Consortium for Educational Communication

Module on

SALTING AND CURING OF MEAT

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TEXT

Curing refers to the application of nitrite or nitrate with salt and other ingredients to meat for improved preservation. Curing is not used as much today for preservation of meats (except in very salty items like country ham and proscuitto). Rather it provides for the development of a characteristic flavor and color and also provides protection against *Clostridium botulinum* outgrowth. Although curing was used in ancient times as a means of meat preservation, it is employed now more for flavor and color development. The classic meat cure ingredients are NaCl, nitrite or nitrate, and sugar (sucrose or glucose), with NaCl being the major ingredient. In addition to these, some products may contain curing adjuncts such as phosphates, sodium ascorbate or erythorbate, potassium sorbate, monosodium glutamate, hydrolyzed vegetable proteins, lactates, or spices that results in the distinctive characteristics of cured meat.

Meat Curing Ingredients

1. **Salt**

Salt is the most basic ingredient in all curing brines and dry mixes. Without the inclusion of salt the curing process would be impossible. Originally it served as a preservative by dehydration and osmotic pressure which inhibits bacterial growth. Salt still functions as a preservative in the "country style" cured meat product. The main function of salt in other cured products is to add flavors and is essential in solubilizing muscle proteins. Granulated or grain salt was commonly called "corn", thus the term corned beef. Due to its undesirably harsh flavor, salt is often used in conjunction with various sweeteners to provide a mild flavor. Additionally, salt improves yields and influences textural characteristics. Food grade salt that is of the highest purity should be used in meat curing practices. The amount of salt used in brines and dry mixtures can vary considerably. Usually the level is self-limiting. Extreme levels of salt make the product too salty, and too little salt can result in inadequate protein extraction. Most curing brines range from 35° to 85° salometer. Brine strength is checked by use of the salometer, a hydrometer that is graduated to show the extent of saturation of brines.

2. **Sweeteners**

There are several types of sugars that may be used in formulating curing brines and dry mixtures. Some examples of commonly used sugars are sucrose, dextrose and corn syrup. These constitute the most commonly used sweeteners by the meat industry today. Sweeteners function to counteract the harshness of salt and provide roundness and enrichment of flavor. Sucrose also functions as a preservative, but the levels required to provide this effect would probably render most cured meats too sweet. Also sugar provides a surface color characteristic of aged ham, if caramelized sugar is used. Both brown and white sugars can be used. The amount of sugar used is self-limiting due to its sweetening power.

3. **Nitrate and Nitrite**

Through attempts to preserve and extend the available meat supply, early humans used salt as a means of preservation. Nitrate impurities in salt used for this purpose led to the observation of reddish pink colors in meat. This observation lead to the direct addition of nitrate to preserved meat in order to maintain a uniform colour. During the past century, research demonstrated that nitrate added to meats is reduced to nitrite upon degradation by bacteria. Hence it was decided that nitrite was responsible for the fixation of cured meat colour through its reaction with the water soluble proteins myoglobin and hemoglobin. The properties nitrite contributes to cured meat are indeed unique. The original function of nitrite in meat curing was the production of the cured meat colour. In addition to colour, nitrite works as an antibacterial agent, it retards the progression of oxidative rancidity and it has a profound influence on the flavor of cured meats. The use of nitrates in food preservation is controversial. This is due to the potential for the formation of nitrosamines when nitrates are present in high concentrations and the product is cooked at high temperatures. The usage of either compound is therefore regulated; for example, in the United States, the concentration of nitrates and nitrites is generally limited to 200 ppm or lower. They are considered irreplaceable in the prevention of botulinum poisoning from consumption of cured dry sausages by preventing spore germination.

Curing Adjuncts:

In addition to the commonly accepted curing agents, the meat processor in the curing process commonly includes several other adjuncts e.g., ascorbates and erythorbates, phosphates, starches, and hydrocolloids. Problems over the decades associated with colour and yields have been the primary motivation for inclusion of these ingredients.

