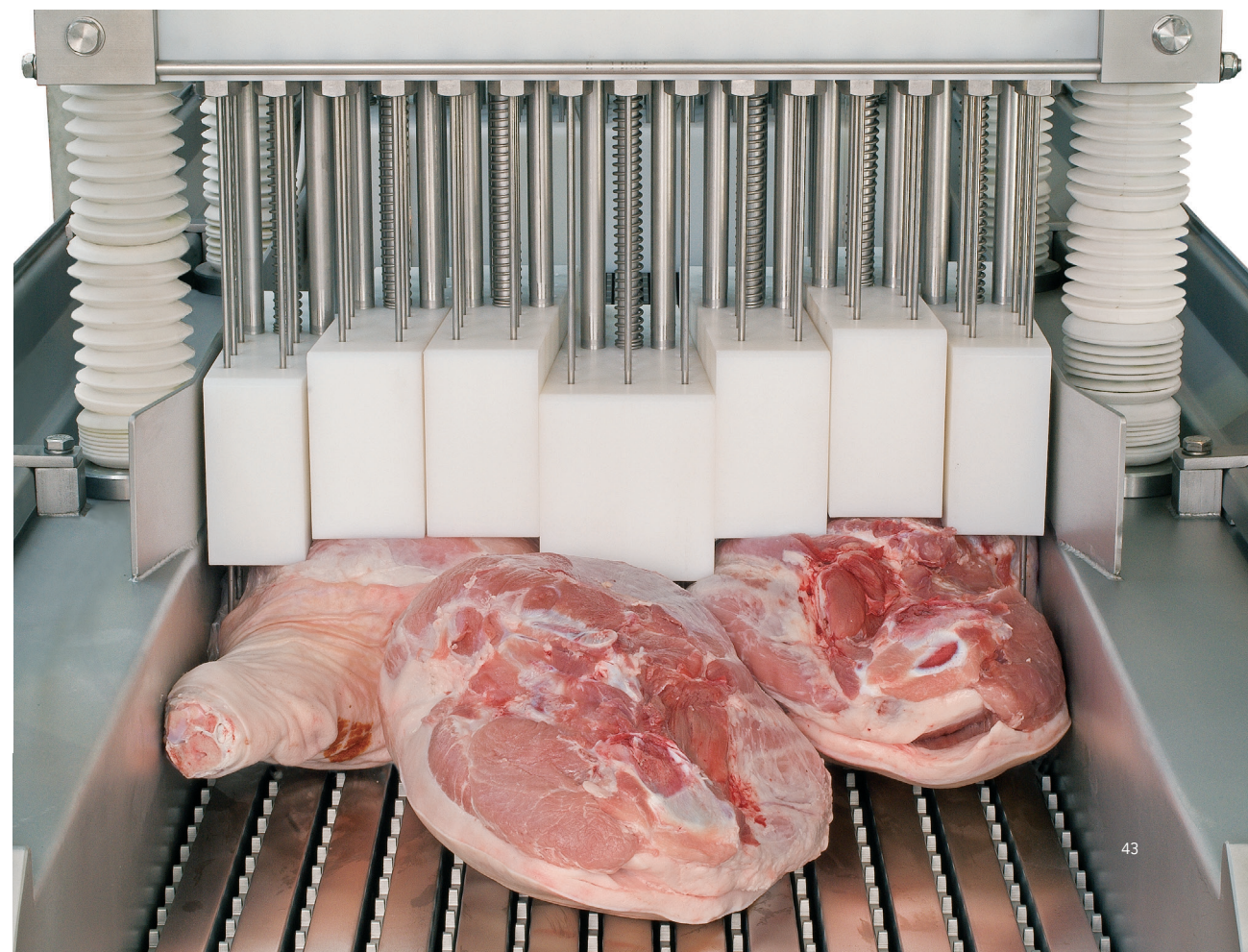


Manufacturing process for whole muscle cooked meat products II: injection and tenderization

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As was mentioned in the previous article, the definition of a manufacturing process is the most important factor in planning a plant for cooked products, since it must cover the needs and demands of said process. Therefore the initial planning stage will stem from the desired range of products to be produced, including those for possible future phases. For this, it is necessary to select the most versatile possible machinery integral to said process in order to anticipate said phases, as well as changes in market demands or simply policy changes within the company.

