

# Ingredients in Processed Meat Products



**Montana Meat Processors Convention**



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**Basic Chemistry of Meat**

The chemistry and functional behavior of meat as a raw material for processing is derived from the characteristics of muscle. Muscle is a very highly organized biological tissue with an intricate, complex structure, a unique composition and very active biochemical capability. All these characteristics carry over to the meat used for further processing and impart specific and sometimes variable properties to meat. The composition, anatomy, rigor mortis and functional properties are important in developing an understanding of the use of this tissue in processed meat products.

Meat composition is important to final product composition. Lean meat, by itself, is relatively constant in composition but whole meat cuts (including external fat, etc.) is highly variable as can be seen in the range of values in Table 1.

Table 1. Composition of muscle and range in meat products. (Modified from Kiernat, 1964)

<b>Characteristic</b>	<b>Typical Lean Meat</b>	<b>Range in Meat Products</b>
Water	70%	22-80%
Protein	20%	9-34%
Fat	3%	1.5-65%
Ash	1%	1-12%

Additional variables to be concerned with are the biochemical changes that occur in muscle after an animal is slaughtered. These changes can alter product color, influence flavor, and change shelf-life potential. Post-mortem biochemistry can also induce some very undesirable changes.

Structural, compositional, and biochemical properties will vary considerably between different muscles on a particular carcass and will vary even within a particular muscle. Furthermore, animal variation due to age, sex, species, and pre-slaughter handling affect the properties of meat.

It is important to keep in mind that meat remains highly variable as a raw material and a proper understanding of the different properties will help achieve the best finished products. Not only can the most effective preservation be accomplished but the highest level of consumer satisfaction can be attained as well. Consequently, this discussion will cover basic characteristics inherent to muscle, biochemical changes that occur in converting muscle to meat and the chemical properties of the most prevalent meat components.

## **Composition**

The three major components of meat are water, protein and fat.

### ***Water***

Water is, by far, the largest component, comprising about 70% of lean tissue. Generally, water content is about 3.5 to 7.7 times the amount of protein present. In living tissue, for every kilogram of protein the body synthesizes, 3.5 to 3.7 kilogram of water is needed to surround the proteins. Fat tissue commonly contains 5 to 8% water. Meat with high fat content will have lower amounts of protein and water. Water plays a significant role in processed meats because additional water is added to emulsion products and to cured meats through the use of curing brines. Water loss lowers yields, but it is desired in dry fermented products.

### ***Protein***

Protein is categorized in three groups: myofibrillar (salt soluble), sarcoplasmic (water soluble) and connective tissue (salt insoluble). These protein groups have different basic properties that affect processed meats differently.

The myofibrillar proteins, also called contractile proteins, form the largest structure and bulk of muscle. These proteins are responsible for the contraction ability of living muscle and are found inside the muscle cell. They form the structure called myofibrils. Raw meat materials that are the most expensive generally have the highest level of this protein group. The proteins are the workhorses in processed meats. Much of the processed meat technology is centered on manipulation of the proteins in this group. The myofibrillar proteins (contractile proteins) are distinguished from other meat proteins because they are soluble in high salt solutions. They form filamentous structures in normal meat, but they will absorb enough water in the presence of salt (i.e. high ion concentration) so that they become soluble or go into solution. The ability of these proteins to become solubilized makes them very valuable in processed meats manufacturing. For example, myofibrillar proteins play an integral role in boneless, and chunked and formed ham or roast beef production. The solubilization of myofibrillar proteins makes the glue that holds boneless products together. Salt soluble proteins are also very important to holding water and contributing to the firmness of products.

The plasma proteins, also called the sarcoplasmic proteins, are found inside the muscle cell. They are part of the fluid mass that bathes the myofibrillar proteins (i.e. myofibrils) and provides the necessary biochemical functions to provide energy protein synthesis and remove metabolic by-products. The plasma proteins are already soluble in the muscle cell and are easily extracted from the muscle with water, hence they are called water-soluble proteins. This group of

proteins is most easily identified by observing the fluid that drips from thawed meat. In this group, there are hundreds of different proteins, but in small quantities. Myoglobin is one protein in this group that has significant importance in processed meats. Myoglobin gives meat its color. The heme portion of myoglobin has an active site that binds various compounds. The compounds (e.g. oxygen, nitric oxide) bound to myoglobin gives different colors to meat.

The connective tissue proteins transmit the movement generated by contraction of the myofibrillar proteins to the skeleton of the body. This function requires connective tissue protein to be very tough and strong. Collagen is the major connective tissue protein in meat and it is similar to the collagen found in skin, ligaments and tendons. Collagen content varies between different muscles and even within the same muscle. Muscles used for locomotion, such as leg muscles, have higher collagen levels than muscles used for support such as the loin. Collagen levels in meat increases where muscle attaches to bone. Older animals do not necessarily have greater amounts of collagen, but they do have tougher collagen. This protein group is important to processed products because cheaper lean meat sources tend to contain large amounts of connective tissue. If too much connective tissue proteins are present in the processed meat product you could have product failure or at least have a detrimental impact on the finished product texture.

### ***Fat***

Fat is the most variable component in processed meat. It is extremely important because it directly affects flavor, texture, shelf-life and profits. Fat cells are almost completely filled with lipid. Animal lipids are generally triglycerides, which are glycerol molecules with three fatty acids attached.

There are many different fatty acids. Fatty acids differ due to the differing number of carbon atoms and number of unsaturated bonds in the carbon chain. A single bond between carbons is called a saturated bond and a double bond between carbons is called an unsaturated bond. The combination of different carbon lengths and different numbers of unsaturated bonds give fatty acids varying properties, and fat its unique characteristics. The fat melting point is one measure of the effect of varying chain length and unsaturation. With decreased chain length and increased unsaturation, melting point decreases (liquid at room temperature). Unsaturated bonds have the greatest influence on melting point because they are more susceptible to breakage by heat than are saturated bonds. This greater susceptibility of double bonds is important in processed meats during the manufacture of finely chopped sausages and in shelf-life.

