Compacting of meat during the ham stuffing process: A new step forward in the automation of high-quality cooked products

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INTRODUCTION

Cooked ham of the highest quality, manufactured mainly in the center of Europe, has traditionally been made from whole hams that are selected, deboned and lightly trimmed, with the skin and outer fat kept intact. These are products with a low level of injection, phosphate-free or with a very low dosage of phosphates, and with enough maturation time to develop the flavor, aroma and texture characteristic of these high-quality products.

For decades these products have been stuffed by hand in individual molds by specialized operators, able to adapt to the mold or to the bag hams that, after massage and maturation, are quite dry and tough, with a rigid consistency that complicates correct recomposition of the piece. As a result of these characteristics of the meat, during stuffing and/or molding structural defects are produced that are as traditional as the process itself; among them, perhaps, the most common are the holes that form due to lack of compacting between muscles, or the fissures that stem from lack of binding. These defects appear to a greater or lesser degree depending on the process and the quality of the meat, and have been aggravated in recent years because of a higher incidence of PSE in pork. The decrease in functionality of protein in PSE muscles, added to the limited use or complete lack of phosphates, produces soft and gummy textures that are totally undesirable in this type of products.

With the change in consumer habits of recent years, sliced products have come to represent a higher percentage than individual pieces destined for small retail outlets. This means that many of these products have had to adapt their manufacturing process, working with separated muscles instead of whole hams, and then restructuring them in bar molds in order to have sliceable pieces of higher yield. Consequently, if the individual pieces presented slicing problems, having hams of this type undergo the aggressive action of industrial slicers has done nothing but magnify the problem even further.

Even though there exists a special category of more traditional cooked hams in Central Europe, such as the French *Jambon Supérieur* or the Italian *Prosciutto Cotto di Alta Qualità* or *Scelto* – which in many cases are still made from whole hams molded by hand – attempts have been made repeatedly to vacuum stuff these products automatically, in order to obtain a better compacting of the piece that could reduce the slicing problems and defects typical of these cooked hams, as well as to automate the process. But so far the only machines capable of working with these whole-muscle products, such as twin-piston vacuum stuffers, have not been able to achieve the level of compression necessary, causing on occasion the appearance of air and separation between muscles in the finished product.

DETECTION AND ANALYSIS OF THE PROBLEM

A team made up of meat industry technicians and technologists carried out testing and analysis of these processing limitations, arriving at the conclusion that the main problem lay in the lack of meat compacting inside the stuffing plastic, because the degree of dryness and muscle rigidity makes it very difficult for the meat to flow easily through the tubing of the machines.

All efforts were concentrated on this line of research in order to provide a definitive solution for the automatic stuffing of low-injection, whole-muscle products.

First, the objectives to be met were established so that the "solution" to this problem would lead to a machine allowing for production of this product, without compromising its traditional characteristics. These starting points were the following:

1. Stuffing of large whole muscles, of slightly tough texture and with a not very slippery surface.
2. Production of long bars of ham to be fed into a slicer, without fissures or external holes.
3. Internal compacting of the meat in order to eliminate all air between muscles.
4. Preservation of the muscle structure corresponding to these products, without detriment to the fibrous whole muscle look that is expected in a product of these characteristics and in this price range.
5. Fulfillment of all the above requirements while keeping within a production schedule that satisfies the demands of processors.

The result of these studies and experiments, carried out with the collaboration of various processors, was the development of the COMPACTA solution.

THE SOLUTION TO THE PROBLEM: "COMPACTA"

The new machine, designed to be coupled to the outlet of an automatic twin-piston stuffer, performs compacting of the meat before it is transferred to the plastic casing and to the clipper. In this case, the stuffer acts only as a continuous vacuum pump to move the meat, and what really determines the weight of the piece to be stuffed is the COMPACTA device itself (Photo No1).