What are manufacturing processes for whole muscle cooked meat Products?

This could be defined as all the existing phases between arrival of the meat and dispatch of the finished product. Each of these phases must function in relation to the others to avoid unnecessary accumulation of material and wasted time on the part of the workers. Therefore it is of utmost importance that the planning stages be elaborated by a team, covering all integral aspects, to prevent imbalances and lack of coordination in a plant once it is built and operating.

The process of manufacturing whole muscle cooked meat products was in constant flux during the second half of the 20th century. Up until twenty or thirty years ago this work was carried out in a traditional manner, obtaining a very limited series of products due to the lack of equipment and scientific knowledge concerning the properties of meat and the technology for its production.

Thanks to theoretical studies of universities and scientific centers and the theory-practice study of consulting firms and equipment manufacturers, or of the producers themselves, a fairly extensive scientific and technological knowledge has been attained, allowing for the development of new kinds of products which can be sent all over the world due to a longer shelf life.

The causes of the change in the manufacturing process can be summarized in the following points:

- Technological and technical progress of machinery and auxiliary components which make up the line, obtaining more versatility and automation. This has made it possible to standardize the processes and offer the consumer a continuity in product quality.
- Changes in the properties of meat due to animal feed and production systems.
- Discovery and development of additives to compensate for deficiencies in the meat or enhance its properties. This is almost always aimed at "extending" the quantity of meat in the finished product.
- Changes in the purchasing power of society which have modified market demands.
- Most countries have introduced legislation to control the use of additives and protect the consumer. This has made it necessary to look for alternative means by which to be able to continue achieving profitability and quality.
- The evolution of refrigeration facilities and distribution networks has made it possible to do without preservatives formerly used and has improved quality considerably.
- Changes in the big distribution chains and in consumer habits that have brought an increase in semi-prepared and sliced products.

RAW MATERIAL

Meat quality is a determining factor in the finished product. The great variety of existing breeds and different types of animal feed would make standardization of products impossible if not for progress in the field of processing technology, and the versatility of lines able to adapt to different kinds of meat.

The most important factors to be kept in mind regarding meat quality are the following:

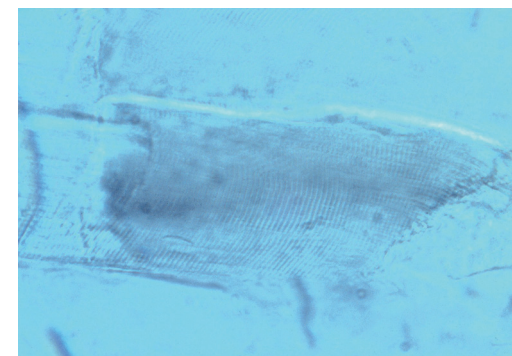
- The pH, which principally affects yield of the finished product and the appearance of the slice. Meat with

pH below 5.6 (PSE meat = pale, soft, exudative) will have less water holding capacity and a pale colour. This means that if the percentage of PSE is very high in a particular batch of meat, problems with cooking loss can result, affecting its appearance. In meat with pH higher than 6.3 (DDF = dark, dry, firm) exactly the opposite occurs, but it has the disadvantage of a greater risk of contamination and too dark a colouring.

- Proportion of fat in relation to muscle tissue. Technologically, fat is of interest because of the problems it can cause in the binding of different muscles and in cooking loss. The fat between muscles will have a tendency to retain juice, giving a spongy look and hindering binding between muscles. It is also of interest because of the way it affects appearance of the slice. The amount of fat accepted by the consumer depends on the social customs of each region or country. For example, in the United States the product is expected to be completely free of fat, while in countries like Italy or France the product must be presented with all its outer fat intact, not only to give it a more traditional appearance, but because said fat will contribute importantly toward the enhancement of flavor. In this case it is also important that the meat be marbled, that is, having threads of fat between the muscle fibers, because this considerably improves the product's texture and chewability.

