

Manufacturing process for whole muscle cooked meat products V: **Cooking**

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Continuing with the series of articles on the manufacture of whole muscle cooked meat products, in this article we shall explain the characteristics and peculiarities of the last phases of the process, which are: cooking, cooling and final preparation (if necessary).

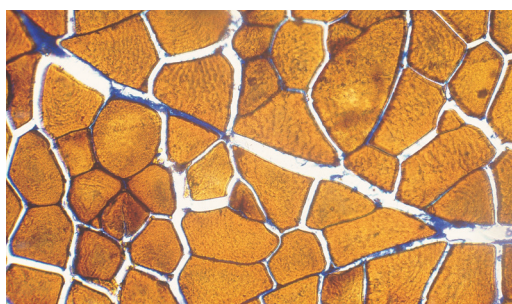
After the process of injection, tenderizing, massage/maturation, stuffing and/or moulding (extensively explained in the previous articles), the meat will go through a phase of cooking, cooling and final preparation (in the case of products with cooking loss) and will result in the cooked product, ready for dispatch and sale. In this article, this final part of the process will be discussed in detail.

COOKING

The cooking process can be defined as the thermal processing the meat undergoes, involving a whole series of physicochemical, biochemical and microbiological phenomena, which will define the quality and the organoleptic properties of the finished product.

The main objectives that are pursued with said thermal processing could be summarized in the following points: development of sensory characteristics [color, flavor, structure, texture, etc.], microbiological stabilization of the product and limiting the effects of overcooking [cooking loss, degradation of organoleptic characteristics].

▼ Photo 1: Matured meat after 3rd massage and before cooking



Development of sensory characteristics

• Stabilization of structure: Coagulation of muscle proteins

The two muscular constituents responsible for the development and stabilization of the cooked product's structure are: myofibrillar proteins actin and myosin and collagen.

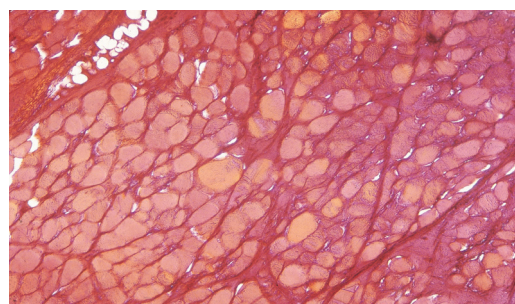
The muscle proteins solubilized by the combined effect of certain ingredients (phosphates and salt) and by the massage process undergo a process of denaturalization due to the effect of heat which brings about a reduction of the intercellular spaces [see photographs 1 and 2], a compacting of the denaturalized fibers and the formation of a three-dimensional network able to hold water, giving the finished product consistency, firmness and muscular binding.

In certain products (for example polyphosphate-free products), hydrolysis of the muscle collagen by means of heat, followed by its subsequent gellification, will be the determining factor in ensuring a good degree of binding between the different muscles.

• Formation of characteristic flavor and aroma

The aromatic aspect of meat is developed and stabilized in two consecutive stages of the manufacturing process:

▼ Photo 2: Meat after cooking.



• The operative phases prior to cooking give rise to the formation of the aromatic precursors (fatty acids, triglycerides, phospholipids, peptides, acid amines, sugars, etc.).

• Transformation of these precursors, by means of heat, into aromatic compounds (aldehydes, ketones, lactones, saturated and unsaturated alcohols, furans, etc.)

The application of heat gives rise to a series of reactions [oxidation, esterification, Maillard reaction, etc.] among the components of the meat mass, forming new compounds of greater digestibility while giving the cooked meat product its characteristic "Flavor".

• Color stabilization

Heat is the cause of the denaturalization of the red pigment in cured meat (nitrosomyoglobin) transforming it into the pink pigment characteristic of these products (nitrosochromogen). Stabilization of this pigment is produced basically in the final phase of cooking, and the minimum temperature for this to occur is 65°C. For this reason the optimum working temperatures will be between 65-75°C, to ensure a good development and color stabilization.

• Microbiological stabilization

During the preparatory phases prior to cooking, the meat will be acquiring a certain microbiological contamination, which conditions the product's salubrity and its expiration date. The objective of thermal processing will be to reduce this contamination to a sufficiently reliable level to ensure stability of the finished product.

Thermal processing is governed by the parameters of temperature and exposure time, which will correspond to a determined degree of destruction. If the initial microbial load is very high, more severe

heat treatments must be applied, keeping in mind that the product's sensory qualities will also be affected.