Because pork fat has more unsaturated fatty acids than beef or lamb fat, it is more susceptible to oxidation. Fatty acid oxidation occurs at double bonds that eventually break. Many different compounds form from the breakage of fatty acid double bonds, such as aldehydes, acids, and ketones. These compounds impart

atypical flavors and odors in meat. The composite of these off-odors and off-flavors is known as rancidity in raw product and warmed-over-flavor in cooked products. The oxidation of fatty acids develops spontaneously. This chemical reaction is slowed at low temperatures but not stopped. Meat stored in a freezer will turn rancid much more slowly than meat stored in a cooler. Rancid meat is often associated more with frozen meat than refrigerated meat because bacteria can spoil meat in a cooler before rancidity develops. Some flavors associated with "country cured" hams are from oxidative rancidity.

Metals accelerate rancidity development. Heavy metals (iron, lead, copper, etc.) in particular promote fatty acid oxidation; therefore, hard water should not be used to manufacture processed meat products. Sodium from salt also promotes fatty acid oxidation and hence rancidity development. Antioxidants are not used in most cured meat products because they contain nitrite, a potent antioxidant. Products such as ham and pastrami have a long shelf-life even in refrigerated storage because nitrite greatly slows rancidity development and inhibits the growth of some microorganisms.

It is important to remember that fat oxidation occurs spontaneously and is not stopped in the freezer. Meat should be frozen before the initial stages of fatty acid oxidation begin. If meat has started to develop rancidity before freezing, it will be rancid when it is removed from the freezer. Another important point is that once fatty acids oxidize, the compounds formed are very reactive. These reactive compounds cause rancidity to develop very rapidly throughout the product. Therefore, rancidity cannot be masked by mixing a small amount of rancid meat with good meat because the entire product will develop rancidity very rapidly. Generally, it is better to discard rancid meat than use it in any quality meat products. Freezer burn is a type of oxidation, therefore freezer burnt meat should not be used in quality products.

### ***Other compounds***

Other compounds in meat include carbohydrates, minerals and vitamins. These compounds comprise about 1% of meat and have little influence on the production of processed meat products.

### **Conversion of Muscle to Meat**

Several very significant changes occur in muscle immediately following slaughter. Muscle remains functional for some time, but because there is no longer a circulating blood supply oxygen is not conveyed to the muscle and metabolic end-products are not removed. As a result, the muscle utilizes glycogen as an energy source for ATP and in the process generates and accumulates lactic acid. Ordinarily, with oxygen present, the energy sources are more completely broken down and excess lactic acid is removed via the blood. Without blood circulation, oxygen is unavailable for energy production and lactic

acid is not removed from the muscle. The accumulation of lactic acid causes an increase in muscle acidity; from a near neutral pH of 6.8-7.2 to approximately 5.6. The increased acidity causes a loss in water binding ability and causes calcium release. As the concentration of glycogen stored in the muscle goes down, the energy available to keep muscle relaxed is also depleted. Due to the energy being used up, there comes a point at which the permanent crossbridges occur and rigor mortis develops. The events seen in the development of rigor are the decrease in pH, ATP and CP, and a concurrent loss in muscle extensibility (Fig. 3). The time required to achieve rigor mortis varies with the type of muscle and animal species. Poultry may require only 1 to 2 hours whereas beef is likely to require 20 to 24 hours. There are several factors that can affect the extent of contraction associated with rigor mortis.

There are some potential problems that can occur during the conversion of muscle to meat. These fall into two categories; PSE (pale, soft, exudative) and DFD (dark, firm and dry). The PSE muscle is most frequently noted in pork and results from a rapid formation of lactic acid in the muscle and therefore a rapid pH decline postmortem (Fig. 4)

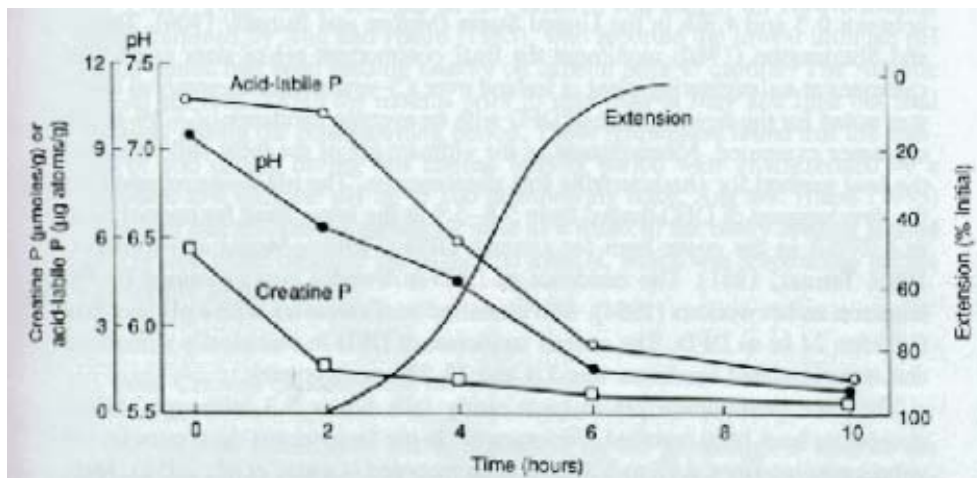


Fig. 3. Chemical and physical changes in beef muscle held at 37° C (Newbold, 1966).

This condition is magnified if carcass chilling happens to be slow, because the combination of acid conditions and high temperature causes protein denaturation and loss of functional capability. Decreased processing yields and poor bind in processed meat products will result from poorly colored watery muscle. The problem is caused by stress (crowding, shipping, pre-slaughter handling) in live animals with certain genetic strains being more susceptible. PSE meat, at best, can only be used as a portion of a restructured product.