- Prematuration or the period of time between slaughter and processing of meat. The minimum

▼ Untenderized meat.



time to overcome "rigor mortis" (muscular toughness which appears after slaughter) in pigs is considered to be 36 hours. In Spain the processing of meat usually begins after 48 to 72 hours, since the animals dealt with are of light weight (80-90 Kgs.) without highly developed muscle fiber. In countries where the animals slaughtered are usually older, and therefore heavier in weight (120-150 Kgs. or more), the prematuration time is customarily longer since the muscle fiber is tougher and must be broken down by the proteases responsible for autolysis (cathepsins and neutral proteases). This is also the case for beef which requires a long period of storage, from one to two weeks, before being processed.

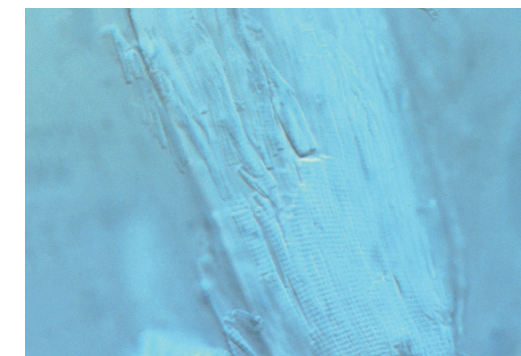
PHASES IN THE MANUFACTURING PROCESS FOR WHOLE MUSCLE COOKED MEAT PRODUCTS

MEAT PREPARATION

This is divided into three phases: boning, cutting and trimming.

Boning: Except for a few exceptions, this procedure is generally carried out manually due to the lack of appropriate machinery. There have been attempts to design machines for this purpose but they still need to be improved since they break up the meat pieces too much, leaving a lot of meat on the bone. In Spain and most other countries, boning of ham is done in an open form, that is, the piece is cut

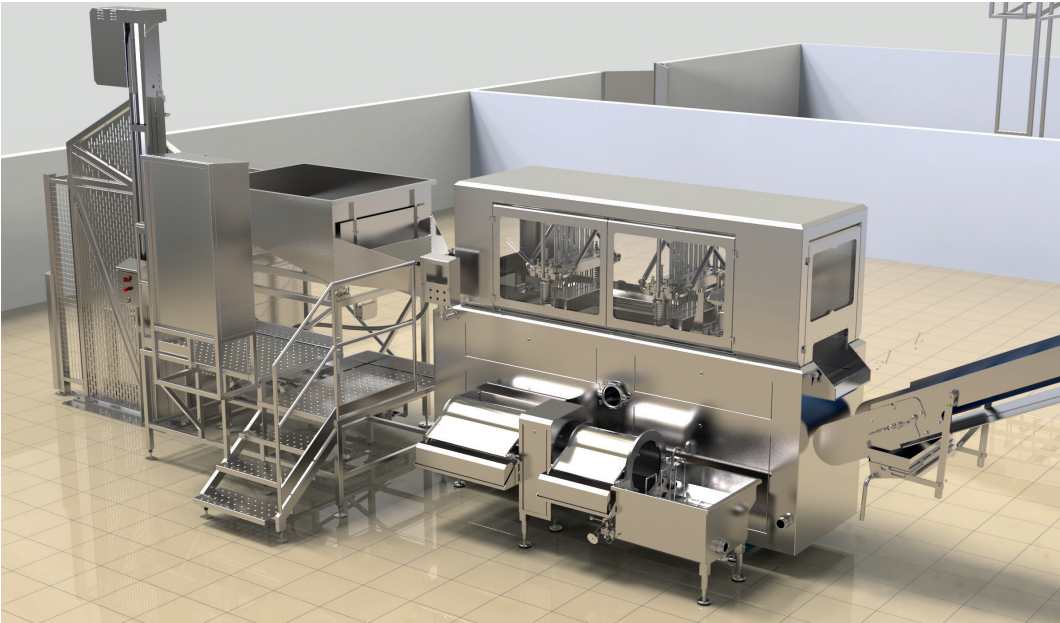
▼ Tenderized meat.



