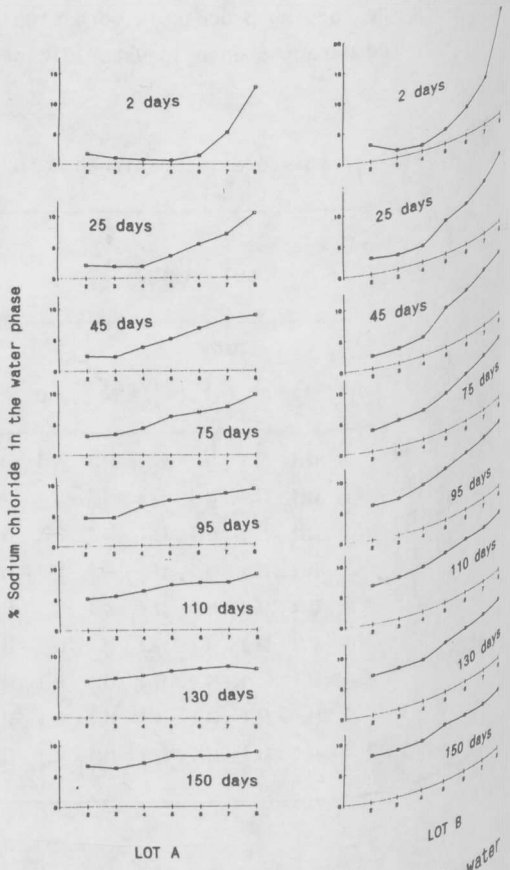

Figure 2: Distribution of salt in the water phase in Spanish han during post-salting

the minumum period of cold storage to achieve stability is 87 days in lot A and 43 days in lot B. However, stability versus clostridia growth is not obtained after 150 days in both lots in samples 9 and 10, corresponding to the area under the skin near the tibiofibular joint.

Table 3 : Best fitting equations for salt in water concentration in the studied samples versus time

SAMPLE	LOT A			LOT B		
	r*	best fitting line**	days***	r*	best fitting line**	days***
2	0.8739	$Y = 0.8545 . X^{0.3566}$	142	0.7455	$Y = 2.0646 . X^{0.2075}$	71
3	0.9521	$Y = 0.4640 . X^{0.4972}$	120	0.9442	$Y = 1.2043 . X^{0.3549}$	56
4	0.9823	$Y = 0.3305 . X^{0.6098}$	87	0.9521	$Y = 1.1969 . X^{0.3816}$	43
5	0.9892	$Y = 0.3350 . X^{0.6667}$	58	0.9169	$Y = 3.0257 . X^{0.2217}$	10
6	0.9701	$Y = 1.0334 . X^{0.4411}$	36	0.9433	$Y = 5.1360 . X^{0.1204}$	1
7	0.9422	$Y = 4.7038 . X^{0.1204}$	2	0.7710	$Y = 8.1216 . X^{0.0290}$	1
8	0.9370	$Y = 14.0467 . X^{-0.0988}$	1	0.8737	$Y = 14.9448 . X^{-0.0999}$	1
9	0.9750	$Y = 0.6146 . X^{0.3858}$	>150	0.9196	$Y = 2.0558 . X^{0.1607}$	>150
10	0.9517	$Y = 0.5886 . X^{0.3879}$	>150	0.9664	$Y = 1.6374 . X^{0.2260}$	>150

* Correlation coeficient
** Y: percent of salt in the water phase; X : days post-salting
*** Days required to obtain a 5% salt in water in that particular sample

CONCLUSIONS The post-salting period in ham presents a complex view of changes in salt and water content in the deep of muscle, depending on whether muscle tissue is exposed directly to air or it is located under the fatty tissue or skin. The salt concentration in the water phase tends towards equilibration with time and the critical period for cold storage to prevent internal spoilage last for 43 to 87 days in the area near the hip joint depending of the lenght of the initial salting step, and last more than 150 days near the tibiofibular joint to reach a critical 5% salt in the water phase.

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