In the case of cured cooked products, to obtain an optimum degree of destruction it will be necessary for the center of the product to be heated at a constant temperature of 68°C or 70°C for 30 to 60 minutes. Another factor that must be taken into consideration is the speed at which the temperature increases during cooking, since slow speeds can give rise to phenomena of bacterial stress and the development of thermal-resistant strains. Therefore, one must try to limit or reduce the time a product remains exposed to temperatures favorable to thermal tolerance (40-50°C).

Avoid the effects of overcooking

• Control of cooking loss

An uncontrolled cooking process can generate high water losses that can be detrimental both for the consumer (sensory aspect) and for the product (economic aspect). The two phenomena that regulate this water loss are: liberation and migration.

The liberation of water depends essentially on the temperature, in that an increase in temperature produces an acceleration of the free water's molecules (water not bound to the proteins). This phenomenon is practically instantaneous. At the same time, a certain amount of bound water is also transformed into free water in motion, as a consequence of the reduction of water-holding capacity and the increase in temperature to above 45°C. In this way, the total quantity of free water is increased.

The migration process is influenced by the temperature as well as by the exposure time to heating. In the most outer parts of the product, this migration takes place in the form of evaporation [in the case of unpackaged products] or liquid freed



▲ Photo 3: Automatic cook processing system: COOKLINE.

into the exterior environment. It must be kept in mind that not only water is lost, but also other elements dissolved in it such as proteins, collagen, salt, polyphosphates, flavorings, etc.

The cooking processes that limit evaporation phenomena are, for example, cooking in water, steam, vacuum, etc., but the temperature must also be controlled with these methods (low temperature to prevent liberation) and not too long cooking times (due to its effect on migration).

• Degradation of sensory qualities

Excessive cooking systematically leads to degradation of sensory qualities. Development of flavor is optimum at temperatures of around 60-65°C. At higher temperatures, the appreciation of flavor becomes unfavorable, worsening proportionally as cooking time gets longer.

COOKING SYSTEMS

Traditional or classic cooking systems are based on the heating of an external fluid (air or water) by means of steam injection, electric resistance, etc.

In these cases, heat is transmitted to the surface of the products and is diffused to their interior by conduction. The characteristics of the fluid, mainly the relative humidity, have a strong influence on the result obtained.

Cooking in water

This consists of the discontinuous loading of cooking baskets containing the packaged and/or moulded product into a water boiler, which is set at a preset temperature, depending on the cooking requirements of each particular product.

Water cooking has the advantage of an excellent exchange and transmission of heat, resulting in a shorter cooking time while allowing for a good homogeneity and regulation of the temperature. However, it is also somewhat inconvenient in terms of hygiene, especially in products with cooking loss in which the meat can come into direct contact with the water. In addition, the space occupied by water baths is a clear disadvantage when compared to oven cooking.

Cooking in steam oven

The product to be cooked is placed in cooking trolleys provided inside the cooking cells. As in the above system, the operation is discontinuous. There are certain disadvantages compared to water cooking, among which we could mention the following:

- Heat exchange and transmission lower than water (longer cooking times).
- Imperative need for a good heat homogenization design and system, in order to prevent possible temperature differences inside the oven which would lead to the irregular cooking of pieces of the same batch. Recently ovens have been greatly improved in this respect, and there are now ovens on the market in which these differences are minimal.

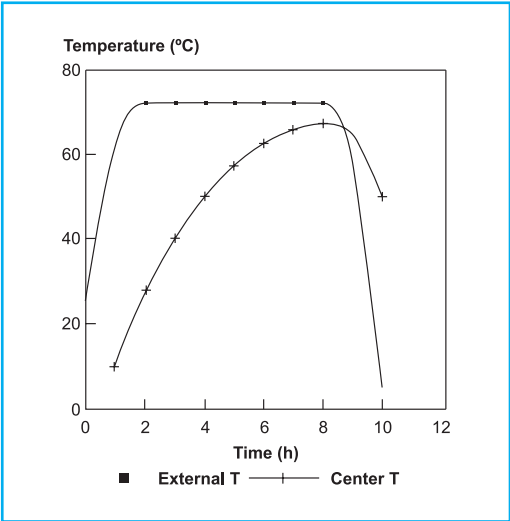
On the other hand, steam oven cooking is a system involving low energy costs and easy maintenance, useful for products with cooking loss that are cooked without vacuum and in open bags.