open as if it were a book. In some cases, when the shape of the ham must be reproduced exactly in order to present a higher quality, the piece is left whole without cutting and the bones are removed with a gouge (knife specially designed to separate the meat from the bone without cutting open the piece). This process is much more handcrafted and requires more manpower, and therefore has been reduced to a determined type of product, generally of high quality, in which the market price allows for this increase in labor cost.

Cutting: The existence of a wide variety of products means that the cut of the piece along different muscles is also highly varied. In general, the cutting degree is proportional to the product's quality since, from the point of view of yield, it is much easier to work with small pieces. In the case of ham, the piece is usually separated into its four principal muscles, and if the meat is then submitted to proper processing, it is possible to reproduce the entire piece whole from these four muscles, regardless of the product's final yield.

▼ Injection line.



Trimming: As has already been mentioned, separation of the fat is important in certain types of products. But it is equally necessary to eliminate the connective tissue which surrounds the muscle in order to facilitate solubilization of proteins, improve binding of muscles and prevent retraction during thermal treatment. The same is true of tendons and nerves that can cause holes to appear between muscles.

In cases where this operation is not deemed profitable, it is indispensable to make a series of transversal cuts in the nerves and tendons to reduce the degree of contraction. This operation can be carried out mechanically with a "tenderizer" which will make a series of cuts in the entire piece, preventing problems of binding and considerably increasing the surface of protein extraction. For sliced products, this phase must be very rigorous in order to prevent problems and to improve yield in the cutting line. It is a great help to have a membrane skinner at one's disposal, which eliminates the aponeurosis that wraps around the muscle.

INJECTION

The curing process of meat requires the addition of a number of additives and ingredients which are indispensable for its coloring and flavor. These, together with water, form the brine which will be injected into the meat in a homogeneous way. An irregular distribution of brine will result in a deficiency or excess of ingredients in differing zones, causing irregularities of coloring, binding, cooking loss and flavor.

The percentage of brine to be injected will be determined by the quality wished to be obtained in the finished product, and all the subsequent phases of the process will depend on this factor.

The injection percentage will be given in the following relation:

$$\text{Injection \%} = \frac{\text{Green meat weight} + \text{Injected brine weight}}{\text{Green meat weight}}$$

The choice of an injector is very important when deciding on a processing line since this will directly condition the results of the production.

The characteristics of interest when selecting an injector are the following :

Homogeneous distribution of brine in the meat muscles. This will influence the appearance of the slice, preventing visible brine lines and color irregularities, and above all the product's final yield, since the brine ingredients responsible for the solubilization of proteins will be received by all the muscle fibers.

Precision in the injection percentage. This assures a minimum standard deviation in the brine content of different meat pieces and enables you to offer the consumer a continuity in quality. In some legislation, the injection percentage is regulated

according to categories of quality. The less standard deviation there is, the greater the precision of injection, obtaining fewer under-injected pieces (which could cause problems with flavor, and water holding capacity due to a lower concentration of brine) and also fewer over-injected pieces (over legal analytical limits).

The following example, taken from comparative tests of two injectors of differing brands carried out at a plant for cooked ham, will illustrate this point : A batch of 100 whole ham pieces was put through each of the two injectors (A and B), calculating the injection percentage piece by piece. A normative maximum of 25.2% injection was permitted (figure derived from the numerous analyses carried out). The purpose of the test was to calculate what the average injection percentage should be, maintaining a 99% rate of reliability. The reliability rate indicates the probabilities that a piece will be in a zone of the injection curve. A 99% rate of reliability tells us that 99% of the pieces in a batch are within the limits of values determined for injection. These values are directly related to the typical deviation of injection (σn) through factor "f", statistically established.

