Spray Plus System®, evolution of injection of cooked meat products

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Quality and effectiveness in the injection process is a critical factor in the production of meat products, and is therefore the focus of continuous research with the objective of improving distribution and retention of brine in the meat. In certain products this objective can be affected by the anatomy and/or morphology of the meat pieces (whole bone-in pieces), or by the characteristics of the process. This can result in products of irregular quality and with yields lower than expected.

This article analyzes the evolution of the SPRAY effect or spray injection, by means of the new SprayPlusSystem® technology, to optimize distribution and maximize brine retention in the above-mentioned meat products, in comparison with a conventional injection system (without SPRAY effect). For this purpose, images obtained by computed tomography are used to determine the distribution of salt in diverse consecutive sections of a whole piece of meat. At the same time, a comparative study is conducted on the brine retention and final yield in the production process of injected and cooked bone-in ham. The results show the effectiveness of the new technology in both studies, obtaining a more homogeneous distribution of salt and an increase in yield after cooking of up to 4 percentage points.

INTRODUCTION

Most multi-needle injectors on the market use continuous pumps that impel the brine through needles with between 2 and 4 holes of 1 mm or more in diameter, depositing the brine as the needle passes through the meat. Due to the diameter of the needles, the brine flows through them in a continuous gentle stream inside the meat, resulting in poor distribution and retention. These machines usually operate at variable pressure that does not normally exceed 4 kg/cm^2 and are known as Low Pressure Injectors.

In contrast with the above, injectors with SPRAY effect introduce a volumetrically dosed quantity of brine, only when the needles have completely penetrated the meat and are stopped at the end of their downward stroke (Freixanet, Ll.). The spray effect is achieved by means of a volumetric piston pump that compresses the brine at a pressure of between 6 and 12 kg/cm^2, depending on the machine, and forces it through the micro-holes at high speed, causing dispersion of the brine jet in thousands of micro-drops. The microscopic dimensions of these drops, together with the high speed of their delivery, results in the brine being deposited deeply between the meat fibers without damaging the muscle structure, while covering a greater volume of the muscle. The needles are specifically designed to achieve this spray effect, with a variable number of holes that range from 9 up to 20, depending on the model, and with a diameter of 0.6 mm. The large number of holes provides an increase of 3 to 6 times the number of injection points compared to conventional injectors. The end result is a radical improvement in brine distribution deep within the meat muscle.

The main advantages of the Spray injection system observed over the course of years are the following:

- **High regularity in injected percentage among pieces.**
- **Minimum brine dripping loss after injection.**
- **Uniform brine distribution inside the muscle.**

Injection with SPRAY PLUS SYSTEM® technology

SprayPlusSystem® technology is a further development of the Spray injection system in which the path of the needles can be much wider than that used to date. The needles perform the downward stroke as usual, and brine injection begins once they have reached the end of the stroke. At a given time in the cycle, adjustable according to the type of piece to be injected, the head moves slightly backward while injection continues at constant pressure, thereby increasing the area of brine penetration with respect to conventional SPRAY injection. Thus, a greater amount of brine can be retained inside the muscle, reducing subsequent dripping loss and the formation of pockets in the aponeurosis and intermuscular fat.

To date, the optimization of the Spray system has been tested on products that present the most difficulty with brine distribution, due to morphology or quality. But in some instances the difficulty is a given, such as when processing products without a massage phase or in which the massage cycle is very short, cases in which brine distribution basically depends on the capacity of the injector to distribute the brine uniformly. These products can be summed up in two groups:

1) Whole bone-in pieces (ham, shoulder) in which the distribution of brine in the lower muscles (near the conveyor belt) tends to be uneven. Moreover, since the muscles are surrounded by membrane (aponeurosis) and fat, the brine tends to be retained in these zones. This brine is easily lost during cooking and detracts from the appearance of the cut (spongy effect).

2) Whole boneless muscles that although they do not present the above-mentioned problem, usually have a high presence of PSE. In these cases the meat is very soft and easily torn during massage. To avoid this problem, the time/intensity of massage must be reduced, diminishing uniformity of brine distribution in the muscle.