1. **Ascorbates and Erythorbates**

Ascorbic acid ($C_6H_8O_6$), termed vitamin C, a water soluble vitamin, is often used as a curing accelerator. That is, it helps speed the conversion of nitrite to nitric oxide to hasten the development of cured colour in rapidly processed cured meats. One part of ascorbic acid is equivalent to one part erythorbic acid. The benefits of using ascorbic acid in cured processed meats are: (a) curing time can be substantially reduced, (b) a more uniform colour will result throughout the product, and (c) better colour and flavor can be maintained during storage, distribution, and display. Additionally salt, low acidity levels, high temperature, and freezing accelerated colour fixation. Another possible benefit of using ascorbate is the blocking effect of the compound on the formation of N-nitroso compounds. The USDA, for curing purposes, approves the following forms of ascorbates: ascorbic acid, sodium ascorbate, erythorbic acid, and sodium erythorbate. Sodium erythorbate is the most widely used form of ascorbate, due to its lower cost. Federal regulations permit the addition of 550 ppm of ascorbic acid or erythorbic acid or the equivalent molar level of sodium ascorbate or sodium erythorbate in each 100 gallons of curing pickle.

2. **Phosphates**

The use of alkaline phosphates in meat curing is widely employed by the meat industry. The various phosphates used in meat industry have been used primarily to decrease shrinkage and the degree of purge in processed meats. Phosphates appear to present a mode of action that is twofold: (a) elevating the pH of the meat and (b) solubilization of muscle proteins. At the isoelectric point of meat, pH 5 to 5.5, fluid retention is at a minimum. Thus any additive that significantly elevates the meat pH should increase the fluid retention of isoelectric meat. Phosphates are essentially the salt forms of phosphoric acid. There are two recognized classes of phosphates: (a) the orthophosphates containing a single phosphate anion and (b) the polyphosphates containing two or more phosphate anions.

The following phosphates are approved for use in curing pickles: disodium phosphate, monosodium phosphate, sodium metaphosphate, sodium polyphosphate, sodium tripolyphosphate, sodium pyrophosphate, sodium acid pyrophosphate, sodium hexametaphosphate, dipotassium phosphate, monopotassium phosphate, potassium tripolyphosphate, and potassium pyrophosphate.

3. **Starches and Hydrocolloids:**

Starch is a multifunctional ingredient manifesting properties that can be applied to numerous food products. Starches contribute texture enhancement, binding properties (usually water), and improved mouth feel to meat products. All of the characteristics are dependent on the origin of the starch, and its performance capabilities. The most common starches used by meat processors are extracted either from cereals (corn, wheat and rice), or tubers (potato, konjac and tapioca). Each type of starch has inherent characteristics that can be utilized to produce specific textural and sensory properties in cured meat products. Some hydrocolloids such as carrageenan, locust bean gum, xanthan gum, guar gum and pectins are also used in cured meat products, because they provides enhanced textural improvements in low fat/fat free sausage products.

Role of nitrite and or nitrate in meat colour:

Nitrite and or nitrate are used in curing meat to counteract the undesirable effects of salt on colour. The colour of cured meats is generally dependent on three factors: (a) the concentration of myoglobin in the muscle tissues, (b) the degree of conversion to the nitrosyl pigment, and (c) the state of the muscle proteins.

As indicated, both nitrite and /or nitrate are used in meat curing for colour stabilization. The end result is the same in either case, although the pathway for stabilization of colour by nitrite is more direct. Nitrite requires one less step in stabilization of colour, as shown in the series of reactions below:

Nitrate reducing organisms

Nitrate ---> Nitrite

Favorable conditions

Nitrite---> NO + H2o

Absence of light and air

Nitric oxide water

Favorable conditions

No + Mb ------------------------------------>NOMMb

Nitric oxide myoglobin
Nitric oxide metmyoglobin

Favorable conditions

NOMMb-------------------------------------> NOMb

Nitric oxide myoglobin

NOMb + Heat + Smoke ------------------------------>NO-hemochromogen

Nitroso-hemochromogen

(Stable pink pigment)

All of these reactions are nonreversible. Nitric oxide is the first pigment of cured meat. Upon the application of heat, it is converted to nitrosohemochrome, which is a denatured protein, and exhibits the characteristic pinkish-red colour of cured meats.