Dark, firm and dry (DFD) muscle is caused by limited production of lactic acid and a resulting high pH (Fig 4). It may be induced in animals that are extensively

exercised before slaughter or any other condition that causes **thorough** depletion of muscle energy. Generally, this condition exhibits good water retaining ability but poor color and shelf-life due to microbial spoilage.

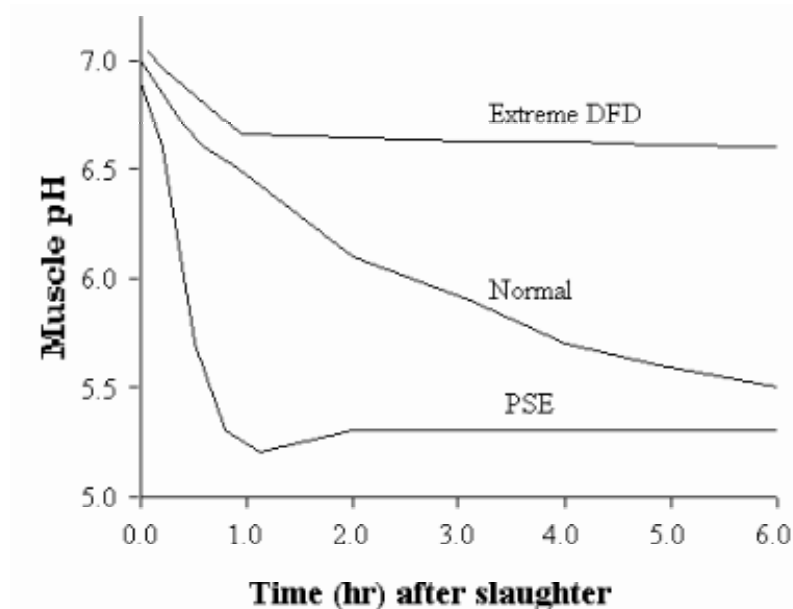


Fig. 4. Examples of the rate and extent of decline in muscle pH for normal muscles and muscles with the DFD or PSE condition (From MIRINZ Bulletin No. 29)

### Water-holding Capacity

Water-holding capacity (WHC) is one of the most important meat properties to processed products. It affects the yield and juiciness of the final product whether you are dealing with fresh whole muscle products or comminuted processed products. WHC is defined as the ability of meat to retain its water during application of external forces such as heating, cutting, mincing or pressing. Many of the physical properties of meat, including color, texture and firmness of raw meat are a result of the water-holding capacity of the meat. Cooked juiciness and tenderness are partially dependent on WHC.

There are three forms of water in muscle: (1) bound, (2) immobilized and (3) free water. Bound water makes up approximately 4-5% of the water in muscle, and is held very tightly by the proteins. Immobilized water is attracted to the bound water molecules in layers that become successively weaker as the distance from the reactive group on the protein becomes greater. The free water is that water which is held only by surface forces. Most of the changes in water-holding capacity are due to changes in protein charges and interactions that change the amount of space available for immobilized and free water to occupy.

In processed meats manufacturing, different techniques are used to raise WHC, such as adding salt and alkaline phosphates. Increasing WHC is achieved by altering the myofibrillar proteins so that they will bind more water. If the myofibrillar proteins bind enough water they become soluble; they will not separate or settle out from a liquid. Solubilizing some of the myofibrillar proteins is essential for binding conventionally restructured meat products.

To increase WHC of the myofibrillar proteins, the space between the protein filaments must be increased. To understand how this is accomplished, a discussion of protein charges, pH, and isoelectric point must be made.

Myofibrillar proteins are large three-dimensional compounds. They have positive and negative charges throughout their structure. These charges act like magnets in the fact that like charges repel each other and opposite charges attract. If the number of negative charges is increased on these proteins, the space between proteins becomes larger because the negative charges repel each other.

The isoelectric point of proteins is the point wherein the numbers of positive and negative charges are the same or the net charge is zero. The isoelectric point of meat occurs at a pH of about 5.4 - 5.6. At this pH, the net charge is zero and the space between proteins is the smallest. When the space is small, they have a low WHC. Increasing protein space increases WHC. If the pH of meat is raised above 5.4 (an increase in the net negative charge), the charges repel each other, the protein space increases and WHC increases (Fig. 5). After normal rigor mortis development meat has a pH of about 5.5, and therefore has the lowest WHC possible. If the meat pH is increased and the isoelectric point of the proteins is decreased, WHC will be drastically increased. These two events occur when salt is added to meat. Salt (sodium chloride) dissolves in water into a sodium ion ( $\text{Na}^+$ ) and a chloride ion ( $\text{Cl}^-$ ). The  $\text{Na}^+$  has little influence on protein space, but the  $\text{Cl}^-$  acts to increase the negative charge on the proteins. Also, salt addition lowers the protein isoelectric point to about pH 4.5 while it raises the pH of the meat slightly. The result of salt addition is a tremendous increase in protein space and WHC.

### **Pale, soft and exudative meat**

A certain percentage of all pork carcasses will develop into pale, soft and exudative (watery) meat, which has a pronounced adverse effect on the muscle proteins. The muscle proteins in this condition are able to bind only a small number of water molecules. The meat, therefore, loses water. The water on the surface, along with the changes in structure, causes light striking the meat surface to be mostly reflected. This gives the meat a very pale appearance regardless of the myoglobin content.

Pale, soft and exudative (PSE) pork has more weight loss during cooking and ends up as a much drier finished product. There are also greater weight losses

during smoking. Due to damage in PSE pork, the emulsifying and binding properties are poorer.