Photo Nº 1: Compacta accessory coupled to an automatic twin-piston Stuffer Mod. TWINVAC PLUS

This accessory consists of two volumetric cylinders, each of them provided with an internal piston. Depending on the internal stroke of this piston, a greater or lesser meat filling volume is defined, which determines a specific weight of the piece. By means of an internal adjustable retention system of said pistons, adapting and internal compacting of muscles takes place before the meat is sent to the tube connected to the clipper or thermoformer. A combination between the meat inlet and outlet valves of the COMPACTA makes the two volumetric cylinders operate reciprocatingly. In this way, there is no slowdown in the in production line, since while one cylinder is being loaded, the other is being unloaded into the clipper and so on reciprocatingly. Regulation of the volume to be stuffed can either be done manually, directly on the COMPACTA, or automatically from the display of the stuffer.

When working with a continuous clipper, the use of the COMPACTA is extremely important for low-injection high-quality phosphate-free products. Stuffing these products without the COMPACTA device gives rise to high pressure and tension inside the plastic casing in order to compact the muscles and extract all the external air (between the casing and the meat), producing continuous breakage of the stuffed pieces because the plastic is unable to withstand such tension. If the clipper is adjusted so that the plastic casing is able to withstand the stuffing process, then the pieces produced are without compacting, with internal holes, and result in slicing problems and reduced yield in the finished product.

IN-PLANT EXPERIMENTAL TESTING

In order to test the efficiency of this device in reducing the above-mentioned defects in a sliced product, a COMPACTA line was installed in a meat-processing plant, where all the ham for slicing was produced in this line for three months. Stuffing had previously been done manually in plastic bags for phosphate-free ham, and with an automatic stuffer with clipper for ham with phosphates.

After this three-month period, comparisons were made of the slicing results obtained for each type of ham with the average usually obtained with the same product.

The average daily production of cooked ham was approximately 23,000 kg, with approximately 34% being phosphate-free products. The cooked ham with phosphates was made entirely from pieces of 6D pork ham, with the exception of the knuckle, while the phosphate-free ham was made from 7D pork ham, using only the pieces denominated silverside and topside. The manufacturing process was as follows:

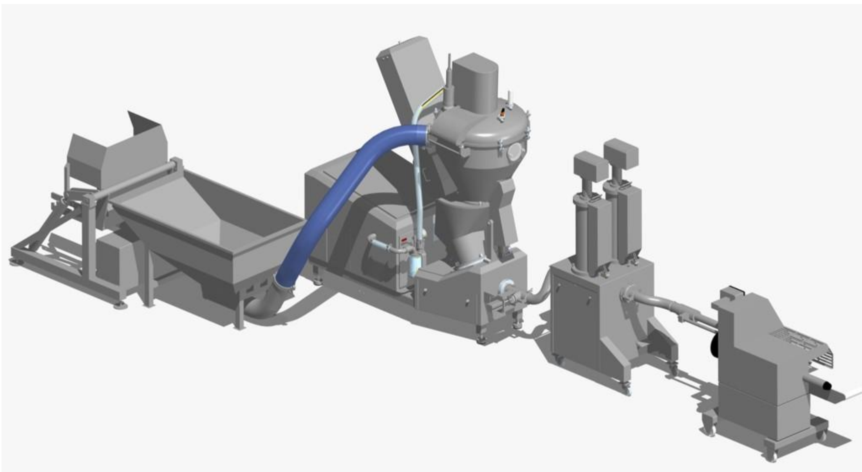

Photo Nº 2 : Complete TWINVAC PLUS & COMPACTA stuffing line

1. Brine preparation.
2. Injection and tenderization.
3. Massage and subsequent resting in cool room.
4. Massage prior to stuffing the next day.
5. Stuffing in COMPACTA with plastic clipped under constant vacuum.
6. Cooking in stages in multimolds.
7. Slicing 6 – 7 days after cooling, with a width of 1.2 mm for phosphate-free cooked ham and 1 mm for the standard cooked ham.

In order to eliminate seasonal tendencies in the data regarding slicing losses usually obtained by the plant, the average annual percentage was used as a reference.