With the values obtained, the degree of precision of the two injectors was calculated, according to the following formula :

$$\text{IP Injection precision} = 100 \sigma n / X$$

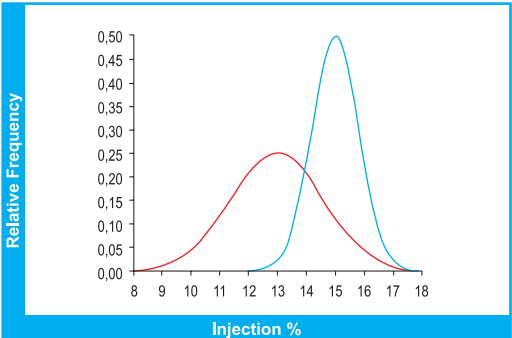
σn = Typical deviation
 X = Average injection

The results obtained were the following :

IP injector A = 10 %
IP injector B = 4,1 %

As can be observed, injector B is much more reliable and precise than A. This allowed us to calculate, starting from the typical deviation, injection precision and with a 99% reliability rate (value f

= 2.58] the average injection percentage which could be reached while staying within the limits demanded by the norm. The result is illustrated in A diagram:



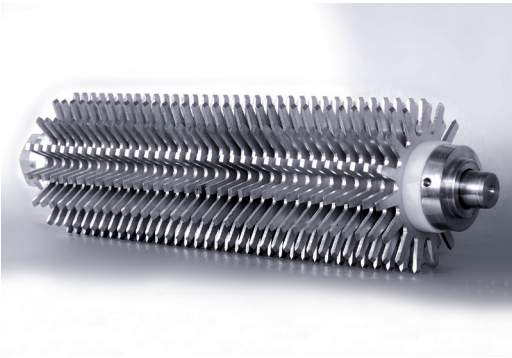
Low pressure injector Metalquimia spray injector

A diagram.

The precision of injector B allows for the injection of a batch of meat at 23%, maintaining the same level of reliability of analytic results as in pieces from injector A with an injection percentage below 20%. This means an increase in the product's final yield of 3% per batch.

Capacity to achieve the percentage desired. Injection rates vary widely in most companies, since their products include a range of varying

Tenderizing rollers.



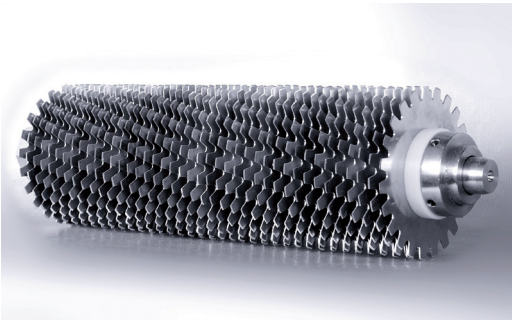
quality. Therefore it is important that an injector be able to inject from a very low percentage, such as 5%, up to a rate of 100% for high-yield products. Both extremes present difficulties, of distribution in the first instance and of capacity in the second, but they are rates which one must bear in mind. Apart from the characteristics of the injector, there are other factors which will influence the percentage reached. The most important of these to keep in mind are the following:

- Meat : size, temperature, fresh or frozen.
- Brine : viscosity and temperature.

Productivity. The rate of productivity will depend on a number of factors other than the injector, such as the size of meat pieces, but it is important that the machine be of sufficient capacity to absorb the production necessities of the plant in the minimum possible time.

Easiness of cleaning. Easy access to all the machine's parts is necessary for a thorough cleaning at the end of each working day, to avoid the risk of contamination that could be spread to the next batch of meat.

Mechanical reliability and low maintenance, so as to avoid production stoppages.



There are many different models of multineedle injectors on the market, but basically they fall into one of two categories:

- Low pressure (most belong to this category).
- Spraying system.

The difference between the two types of machines lies principally in the method used to introduce brine into the meat.