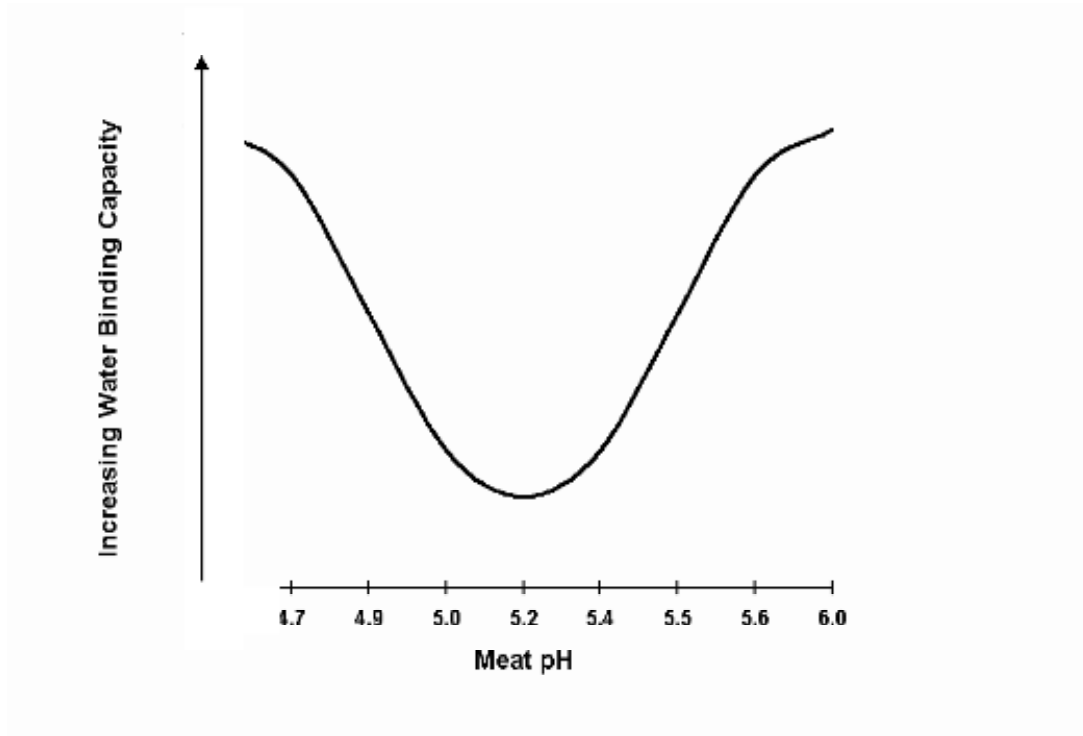


Fig. 4. The effect of pH on the water-holding capacity of meat

The tendency toward the PSE condition is a heritable trait in pigs. When stressed these pigs tend to burn up glycogen more rapidly producing lactic acid. This lactic acid builds up in the tissues and is not removed by the circulatory system as in a normal pig. Thus, these stress prone pig will produce a carcass where the PSE condition is evident. If the stress is prolonged, eventually all of the glycogen supply will be used up and the lactic acid will be removed from the muscle. The end result then is a very dark color.

The PSE condition can be alleviated partially by careful pre-slaughter handling and rapid chilling after slaughter can slow postmortem glycolysis.

## **Dark meat**

Abnormally dark meat may occur occasionally. This condition results from animals that have completely exhausted their energy supply before slaughter. Normal energy utilization after slaughter cannot occur, thus causing the muscle proteins to retain most of their charges and bound water. The high water content of this muscle makes the fibres swell and results in most of the light striking the meat surface to be absorbed giving a dark appearance.

Dark meat has a "sticky" texture. Decreased moisture loss occurs during processing and cooking as a result of the higher pH and the greater water binding capacity. There are claims of improved tenderness with this meat, but salt penetration is restricted and conditions of growth of some microorganisms are improved. Frequent complaints in very dark muscle are of uncured spots. While dark muscle is principally a problem with beef, it is also encountered in pork.

Both PSE pork and "dark meat" have a similar underlying cause, depletion of glycogen. In the case of PSE condition the muscle has an acid pH, the result of turning glycogen to lactic acid during short term stress.

Dark meat has a higher, less acid pH caused by prolonged stress. Glycogen has been all used up and there is none or little to form lactic acid after slaughter.

## **Non Meat Ingredients**

Meat curing was used originally almost entirely as a means of preserving meat during times of plenty to carry over to times of scarcity. Until the successful advent of refrigeration and its availability in the home, curing continued to be designed solely as a means of preservation. The almost universal availability of home refrigerators has, however, greatly altered the reasons for curing. Today, cured meat products are generally mild-cured and must be stored under refrigeration.

Although a variety of compounds can be used in curing meat, the basic curing ingredients are salt, sugar or some other sweetener, and nitrite and /or nitrate. In addition, phosphates are commonly added to brine cures in commercial operations. A number of other compounds are sometimes used in curing mixtures, such as various spices, baking soda, sodium erythorbate, hydrolyzed vegetable proteins, carageenan and non-meat proteins.

## **Salt**

Salt is basic to most curing mixtures. It is the only ingredient necessary for curing. Salt acts by dehydration and altering of the osmotic pressure so that it inhibits bacterial growth and subsequent spoilage. Originally salt served as a preservative and for that matter, still does in the "country-style" cured meat products. Salt when used alone gives a harsh, dry, salty product that is not very palatable. In addition, salt when used alone results in a dark undesirable colored lean that is unattractive and objectionable to consumers.

Today, while some preservative action is still important, the basic need for salt is to impart flavor. Because of its impact on flavor, no regulations have been established for salt content. In most modern cured meat products, a concentration of 1.8 to 2.5 percent in the final product is about right. Much above this concentration and you will begin to find a "salty" taste. Since salt tolerance levels vary, it is difficult to set a specific point at which salt levels are acceptable or unacceptable. Only a good consumer test can tell you what best suits your customer's tastes. Once you establish a salt level, stick to it.