Bacterial inhibition:

Nitrite addition to meat is responsible for the traditional and distinct colour and flavor of products such as ham, bologna, and frankfurters. An additional major benefit is the retardation of *Clostridium botulinum* growth and toxin production. Botulism was first reported in Europe as a disease caused by the consumption of sausage products. The word "botulism" was derived from the Latin botulus, meaning sausage. Current research efforts have suggested possible inhibitory mechanisms by which nitrite inhibits *C. botulinum.* These include: (a) formation of an inhibitory substance from nitrite and other meat components, (b) nitrite or intermediates acting as an oxidant or reductant on intracellular enzymes or nucleic acids, (c) restriction of iron or other metals essential to *C. botulinum* by nitrite, thereby interfering with the organisms metabolism or biological repair system, and (d) reaction of nitrite with cell membranes to limit metabolic exchanges or substrate transport. Metal-sequestering agents such as EDTA have been demonstrated to enhance the inhibitory activity of nitrite, whereas excess iron caused a decreased inhibition. Another theory is the conversion of extracellular iron, which is essential to *C. botulinum* to an unavailable form after reaction with nitric oxide. Recent evidence indicates that they may also inhibit *E. coli*, *Salmonella*, and *Campylobacter* if in sufficient quantities

Flavor

Nitrite commonly used in the production of cured meats, is a major contributor towards development of the characteristic cured meat flavor. This function of nitrite in cured meats has not been linked to any specific flavor components. Sodium nitrite alone is a very potent flavor enhancer in cured meat. Salt is a catalyst for increased fat oxidation and rancidity. Claims have been made that salt is the major factor responsible for cured meat flavor, rather than nitrite or the absence of oxidative rancidity. It should be noted however that salt pork and bacon have quite different flavours, suggesting a positive role of nitrite in flavor formation.

Lipid oxidation:

Nitrite commonly used in the production of cured meats, is a major contributor toward retardation of lipid oxidation. The effect of nitrite on retarding development of rancidity is probably due to the same reaction that is responsible for the colour development. The heme compounds of muscle contain iron ions that are quite active as catalysts of lipid oxidation. When nitrite reacts to form cure pigments, iron is retained in the heme, usually in the reduced (Fe^{2+}) form, making it unavailable as a catalyst for lipid oxidation. This reaction therefore probably accounts for the prevention of "warmed-over" flavor in cured meats. Nitric oxide, as a free radical, can also terminate lipid autooxidation. Unsaturated fatty acids are targets of lipid oxidation and the nitrosation of double bonds also could decrease lipid oxidation. The addition of 50 ppm of sodium nitrite has been shown to reduce lipid oxidation products by nearly 65%.

Nitrite intake and nitrosamines

Concerns have been expressed over the potential hazard of using nitrite in cured meats since this compound can react with amines, especially secondary amines, to form *N*-nitrosamines, which may be carcinogenic:

$$R_2NH + NO_2^- \xrightarrow{H^+} R_2NNO + H_2O$$

Used under the existing regulations, nitrite is not considered a health hazard. There are reported rare toxic episodes, mostly due to accidental overuse. The lethal nitrite dose is 300mg/kg of body weight. Nitrite can react as a vasodilator and hypotensive agent. It can reduce the storage of vitamin A in the liver and it can interfere with thyroid function. It is firmly established that nitrite can oxidize hemoglobin to methemoglobin, lowering the bloods ability to transport oxygen. This anomaly is called methemoglobinemia. It can be fatal and most commonly occurs in infants.

Methods of curing

The meat industry employs several methods of meat curing. However they are all modifications of two basic procedures: dry salt curing and pickle curing. Dry salt curing is the oldest method. Evolution of the curing art eventually led up to the more modern method of pickle curing.

1. **Dry salt curing**

Dry salt curing is a method dating back to prehistoric times and was the first curing method practiced by humans. The process uses salt alone, or sometimes in conjunction with nitrite or nitrate. The moisture is drawn out of the meat by the curing agents and drains off, leaving the meats drier and harder. The product is usually laid skin side down, and all areas of exposed lean are plastered with the curing mix. This process is commonly used for fatty cuts such as jowls and fat backs.