Tests conducted

This article analyzes the effect of SprayPlusSystem® technology on the first group of products, while the second group will be evaluated in a following article. A series of comparative tests between the conventional injection system (Low Pressure) and an injector equipped with SprayPlusSystem® technology were designed:

Test 1: Improvement in brine distribution in whole bone-in ham.
Test 2: Reduction in dripping loss in bone-in ham (Virginia Ham).

Test 1: Improvement in brine distribution in the injection of whole ham

In this test 12 pieces of whole pork ham (bone-in) were injected with the two above-mentioned machines: a conventional low-pressure injector (I1) and a Metalquimia injector, model MOVISTICK 3000 CR, equipped with "SprayPlusSystem®" technology (I2). The pieces were injected at about 40%, with brine made up of sodium tripolyphosphate, salt, sodium nitrite, sodium erythorbate and water. After injection the analysis was immediately conducted by means of computed tomography.

Analysis of the hams by means of Computed Tomography (TC)

Following the injection process, all the pieces underwent, one by one, a CT (Computed Tomography) scan to determine the distribution of brine inside each one. The CT analysis was performed by a HiSpeed Zx/i model scanner manufactured by General Electric Healthcare (GE Healthcare-United Kingdom). The equipment is located at the CENTA-IRTA (Center for New Technologies and Food Processes of the Institute of Food Technology and Research) facilities in Monells (Girona - Spain). The defined scanning parameters were the following: 80 kV, 250 mA, rotation time of 2 s, 512 x 512 pixels in image size, 461 x 461 mm^2 displayed field of view and the algorithm of reconstruction STD+. Ten consecutive sections, 10 mm thick, from the thickest part of each ham (Figure 1) were scanned. Each pixel of the image represents one voxel with a volume of 10 x 0.9 x 0.9 mm3. The images obtained directly from the CT were in DICOM format. By means of an application developed with the program Matlab Version 7.7.0 (R2008b © The MathWorks, Inc.) the images were converted to TIFF format and mathematical models for predicting salt content in all points of the ham were applied, thus obtaining the images of salt distribution (Fulladosa et al. 2010).

The application of CT is based on the different attenuations of X-rays produced by the tissues

▲ Fig. 1: Scanned zone.

according to their density, and whose average provides for obtaining a matrix of attenuations called CT values, expressed as Hounsfield units (HU). These matrixes of values are used to create an image with varying tones of grey, in which the brighter areas signify greater attenuation. Thanks to the high density of salt, a noticeable increase in the values of attenuation in the muscle is produced (Sorheim et al, 1987,1989), allowing for quantification of its distribution by applying the above-mentioned mathematical models. Many other authors have demonstrated correlations between CT values and salt concentrations in various pork muscles (Vestergaard et al., 2004).

Results

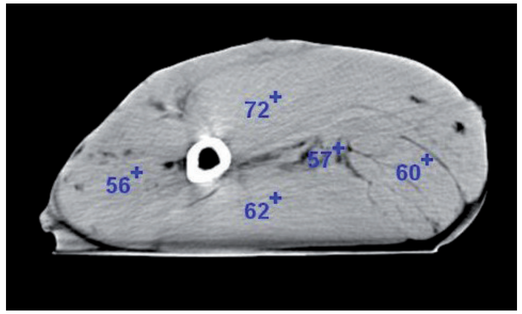
The results obtained from scanning of the pieces can be observed in Figures 2 and 3, which show transversal cuts of ham injected with the two injection systems. Black areas signify zero attenuation and correspond to air (holes). Low attenuation appears as dark zones that correspond to areas of fat. Higher values of attenuation result in different tones of grey and show diffusion of the salt in the muscle. Very high attenuation appears as white areas, which are bone and rind. The numbers that appears in the figures correspond to HU units in specific areas but representative of different muscles.

Figure 2 corresponds to a ham injected with low-pressure injector I1 and Figure 3 to a piece injected with injector I2, equipped with SprayPlusSystem® technology to improve brine distribution and retention.