Alternatives/Automation

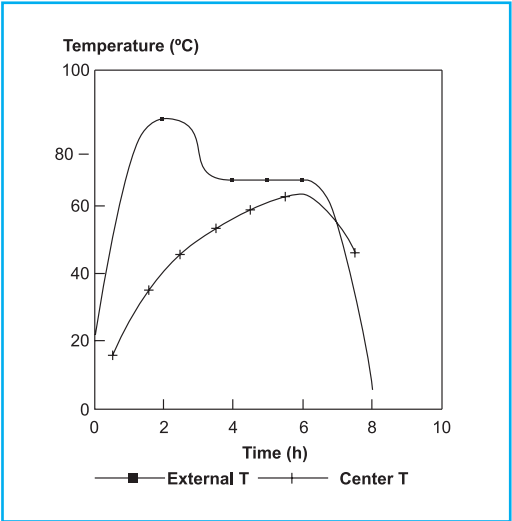
There are other methods that are still in the research and development stage (infrared, microwave, ohmic heating), with the goal of achieving the fastest possible transmission of heat without the need for preheating. So far, none of these methods is used for this type of products, due to the lack of uniformity and because it is impossible to effectively control the processing temperature.

At present, the most modern cooking equipment is still based on the classic systems, but with a high degree of automation for better control of the process. The cooking and cooling phase can be carried out in the same receptacle, eliminating unnecessary transport. The phases of loading and unloading the moulds or cooking baskets can be automated, which cuts down on manpower and facilitates the work of the operators. All the operations (cooking, cooling, loading, unloading) can be integrated in the same program that will automatically manage the cooking/cooling phase with total product control/traceability.

▼ Chart 1: Constant T.



▼ Chart 2: Decreasing T.



COOKING PROCESSES

It is very difficult to determine an optimum cooking method. Our experience has taught us that each product can have its optimum type of cooking and that similar products may give different results depending on the factory and/or the country. There are three basic types of cooking, which must ensure: good development of the products' sensory characteristics, obtaining an adequate internal temperature and a sufficient pasteurization value.

• Cooking at constant temperature

In this type of cooking, the temperature of the medium (air or water) or external temperature is maintained constant, at a maximum value, from beginning to end of the thermal processing. The end of the cooking cycle will be determined by when the center of the piece reaches a certain temperature, known as core temperature. This kind of cooking is the most extensively used, giving overall acceptable results [see chart 1].

• Cooking at decreasing temperature

This is the traditional method of cooking. It begins

with a high initial external temperature [for example, between 80 - 90° C], which is maintained for a certain length of time until the thermal center of the piece reaches a predetermined temperature [for example, between 50 - 55° C]. Then the external temperature is regulated to a lower temperature [70 - 75° C] for the duration of the cooking process [see chart 2].

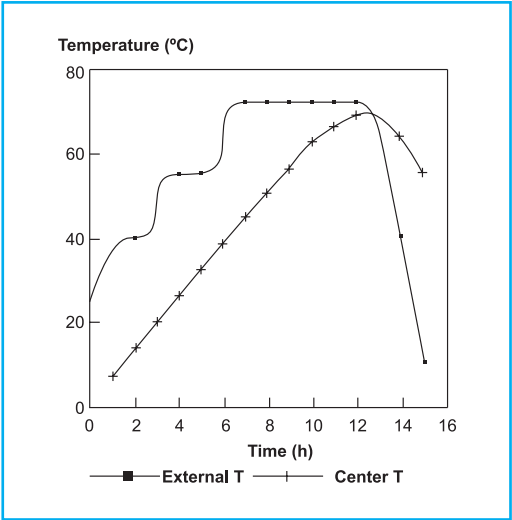
In comparison with other cooking methods, this one usually results in products of lower yield and shorter shelf life as well as a lack of cohesion in the slices. It also has a negative impact on organoleptic properties of the product's surface, creating problems of overcooking in this area of the piece. This method should be ruled out from the outset unless some imperative need exists [lack of time, insufficient material, etc.].

• Cooking at increasing temperature

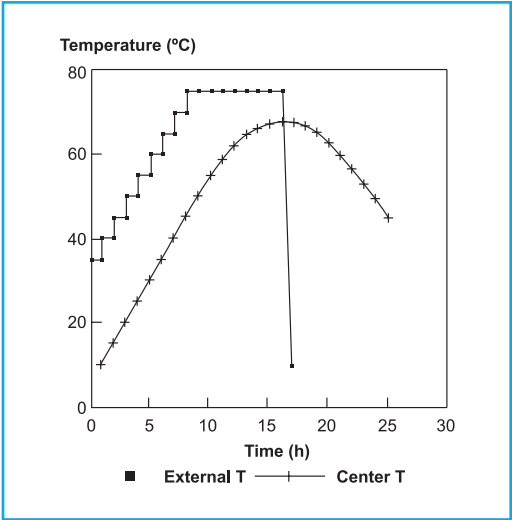
We can distinguish between two types: *Step by step Cooking* and *Delta T Cooking*.

Step by step cooking: In this cooking method, the external temperature is increased in a graded fashion, in various successive stages, until the

▼ Chart 3: Step-by-step.