Salt is used in most instances as a flavor enhancer but it is also important to water binding ability of meat and extraction of meat proteins necessary for the manufacture of boneless or chopped and formed hams. When salt is added to meat it causes swelling of the myofibrils (Hamm, 1960). With the addition of salt the isoelectric point (lowest water holding capacity) is shifted to a more acidic pH, increasing the water binding ability of meat at its normal ultimate pH of 5.5-5.6 (Hamm 1960).

Salt improves water binding but also is necessary to extract proteins in the manufacture of boneless hams. Salt solubilizes actin and myosin to form the glue between muscle pieces so boneless products appear as one piece and aids in the sliceability of the finished product. Increasing levels of salt will extract more muscle proteins but the amount that can be used is limited by the taste of the product.

In the past, to determine salt levels of brines, a salometer was used. The presence of sugar or phosphates added into the brine will raise the salometer readings giving an incorrect salt level measurement. Therefore, salometer readings of complex brines are not reflecting salt level but solids levels. A salometer reading in this instance should be used only as a check of the consistency of the brine from day to day not an exact measurement of salt.

Only food-grade salt should be used in curing and marination, since impure salt can cause flavor and color problems. Although dry salt curing utilizes salt in excess the amount used in dry curing methods and brines is variable depending upon the end product desired

Recently, emphasis has been placed on reducing levels of salt in meat products in view of its relationship to hypertension. Thus, processors are attempting to decrease salt in most meat products. Since the sodium is the element in salt that causes hypertension other chloride-containing salts are used as alternatives to sodium chloride. Most of the salt substitutes taste bitter and must be used at lower levels than salt. A combination of sodium chloride and potassium chloride at a 1:1 ratio shows some promise for replacing ordinary salt. Higher levels of potassium chloride have an unacceptable bitter taste. Reduction or replacement of sodium chloride should be done with caution because it will alter the shelf-life of the product.

### **Nitrite / Nitrate**

Historically these compounds came into use as naturally occurring contaminants of salt. People found that cured meat containing them was superior to that without and finally, when early chemists identified the compounds, they were added deliberately.

Nitrates and nitrites must be used with caution during curing. Both are poisonous and therefore, strict limits on their use have been established. Excessive use of nitrates and nitrites not only presents a health hazard but may also result in nitrite burn that is a green or white discoloration in the cured meat.

In addition to the color role these products perform other very critical functions in cured meats. Nitrates and nitrites have a pronounced effect on flavor. Without them a cured ham would simply be a salty pork roast. They further affect flavor by acting as a powerful antioxidant. Antioxidants are compounds that prevent the development of oxidative rancidity.

The bacteriostatic properties of nitrites are also important in cured meats, particularly in canned hams. Sodium nitrite is a very effective inhibitor of the growth of *Clostridia*, particularly *Clostridium botulinum*, the bacteria that causes botulism (Jay, 1986). Without nitrite you could not safely produce pasteurized canned hams.

Nitrate in itself is not effective in producing the curing reaction. It must first be broken down to nitrite by microorganisms to cause color change. With the need for rapid curing to meet today's modern processing schedules, nitrite is added directly into ham brines except when long processing schemes are used for example in "country cured" hams or Westphalian hams, then nitrates may be used. US regulations only allow the use of nitrates in specialty products requiring long cure time such as country cured hams or dry cured bacon.

Nitrites provide the ultimate source of the nitric oxide that combines with the myoglobin pigment. The level is highly regulated in many countries. United States regulations allow only 200 ppm in hams and 120 ppm in bacon.

Since only small amounts of nitrites are needed, they must be handled carefully. To insure distribution they should be carefully dissolved in the brine and the brine properly mixed. Premixed cures offer a simple solution to the control problem. Many suppliers have a mixture of salt and nitrite that is often sold to customers. Prague powder or Cure #1 has a set level of nitrite (6.4%) while the majority is salt. Ask the supplier what level of nitrite is in you specific blend. Don't forget to adjust your overall salt level when using these products.

### ***Sodium ascorbate or erythorbate***

The two primary reactions that occur after the curing ingredients are introduced into the meat are a reduction of metmyoglobin to myoglobin and a reduction of nitrite to nitric oxide. The nitric oxide is then available to combine with myoglobin to form nitrosyl myoglobin. To speed these reactions and shorten curing times, a strong reducing agent is commonly added to the brine. The most frequently used compounds are sodium ascorbate or sodium erythorbate. Ascorbate or erythorbate accelerate the conversion of metmyoglobin to myoglobin and nitrite to nitric oxide; respectively, and also suppress the reverse reaction. This results in a more complete conversion of the muscle pigment to the cured pigment form. Residual amounts of ascorbate or erythorbate will also add stability to the cured meat pigment by reducing the deterioration of the nitrosohemochrome and thus giving the product a longer shelf life

The use of reducing agents result in lower levels of residual nitrites in the product. Use of reducing agents is required in some countries to ensure the complete reaction of nitrite to nitric oxide and less residual nitrites to form nitrosamines in the cooked product.

These strong reducing compounds may have undesirable effects if the recommended uses are not closely followed. Curing brines containing these compounds may convert the nitrites to nitric oxide prematurely if the brine is held for long periods of time or at elevated temperatures. The nitric oxide would escape into the air as a gas creating a health hazard. It would also lower the nitrite level of the brine reducing its effectiveness for processing. Curing brines containing ascorbate or erythorbate are stable for about a day if the brine is held at less than 40° F and in an alkaline or very slightly acid condition. If the brine becomes acid, the reduction reaction takes place very rapidly and more nitric oxide is lost to the atmosphere.

Reducing agents are allowed at 500 ppm in ham and sausage products and 550 in bacon.