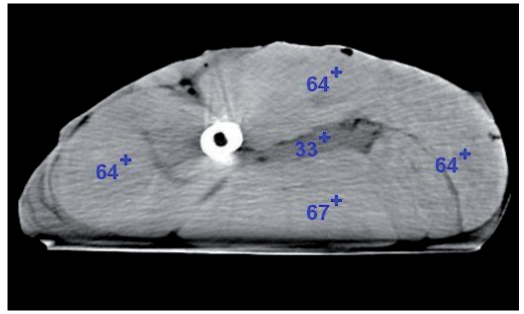
At first glance it appears that the grey coloration is fairly uniform in both images, which could lead to the conclusion that the salt has been distributed fairly uniformly in both cases. However, quantification of the HU units in the various muscles reveals significant differences. In Fig 2 it can be observed that the difference in HU between the upper muscle or *Semimenbranosus* (SM) and the lower muscle *Bicep femoris* (BF) is 10 units. And between SM y lateral muscle *Semitendinosus* (ST) the difference is 16 HU. This means that most of the brine has concentrated in the upper part of the ham, leaving the lower part with less injection and therefore poor distribution of salt. Whereas if we observe Fig 3, the difference in units between the same muscles is a maximum of 3 units, which indicates greater homogeneity in the distribution of salt.

Moreover, the central zone where the fat that usually appears with the above-mentioned “spongy” effect is located, in the first case 57 HU units can be observed, whereas in Fig 3 only 33. This means that there is less salt and therefore less brine retained in this area of fat. In Fig 2 black holes can also be observed, which indicates, together with the values observed, poor distribution. In Fig 3 these holes are not observed and all the fat displays similar attenuation values, indicating greater homogeneity in salt distribution and therefore a reduction in the “spongy” effect.

The same data can be observed and confirmed in the distribution diagrams of the same hams:



▲ Fig. 2: Injector without spray effect .

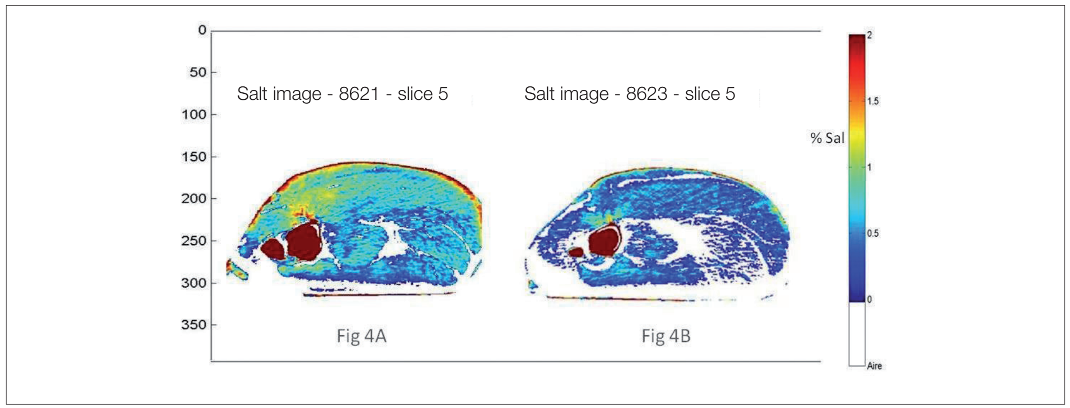


▲ Fig. 3: Injector with Spray Plus System technology .

In these images the distribution of salt can be observed according to distribution of color. Greater uniformity of color indicates greater uniformity of salt distribution. The white areas correspond to the fat in the piece. Image 4A corresponds to the same ham that appears in Fig. 2 (Injector I1) while 4B corresponds to that in Fig 3 (Injector I2). In image 4A a greater concentration of salt can be observed in the uppermost part of the ham (superficial red coloration and uneven in the rest of the muscle) as was observed in Fig 2. A greater concentration can also be observed above the bone. Image 4B shows a much more uniform distribution in all the muscles (uniform blue coloration in the entire cut), leading to the conclusion that the injection resulted in a more uniform distribution of salt.