▼ Chart 4: Delta-T.



desired temperature is reached in the thermal center of the piece [see chart 3]. This type of cooking produces good results, above all in zero cooking loss products, although the cooking times are longer than in the methods explained above.

Delta T cooking: What is known as Delta T cooking is the thermal processing in which the external temperature is increased continuously, in a line with the increase in temperature in the thermal center of the meat piece.

At the end of the process the external temperature is maintained constant, as in the constant temperature heating method explained above [see chart 4].

This type of heating produces very good results from the organoleptic point of view [the alterations due to overcooking of the surface are practically zero] as well as in regard to yield of the finished product. One negative point, however, is its long duration, and therefore, at an industrial level, it is not very viable and is rarely used. It has been shown that a Delta T heating at 25° C produces optimum results from the point of view of yield, as well as with respect to the organoleptic aspects of the finished product.

FINAL TEMPERTAURES

Whatever cooking process is used, the temperature in the thermal center of the piece is what will delimit the end of the cooking process. These temperatures will vary depending on the type of product being processed, the desired yield and the organoleptic characteristics wished for in the finished product.

In general, it can be said:

- Cook-in Products: Final core temperatures from 65 to 69° C.
- Products with Cooking Loss [open bag cooking]: Final core temperatures between 67 - 71° C.
- High Quality Products: In these products it is precisely the cooking loss that is desired, therefore thee final core temperature in them usually reaches 70-71° C.

COOLING

This phase has a strong influence on the final characteristics and quality of the finished product. Cooling of the meat pieces after cooking, and the way in which this has been carried out, can affect the final yield as well as cohesion of the slices and the degree of pasteurization.

Once the cooking process has been completed, it is recommendable to pre-cool the product by means of shower or immersion in water. The high water transmission coefficient allows for a rapid reduction of the internal temperature to 50-60°C, to slow down the temperature increase in the core and prevent excessive heating of the chilling rooms.

Immediately after pre-cooling, the product must remain in the chilling room for a minimum of 24 hours before being removed from its mould and a minimum of 48 hours is required before dispatch, in order to make sure that the color and the other organoleptic properties of the cooked meat product have stabilized. At the very least, it must be made sure that the thermal center of the ham product reaches temperatures of below 4° C. In products of a certain quality, and above all those containing a layer of skin or fat, changes have been detected in the organoleptic properties during the period subsequent to cooking. Put simply, it could be said that the product “settles”, giving rise to a softer texture and better development of aroma. It is therefore recommended to wait an optimum

period of time, depending on the product, before proceeding to dispatch.

FINAL PREPARATION

Those products which have suffered cooking loss, with the exception of those smoked in permeable fibrous casing or products to be sold in slices, must be removed from their moulds and vacuum packed (thermosealed or clipped).

Because this always involves some handling of the product, extreme care should be taken to reduce to a minimum the unavoidable recontamination the product undergoes. This contamination becomes evident after some time in the appearance of juices in the bag or final packaging. In some countries, manufacturers try to prevent this phenomenon by adding gelatin, by bathing the piece in solutions of preservative substances, by means of a superficial roasting of the piece; or by the application of ultraviolet radiation (UV), etc.

In recent years, a lot of work has been done on this subject, leading to the conclusion that the

most efficient method is thermal processing (pasteurization or sterilization) of the product surface once it has been repackaged, regardless of whether or not gelatin is added. This method gives the finished product a shelf life that is clearly longer than products processed with the other above-mentioned methods.

However, the final shelf life will depend on, as in all thermal processing, the relation between processing time and temperature to which the product is submitted. For conventional pasteurization processes at atmospheric pressure, the minimum time must be that necessary for the temperature to penetrate some 4-5 mm into the meat surface.

This final preparation phase is unnecessary in those products cooked in their final packaging (Cook-in-ham) which have not exuded juices during the cooking process.

Cook-in technology is a sophisticated technology that requires rigorous control and care in all phases of the process, with great technological know-how and proper selection of the machinery. The advantages offered by this system, including extended shelf life of the finished product and increased profitability, make cook-in technology a very attractive option for the meat industry.

Finally, regardless of whether the process used has been cook-in or the product has been repackaged, it must be stored in a chilling room (between 2 and 4° C) and in darkness until its final arrival in the hands of the consumer.

CONCLUSIONS

The attainment of a technologically correct cooked meat product is not the fruit of chance. In this article we have shown the importance of thermal processing, cooling and final preparation in achieving this goal. In any case, this final technological effort will not be of any use unless it has been preceded by a careful selection of raw material as well as proper

processing and strict control of each and every previous phase (from the preparation of the brine to the moulding of the matured meat).

This correct processing and rigorous control will help, without doubt, the meat manufacturer to obtain a high quality product while minimizing all risks.