Low pressure injectors deposit the brine during the needle stroke through the meat, with needles usually having 2 to 4 holes of more than 1 mm. in diameter, forming brine deposits which must then be distributed by mechanical action. In contrast, Spray System injectors introduce a volumetrically measured dose of brine with a spraying effect. When the needles have completely penetrated the meat, and are stopped at the end of their downstroke, the brine is injected into the meat by means of a spraying technique. The brine is distributed throughout the entire piece of meat homogeneously, since the needles are specially designed, usually with 11 to 14 holes of 0.6 mm. in diameter distributed at different heights, depending on the product to be injected. This special design, and the high pressure existing throughout the entire brine circuit (between 6 and 10 kg/cm²),

allows the brine to penetrate muscle fiber in the form of micro-drops without damaging said fiber, preventing brine deposits between fibers.

The advantages offered by this system over the former include its great injection precision and homogeneous brine distribution.

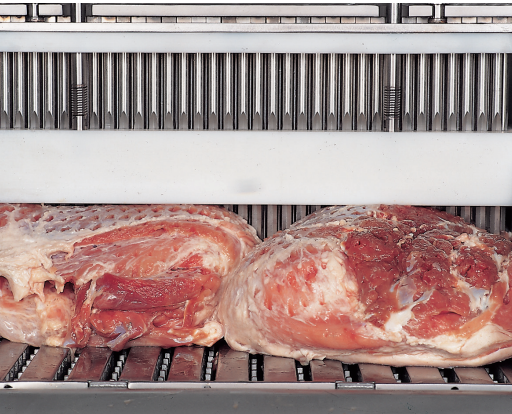
These differences can be observed in in the B diagram.