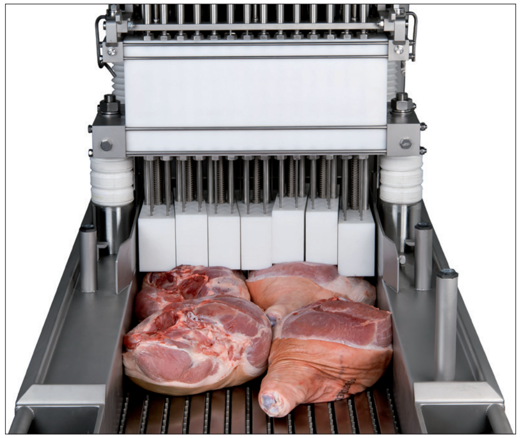
Test 2- Reduction in dripping loss in highly injected bone-in ham (Virginia Ham)

Virginia Ham is a type of cooked ham that is very popular in the United States. Its production process has hardly varied in recent years, but consumer demands with respect to quality and final yield have grown. Since this product is produced without massage and with high dripping loss during cooking, relatively high injections (80-90 %) are required in order to obtain a product with juicy texture and an acceptable yield. The tendency of brine to accumulate in the membranes and fat that surround the muscle has already been mentioned. This brine is poorly retained and tends to drain easily and increase dripping loss in the product.



▲ Fig. 4: Salt distribution diagrams.

In order to evaluate the qualities of the new SprayPlusSystem® technology with regard to brine retention, an industrial test was conducted at a processing plant in the United States, using two injectors with characteristics similar to those in the previous Test, Low-Pressure Injector I1 and a METALQUIMIA, S.A.U. Injector I2 equipped with SprayPlusSystem® technology (Fig 5).



▲ Fig. 5: Head with SprayPlusSystem® .

For said test, whole bone-in pork hams were injected at 80-90% and then prepared for cooking. In most processing plants, weight control is carried out only when the pieces are hung prior to entering the oven (approx 30 minutes after injection) and after cooking. In this test the weight was also verified after injection.

The tests were conducted in parallel with the two machines and with the same brine. 250 hams were used in each test, grouped in 5 batches of 50 hams each. The cooking process was carried out in conventional steam ovens. Data concerning the brine and the cooking process are not specified because they are property of the company that lent its facilities.

Results

The results obtained are shown in Table 1 and correspond to the average of each batch.

INJECTOR	BATCH Nº	INJECTION %	RETENTION % AT 30 MIN.	FINAL YIELD
INJECTOR 1 (Low Pressure)	1	83,1	47,2	119,2
	2	86,5	50,7	121,6
	3	87,1	48,4	118,3
	4	88,6	53,1	122,1
	5	87,3	52,5	121,9
Average		*86,5*	*50,4*	*120,6*
INJECTOR 2 (Spray Plus System)	6	86,4	54,9	124,1
	7	88,2	56,3	124,8
	8	86,7	54,2	123,6
	9	88,5	56,3	125,9
	10	89,3	57,1	125,1
Average		*87,8*	*55,8*	*124,7*

▲ Table 1: Comparative results of yields in injection and cooking.

Analyzing the data provided by the in-plants tests, it can be observed that although the difference between the averages of the injection percentages of the two machines is small (86.5% and 87.8%), the difference in the retention percentage at 30 minutes of injection is increased, with a higher retention percentage in Injector 2. In the average of the batches injected with Injector 1, 36.1 injection points were lost during the time that elapsed between injection and entrance of the product into the oven. In the batches processed with Injector 2, 32 points were lost. This difference of 4.1 points in the retention percentage is maintained in the product's final yield in the pieces processed with SprayPlusSystem® technology.

CONCLUSIONS

Based on the data obtained from the tests conducted, we can conclude that the evolution from the conventional Spray Effect system to the new SprayPlusSystem® technology provides significant advantages in the injection process for cooked meat products. The adjustable backward movement of the needles results in a more uniform distribution of brine, reducing the formation of pockets in fat and aponeurosis. The end result is a cooked meat product with a more pleasing appearance in the cut, better color and flavor; higher regularity and consistency in the injection process; but, above all, an increase in product yield thanks to greater brine retention inside the meat muscle. And although these tests were focused on meat products with a high degree of difficulty with respect to obtaining good brine distribution, the advantages observed in the physical appearance and final yield of the products allows for extrapolating this effect to any other cooked injected product.

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