### ***Phosphates***

Phosphates are added to the cure or brine to increase the water-binding capacity and thereby the yield of the finished product. Polyphosphates help solubilize

muscle proteins and raise the pH of meat by increasing the number of positive charges on the proteins. This increases the space around the proteins. Therefore the proteins hold more water. With increased water binding capacity, product yields increase, product surfaces are drier and firmer, and emulsions are more stable at higher temperatures. Only alkaline phosphates are effective for improving water binding since acid phosphates may lower the pH and cause greater shrinkage.

Phosphates are not easily soluble in most brines, particularly once the salt has been added. It is the recommended practice to dissolve the phosphates first. If levels of phosphate in the brine are too high, or if salt concentrations are too high, the phosphates may precipitate out of solution that lowers their effectiveness. Some of the new commercial blends of phosphates do not need to be put into solution before salt because of modifications that make them more soluble.

As cured products containing phosphates lose moisture after processing, the phosphates may precipitate out on the surface forming "whiskers" of phosphate crystals. Also, excessive levels have been accused of causing a "soapy" taste, especially at levels above 0.5%.

Regulations on phosphates vary greatly from country to country. United States regulations for added residual phosphates are set at 0.5% in the finished product. While other countries still do not allow the use of phosphate in processed meat products.

### ***Sugar and Sweeteners***

The sugar is added to cures primarily for flavor. Sugar softens the products by counteracting the harsh hardening effects of salt especially at high levels. Sugar also interacts with the amino groups of the proteins and, when cooked, forms browning products that enhance the flavor of cured meats. In some instances, the browning reaction may become too pronounced and burned flavors result. This can especially be a problem for marinated products intended for grilling. Sugar substitutes have been used in bacon cures to prevent excessive browning during cooking. Non-reducing sugars are necessary to prevent browning. Corn syrup, molasses and other natural sugar substitutes are sometimes used in place of sugar. The extent of substitution is largely a matter of cost after determining the relative effects on flavor and color.

Sugar, also, is an effective preservative at high levels. However, the level used in meat curing is so low it is doubtful that sugar has any major influence on the bacteria. In long cures, particularly dry cures, the sugar provides food for reducing bacteria, yeasts and molds. Sugar (in this case usually dextrose) also provides food for some of the lactic acid fermenting bacteria that provide the characteristic flavor of some dry cured and fermented sausage products.

Corn syrup and corn syrup solids are frequently substituted for sugar. As the names imply, corn syrup solids consist of corn syrup from which most of the water has been removed while corn syrup contains a higher level of water.

Corn syrup is composed of a mixture of sugars formed by the breakdown of starch and contains dextrose, maltose, higher sugars, dextrans and sugar. Both corn syrup solids and corn syrup are used widely in curing meat because the cost is considerably less, especially in the USA.

Other sweeteners such as honey can also be used in brines. Honey used in brine should be pasteurized or sterilized because it is a good source of microorganisms, especially *Clostridia*.

**Gums**

Carageenans and xanthan gum are thickening and gelling agents. Carageenan can be used in cured pork products at a level of 1.5% but if used in combination with xanthan gum or locust bean gum then the amount can not exceed 0.5% of the product formulation. If gums are used no other binding agent is allowed in the product.

Carageenan is a water soluble polysaccharide in the group of hydrocolloids. Hydrocolloids are water soluble polymers with the ability to thicken or gel water systems. It is extracted from red seaweed and is found in three basic types. These types are kappa, iota and lambda. The connections between the galactose (sugar) molecules, which make up the carageenan, determine which type is formed. The type has some effect on the characteristics of carageenan (Table 1). Combining the three types of carageenan make it possible to tailor effects.

Table 1. Main carageenan types and their properties.

Main Carageenan type	Properties
Kappa	Forms strong and brittle gels that are reversible when heated
Iota	Forms weak elastic gels that reverse when heated
Lambda	Thickens - does not form gels

The ability of carageenan to form a gel in meat products has been proven to give a range of advantages by increasing yield, consistency, sliceability, spreadability, cohesiveness and decreasing purge, fat content and slicing loss.

During processing of meat, water is often added as pure water or as a brine. This, to a certain extent, influences juiciness and consistency of the end product. However, during heat treatment water will often escape from the meat, resulting in cook loss. Furthermore, the diffused water and extracted meat proteins may appear on the surface as an objectionable jelly-like substance. This is where carageenan helps the producer by reducing cook loss.

Because of its ability to form a gel structure in the meat, carageenan is able to create consistency and stability in the product. This also influences the factors concerning sliceability and cohesiveness in the products.

Carageenan can be incorporated into the meat as part of a marinade, or it can be added directly to meat as a dry powder.

Salt makes carageenan insoluble in water and therefore causes carageenan to be dispersed in the system only (not thickening the solution only dispersed). Carageenan should therefore be added after addition of salt so it doesn't bind water (swell) before it is incorporated in the meat product. In some cases it is necessary to disperse carageenan without salt. For this purpose there are special coated carageenans dispersible in pure water. The use of carageenan as a dry powder almost never causes any trouble.

Immediately after incorporation carageenan has no function, but as the temperature rises, and the carageenan starts to swell, the viscosity increases and the water is retained in the meat. Cooking to 68-72° C in the center ensures complete dissolution of carageenan.

During the subsequent cooling process the carageenan at a temperature of approximately 50-60° C, will set to a firm and cohesive gel. Therefore, it is of the utmost importance that the product is cooled as quickly as possible.

### ***Starches***

Starches are long chains of glucose molecules that hold water. Most unmodified starches need heat to thicken, however, some modified and natural starches will thicken at room temperature. These products work well in marinates to help coat the product. Starches aren't, however, allowed in hams or roast beef but can be used in non-standard products.

Starches are allowed in cured pork products at a level not to exceed 2%. You also cannot use starch in conjunction with any other binder.