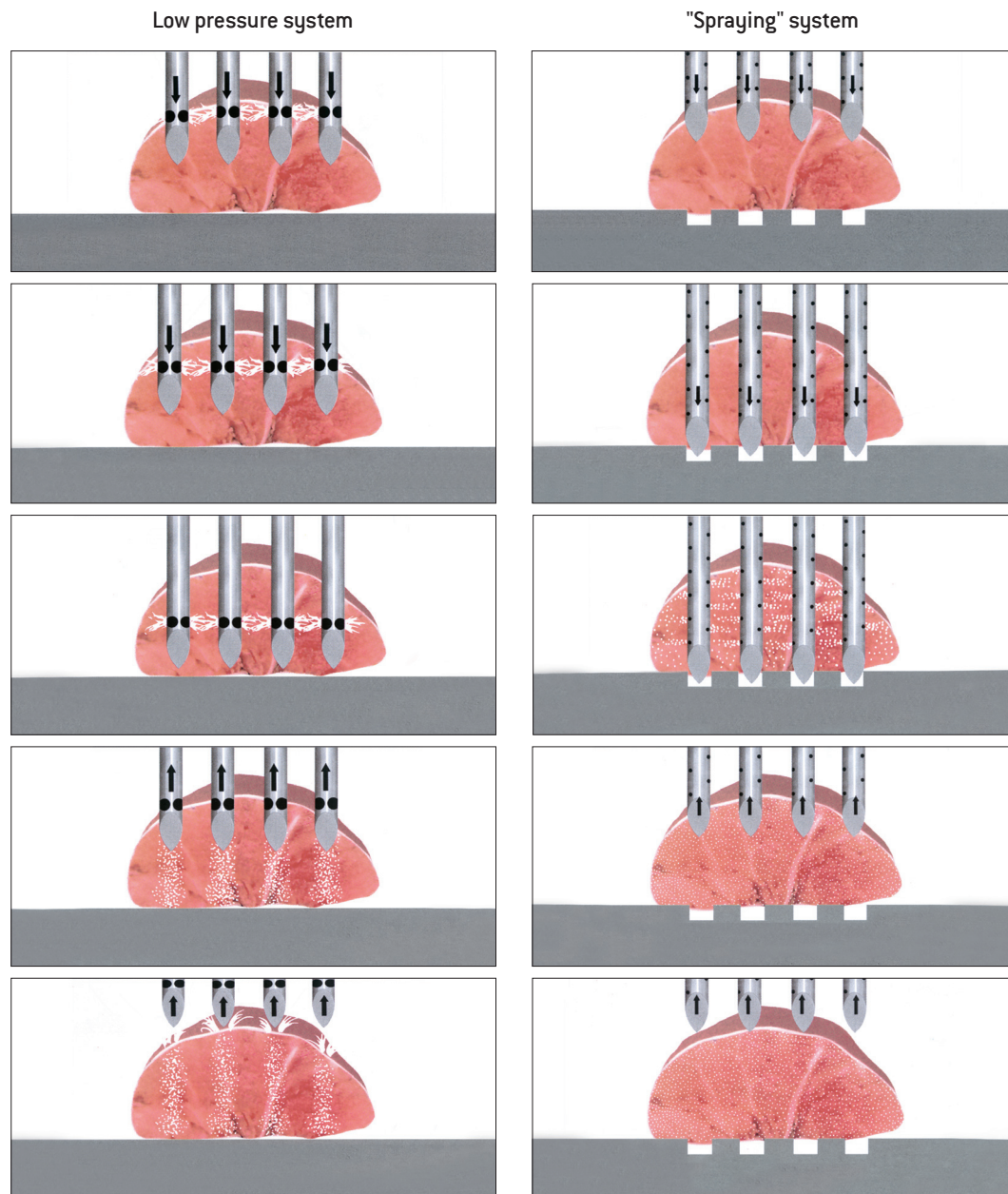
TENDERIZING

Tenderizing is the name given to the mechanical effect of producing a multitude of cuts in the meat muscle to increase the surface of extraction of muscle protein (myofibrillar proteins). This effect will contribute greatly to reduction in cooking loss, and prevent the appearance of holes in the cut of meat as well as preventing binding defects. As was mentioned above, in some products tenderizing can reduce the degree of trimming required, since the structure of connective tissue is broken down, preventing retraction during the cooking process.

Not all products require the same degree of tenderizing. This will depend on the desired yield and on the type of product being processed. In general, it could be said that the higher the yield,

Needle Tenderizing head: BLADETENDER / Tenderizing Needles.





▲ B. Low pressure and spray injection system comparison.

the greater the degree of tenderizing needed. But in certain products it is only necessary to tenderize the meat in order to improve its chewability, and

therefore the mechanical action must be gentler. In some very specific high-quality products, in which the fibrous structure of the meat should be

preserved as much as possible, this technique is usually not applied. Instead, the product goes directly to the massage cycle.

There are three types of tenderizing machines available on the market :

Tenderizer with rollers. This consists of two cross-cutting rollers through which the meat is forcibly passed. There are generally several types of rollers to be used, depending on the product. These can be of knives, which make superficial cuts in the muscular surface, obtaining a high degree of protein extraction. There are also rollers with prongs which make deep cuts in the muscle. This system allows for a strong tenderizing effect without breaking the muscular surface.

The separation between rollers must be adjustable in order to be able to set the cutting level in accordance with what is suitable for each product. Skin-on products can also be put through a tenderizer, substituting one of the cutting rollers for a plastic one, which leaves the skin structure intact.

Tenderizer with blades. This consists of a head with needles which penetrate the meat, producing a series of light cuts in the muscle, softening it but without tearing or separating the muscles. It

▼ Pre-massage / Detail of injection head.



is used principally for whole pieces of high quality but, depending on the model of needle, is also very useful for high-yield products and those called "zero cooking loss", which require a high degree of mechanical processing. The head usually forms part of the injector so that one machine incorporates both phases of the process.

"Hammer" or pre-massage. This involves "hammering" the meat to produce stretching and separation of the muscle fibers, resulting in a high degree of softening the meat muscle. In this way, greater brine absorption is obtained and the required massage time is effectively reduced. In combination with a needle tenderizer, this technique is especially useful for all types of tough meat or for those products where the lack of additives hinders softening of the meat and may cause manufacturing defects, as is the case in sliced, phosphate-free products.