In table 1 the defects included in the slicing loss are characterized, related to the above remarks, and typified by the processor with a brief description:

Defect	Description	Cause	What to do
Holes	Air holes or caverns between muscles	Poor muscle cohesion and/or excessive slicing loss due to lack of vacuum or compacting	Throw away slices if the hole is more than 4 mm in diameter
Intermuscular fissures	Lack of binding between muscles, with physical separations	Excessive rigidity and/or dryness in the meat being stuffed	Throw away slices that are torn or cannot be manipulated during packaging
Intermuscular tearing	Areas of muscle disintegration, without consistency	High incidence of PSE zones	Throw away slices that are torn or have areas of color outside the accepted scale.
Broken up appearance	Accumulation of small pieces in the same cut	Pieces of meat torn during the process	Throw away slices in which the defect affects more than 30% of the surface
Uneven coloring	Excessive color contrast between muscles	Unequal development of inter and/or intramuscular color	Throw away slices in which the defect affects more than 50% of the surface

Table 1: Description of defects found in the slicing of cooked hams

Even though there were certain types of defects on which it seemed *a priori* that the COMPACTA line could have little effectiveness, all were included in order to observe possible interrelatedness. During the testing period the results of slicing losses were collected daily and, once this period was over, the average monthly percentages were calculated for each group of rejected slices, as well as the total overall averages.

RESULTS AND DISCUSSION

The data gathered during three months of production with the COMPACTA line are shown in Table 2, where they are compared with the data obtained during the year prior to the test.

PRODUCT	% slicing loss WITHOUT COMPACTA		% slicing loss WITH COMPACTA	
	A (without phosfates)	B (with phosfates)	A (without phosfates)	B (with phosfates)
Holes (Photo nº3) *(% slicing loss)*	1.76	0.75	0.65 *(-63.1%)*	0.32 *(-57.3%)*
Intermuscular fissures (Photo nº4) *(%slicing loss)*	2.46	1.21	0.72 *(-70.7%)*	0.39 *(-67.7)*
Intramuscular tearing	3.49	2.73	3.35	2.74
Broken up appearance	0.46	1.21	0.47	0.33
Uneven coloring	0.34	-	0.36	-
Total *(%slicing loss)*	*8.51*	*5.9*	*5.55* *(-34.8%)*	*3.8* *(-35.6%)*

Table 2. Results of slicing loss for each defect, according to product type, with or without use of COMPACTA accessory.

An analysis of the results confirmed that slicing losses due to intermuscular holes and fissures are greater in phosphate-free products because toughness and dryness of the muscles make stuffing difficult. If added to this is the fact that the greater the number of empty spaces found in the product during cooking, the greater dripping loss will be during cooking, and this will be deposited in these empty spaces, making them widen, that explains the difference in the incidence of the defect in one type of product or the other.

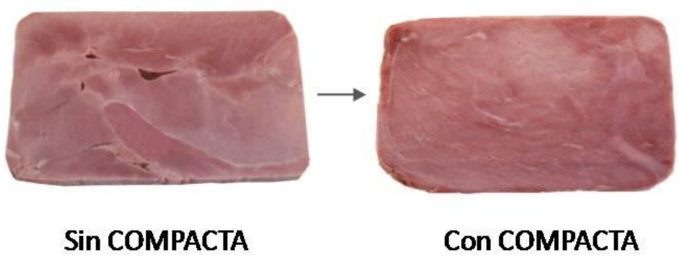

Photo Nº 3: Intermuscular holes and fissures in the automatic stuffing of low-injection productos

A considerable reduction in slicing losses due to holes and fissures was observed in both types of products stuffed with the COMPACTA device in relation to the same products stuffed without said device, which in the case of phosphate-free ham represented a reduction of 63.07% in the category of holes and a reduction of 70.73% in slicing loss due to fissures between muscles. For the products with phosphates, this reduction is less but still very attractive for the processor (57.33 and 67.77% respectively).