2. **Dry "Country Style" curing**

Curing ingredients employed by dry curing generally are salt, sugar, nitrate and nitrite. The common practice is to rub the mixture into the surface of the product and place the products on shelves in a curing room held at about 36 to 38°F. A general rule of thumb is $1_{1/2}$ to 2 days per pound of ham; bellies up to 2 inches thick will cure in 14 days. It is also prudent to remove and " overhaul" or recoat the products with curing mixture half way through this process. Dry curing may also be used in conjunction with brine injection for some products. The product is usually pumped with about 10% of saturated brine, and the balance of the curing ingredients is applied as a dry rub.

3. **Brine Soaking**

Brine soaking probably followed dry curing and was often used commercially for several years. Meat pieces are placed in curing brine, and the cure is allowed to penetrate the entire portion. This process is relatively slow, and spoilage may develop before the process is completed. Some items such as corned beef briskets and tongues may still be processed this way; however, the practice is becoming less frequent.

4. **Curing Pickle injection**

The industry standard today is the injection of curing pickle directly into meat pieces. Internal injection of curing ingredients enhances efficiency and promotes a more rapid and uniform distribution of the cure throughout the product. There are three basic methods used to accomplish pickle injection: (a) artery pumping, (b) stitch pumping, and (c) multiple needle injection pumping. Smaller establishments may use artery and stitch pumping because these techniques are slow and labor intensive. Larger establishments processing thousands of pounds of product daily use multiple needle injection.

a. **Artery pumping**

This method introduces curing pickle through the arterial system of the product. Hams are the only products cured in this manner. The single needle is inserted into the femoral artery, and the cure is pumped into the ham. Great care must be taken during fabrication to preserve intact the femoral artery. The process does not lend itself well to high-speed, high-volume production and is therefore seldom used today.

b. **Stitch pumping**

Stitch pumping utilizes a single needle that has several openings. The operator inserts the needle into the meat piece in many different locations to deliver the appropriate amount of pickle. An experienced operator is required to evenly distribute the curing solution. After pumping, an equilibration period is often required to allow the cure to evenly diffuse throughout the product.

c. **Multiple needle injection curing**

This method is widely used by the meat industry today. Due to its speed and effective distribution of curing agents throughout the tissues, it enables processors to manufacture large quantities of product daily.These injectors may be configured to pump either bone-in or boneless product of various sizes and shapes. Pumping speed and the volume of pickle injected may be adjusted as needed. Pump head pressure must always be closely monitored. This should prevent excessive tissue disruption and formation of pickle pockets in the tissues.

Massaging, Tumbling and Mixing:

After the curing pickle has been introduced into the meat pieces, some type of mechanical energy is usually applied. Massaging, tumbling or mixing the meat pieces for various lengths of time, usually under some degree of vacuum, may carry out this process. These physical processes are employed to extract salt soluble protein and improve and accelerate the distribution of cure throughout the product.

1. **Massaging**

Massaging involves frictional energy resulting from meat pieces rubbing together. Meat massagers are vats that contain a mechanism for the slow stirring of meat pieces. The stirring arms or paddles made are set to various configurations. The agitation time can vary depending on the product but generally ranges between 3 and 6 hours. The massaging process is a gentler form of mechanical energy input and works well with softer textured product. This is especially important if the product is to retain a whole-muscle appearance.

2. **Tumbling**

Tumbling is a more severe type of physical treatment. Tumbling involves the use of impact energy resulting from meat pieces falling and striking baffles or paddles contained in a rotating drum. Tumbling is usually carried out under vacuum to offset the potential problem of incorporating air into the protein exudates. Most products are loaded into trumblers immediately after injection with curing pickle and tumbled from 3 to 6 hours. Longer cycles have been investigated, but due to severe limitations of time in commercial environments, this time frame works best for maximum efficiency and product quality. As with massaging, tumbling is carried out to extract protein for binding, to enhance tenderness and juiciness and to increase product yields.

3. **Mixing**

Mixers generally have some type of paddles or ribbons that rotate around a metal shaft. They may or may not be equipped to hold vacuum, and they impart rather vigorous mechanical energy to the product. Short mixing times are usually the rule because longer mixes tend to both tear up whole-muscle product and smear coarse-ground product. Mixers are most often used in the manufacture of sausage products, but some whole muscle products are processed in this manner.