### ***Flavorings***

Adding various flavorings and spices to cured meat products is becoming increasingly popular. Originally a few spices such as pepper, allspice, etc. were

rubbed on the surface of dry cured hams. These probably did not penetrate too far into the ham itself and their flavor effect was primarily confined to the surface.

With the advent of brine curing, however, flavorings could be introduced directly into the meat. For the most part, spice extracts are used in the flavoring of cured meat products. These are usually combined with dextrose to make them more soluble in water. The most common flavorings are pepper cloves, allspice and cinnamon. Garlic and onion flavors as well as fruit juices may also be added. Additions of flavorings are an easy way for product differentiation in a finite market.

In some products, such as corned beef, whole spices as well as spice extracts are added to the cover brine. This cover brine is sometimes included in the package with the finished product. The most commonly used flavorings for this would be pepper, allspice, bay leaf and garlic. When looking at marinated products anything can be used. Care must be taken with acidic products such as lemon juice or vinegar because of their affect on meat textures and yields.

A water solution of smoke is sometimes introduced into the brine or added to marinades to provide a smoked flavor. These smoke solutions have a very distinct flavor, color and low pH. They cannot be used in very high concentrations without causing discoloration of the cured meat, a reduction in water holding capacity and a premature reduction of the nitrites in the cure. Smoke should not be added to cover brine but can be incorporated into brine for pumping.

The use of flavoring is a matter of taste. Care should be used so as not to overpower the natural cured meat flavor.

Flavor enhancers, such as hydrolyzed vegetable protein, autolysed yeast protein and monosodium glutamate are sometimes added to various processed meats. These products are used to increase the intensity of flavor of the product. These flavor enhancers can be injected into meat products before addition of marinades to increase the impact of the meat flavor.

### ***Non-meat proteins***

Soy proteins and deheated mustard flour are used as protein sources to allow for further extension and as binders for added water. Protein binders cannot be used in products called ham but are allowed in highly extended ham loaves or poultry rolls. The typical usage level is between 0.5% and 5.0%. Levels used depend on the protein used and whether or not it is an isolate or flour. For example soy isolate can bind between seven and ten times its weight in water while soy concentrate will bind less water (approximately five times its weight) while imparting a more beany flavor.

## SOY PROTEINS

[excerpt from an article by Dr. Joe Corday, Meat Business Magazine, July 1990]

During the times when raw sausage materials are expensive, processors are faced with a dilemma. They must either raise the price of their products or find a way to lower their production costs.

Utilization of soy proteins often enables processors to lower their costs while maintaining traditional product characteristics. All too often soy protein gets a bad rap. People complain that soy protein gives products poor taste and texture. These problems can exist if soy proteins are used incorrectly or at too high a level. When soy proteins are used correctly they have limited adverse effect on the flavor or texture of a product. In fact they often improve the product.

The term "soy protein" covers a wide range of products derived from the soybean. These products are classified as: soy flours, soy protein concentrates, or isolated soy proteins. Typical composition of soy protein products is listed in Table 1.

Table 1: Composition of Soy Protein Products

<b>Item</b>	<b>% Protein</b>	<b>% Carbohydrates</b>
Soy Flour	50	38
Soy Protein Concentrate	70	24
Isolated Soy Protein	90	Less Than 3

Depending on the specific brand of soy protein used, the protein content may vary slightly from the value listed in Table 1. Suppliers of soy protein are most happy to provide specification sheets on their products. These enable processors to precisely evaluate the soy protein's composition.

The second principal constituent of soy protein products (protein being the major constituent) is carbohydrate. As the protein content goes up, the carbohydrate content decreases.

A frequent complaint relative to the use of soy proteins in processed meat products is that they give the products a "beany" taste. This off flavor is a result of the carbohydrate fraction of the soy product. To avoid this undesirable flavor, either a low level of the soy product should be used or a soy product with a low level of carbohydrate should be utilized in manufacturing the product.

Soy proteins are available in many different sizes and shapes. Some of the more common forms are: powdered, granular, flake, chunk, fibrous and hydrated. There is a suitable soy protein for virtually any processed meat. Powdered soy proteins work best in products where no visible soy protein is desired in the finished product. Examples are frankfurters and luncheon loaves. Soy proteins also perform excellently in coarse ground fresh products and have the ability to impart texture to the finished product. A lot of low cost hamburger patties are manufactured containing either textured flours or textured concentrates.

Soy proteins are available either colored or uncolored. Uncolored products are white or light tan in appearance. Uncolored, textured products are used in fresh meat products such as beef or pork patties. The most common colored soy protein products have a light caramel appearance. These caramel colored products function effectively in cooked products such as pizza toppings, chili and burritos. Specialty soy proteins can be manufactured in several different colors.

Soy proteins are primarily hydrophilic in nature. This means they have the ability to bind water. They also have the ability to absorb some fat and consequently reduce cook-out during processing. Some soy products achieve this primarily by entrapping the fat, while some of the more sophisticated soy proteins are capable of emulsifying fat. The higher the protein content of a soy product, the greater will be its ability to absorb water and control fat.

Table 2 lists typical average hydration ratios for various soy proteins. The hydration ratio represents how many parts of water each part of soy protein will bind. Hydration ratios for specific products may differ slightly from those listed in this table. Consult your supplier for the hydration ratio of the product you are using.

Table 2: Soy Protein Hydration Ratios

<b>Item</b>	<b>Hydration Ratio</b> <b>(Parts Water: Parts Soy Protein)</b>
Soy Flour	2-2.5:1
Soy Protein Concentrate	3-3.5:1
Soy Protein Isolate	5:1

When evaluating the price of various soy proteins, it is very important to consider the cost per pound of hydrated product. The product with the lowest cost dry does not always have the lowest cost hydrated. It is also important to consider the functionality of the soy protein rather than just the cost.