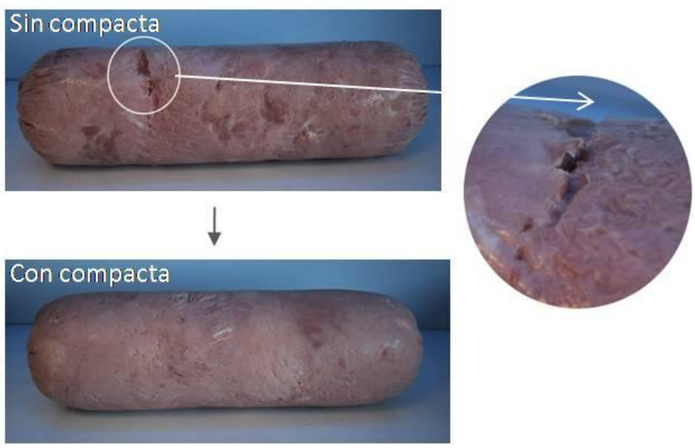

Photo Nº 4: Superficial fissures

The greater compression exerted thanks to the device, as well as being able to work with a better level of intermuscular vacuum, results in a better adaptation of the muscle pieces in the stuffing plastic and, consequently, a reduction of these defects.

Another factor that indirectly influences the reduction of defects in the sliced product is the fact that when stuffing with COMPACTA the deficiencies derived from the manufacturing process (excessive dryness or toughness of the meat, etc) are partly absorbed by the action of this device, helping to standardize production.

It was also observed that a good part of the slicing loss is due to internal tearing of the muscle caused by the presence of PSE meat, with the impact being greater in phosphate-free ham (3.49%) than in the product with phosphates (2.73%). This fact did not come as a surprise, since the existing literature includes numerous references demonstrating that certain ingredients and technological intervention, such as the use of phosphates, can compensate in part for the loss of functionality the muscle protein undergoes in a PSE muscle; this is why muscle tearing is greater in this case in phosphate-free ham.

As was expected, this type of defect did not show any meaningful variation with the use of the Compacta device, and when continuing to work with the same usual conditions, the new system alone cannot significantly improve the incidence of this defect or its variability.

The rest of the defects represent a lesser percentage of the total, although they are still important because of the losses they entail. In the case of ham with phosphates, uneven coloring was not considered as a defect, since when most of the ham pieces are used they will already have a greater natural variation in color. In the case of phosphate-free products, a practically imperceptible increase in this defect is observed, due to going from manual stuffing to automatic.

The percentage of rejected slices due to a broken up appearance did not show any significant variation in either of the products. It is worth noting that while in the phosphate-free ham the arrangement of the muscles was more random, and therefore the placement of each of the two muscles (topside and silverside) not as constant as in the product stuffed by hand, the appearance was not considered to be especially broken in comparison with the usual phosphate-free product.

Finally, the total decrease in slicing loss was similar for both products (34.78% for the phosphate-free ham and 35.59% for the ham with phosphates), although quantitatively a gain of 2.96 points in slicing yield was obtained for the phosphate-free product and 2.10 points for the product with phosphates. This increase in the yield of slicing lines represents a production increase of 55 T/year for the phosphate-free ham, and 77 T/year for the ham with phosphates (increase in yield evaluated in the processing facility where the tests were carried out).

CONCLUSIONS

In the tests carried out over a three-month period, it was demonstrated beyond any doubt that compacting of the meat with the COMPACTA device signified a great step forward in the automatic stuffing of products with extreme characteristics, such as phosphate-free products with low injection rates (8-15%). In products with similar injection rates but with phosphates, the yield is increased but the results are less spectacular because working with this type of meat is less problematic.

The rigidity of the meat makes it difficult for these muscles to adapt to the plastic casing and/or mold, resulting in gaps between muscles. The internal system of adjustable piston retention facilitates adaptation of said muscles, reducing the empty spaces that cannot be eliminated by means of vacuum pumps and that give rise to undesirable fissures and holes.

It must be pointed out that the COMPACTA line represents a “mechanical” solution and does not entail any change in the production process, so that product quality is not affected, nor is there any impact on the operation of the production lines.

With this new contribution to the process of manufacturing cooked ham, automatic stuffing of high-quality products continues to move forward, coming ever closer to hand-stuffed products.

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