When using soy proteins, it is very important that the formulation contain sufficient moisture for complete hydration of the soy protein. Under hydration can result in loss of texture, emulsion breakdown and waste of some of the binding capacity of the soy protein. Overhydration will lessen the gel strength of the finished product. It is important to note that soy proteins have the ability to gel upon heating in the same manner as meat proteins. Often, when adding soy protein to a formulation, it is calculated that one fourth of the water needed for hydration will come from the formulation itself. Table 3 lists typical hydration times for different types of soy proteins. Naturally, the hydration time may be different for specific products. This table is intended to serve only as a guideline. If warm water is used to hydrate textured soy products, hydration time will be less than when using cold water.

Table 3: Typical Hydration Times for Different Soy Proteins

<b>Item</b>	<b>Hydration Times</b>
Powdered Products*	5 minutes
Flake Products	5 minutes
Granular Products	10-15 minutes
Chunk Products	20 minutes

\*Some powdered products, such as isolated soy protein, hydrate best with high shear energy, for example, a bowl chopper. Under these conditions, the soy protein can usually be hydrated in 30-60 seconds.

In order to achieve maximum benefit from the incorporation of soy proteins in a formulation, it is important that they be handled correctly.

## **SPICES A BAKER'S DOZEN FOR PROCESSED MEATS**

by Bruce Armstrong  
WHAT AND HOW YOU TASTE

The tongue is divided into four general regions of taste:

- Sweetness - Tip of tongue
- Saltiness - Front side of tongue
- Sour - Rear side of tongue
- Bitterness - Across rear of tongue

You will absolutely taste these four sensations. Spices and other flavors in meat products DO REQUIRE TRAINING to recognize these tastes. Some spices taste sweet, some taste bitter, some are pungent (strong, sharp flavor), and some are aromatic (distinctive, savory smell). Most spices, which are sweet, are also aromatic, such as cinnamon and coriander. A few are sweet and pungent, such as nutmeg and mace. Many herbs are bitter, such as sage.

The baker's dozen of spices for the meat industry is described as follows:

1. Coriander has a sweet, aromatic, rose-like flavor.
2. Mustard has a slightly bitter flavor, though oriental mustard has a very pungent flavor. Allyl isothiocyanate is the component that gives oriental mustard its pungency, sharp odor and acrid flavor.
3. Fennel has a sweet licorice-like flavor.
4. Garlic has a strongly adored, pungent flavor
5. Cumin has a strong, musty flavor – sometimes described as a "dirty socks" smell.
6. Sage has a bitter, aromatic flavor described by an old boss as the flavor like Vicks Vapo-rub.
7. Paprika has a sweet flavor. As used in the meat industry, paprika offers no flavor to meat products.
8. Chili pepper has a sweet, pungent, slightly burnt flavor.
9. Nutmeg has a sweet, pungent flavor.
10. Mace has a sweet, pungent flavor, which is sweeter than nutmeg.
11. Red pepper has a pungent, biting hot flavor, which is not detected in front of mouth.
12. Black pepper has a hot, pungent flavor.
13. White pepper has a less pungent flavor than black pepper.

As you eat different foods, take time to recognize the various flavors of spices.

This baker's dozen minus two of spices accounts for the flavor of 99% of meat products in the United States. Remember, white pepper and black pepper are interchangeable flavors as are nutmeg and mace.

Other spices are used in meat products such as cardamom, ginger, cinnamon, cloves, anise and allspice. Their use is only to round out or heighten the flavors of the predominant spices.

## **Mustard**

The number-one spice used in the meat industry. It is ground in Montana, North Dakota, and the adjoining Canadian provinces. De-heated Mustard has no flavor, but is 29% protein. A 1% usage of mustard in a frank or bologna emulsion saves the meat processor  $\frac{3}{4}$  to 1¢ per pound of finished product, because of the additional water that can be added to the product.

## **Black Pepper**

Used for its mouth sensation (heat) and pungent flavor.

## **White Pepper**

Same reason as for black pepper, but it does not have black specs of the black pepper

## **Red Pepper**

Used for its throat sensation (heat). A small amount will make a seasoned product seem to have more flavor. Commonly used in crushed form to aid visual appearance.

## **Paprika**

Used mostly for its red color. It has little to no flavor.

## **Nutmeg / Mace**

Both come from same tree. Mace is thin, lacy, bright red "aril" which surrounds the nutmeg. They are the flavor most associated with franks and bologna. Mace has a stronger flavor and lighter color than nutmeg, and is used where these features are an advantage. Typical spice flavor in most hot dogs and bologna.

## **Coriander**

The sweeter, flower-like flavor is used as an alternative to nutmeg in some franks and bologna.

## **Garlic**

The hearty flavor in beef franks and Polish sausage.

## **Sage**

The strong, somewhat bitter flavor in fresh pork sausage.

## **Chili**

Chili is cooked to darken it and give it a cooked (burnt) flavor associated with Tex-Mex products.

## **Cumin**

A heavy and possibly objectionable flavor associated with Tex-Mex meat products, chili powder, and curry powder.

## **Fennel**

The licorice flavor in Italian sausage, pepperoni, and other Italian-flavored meats.

## **WHAT ARE THE FLAVORS IN MEAT PRODUCTS?**

### ***Hot Dogs***

The flavor of most hot dogs is black pepper and nutmeg. Other hot dogs have a garlic flavor as a secondary flavor. Many chicken hot dogs have onion as a secondary flavor. Smoke is another important flavor of hot dogs. It is not a spice, but it can confuse people tasting two products for flavor comparison. Heavy mustard usage is common. Hot dogs are eaten warm and therefore require less flavor (spices) than bologna.

### ***Bologna***

Most bologna has the same flavor as hot dogs. The most consistent difference is bologna usually has garlic to give more flavor to the cold product. Bologna is not smoked, and again, smoke is not a spice, but is a major flavor in processed meat products. Heavy mustard usage is common.

### ***Smoked Sausage***

Smoked sausage is a simple seasoned product. Black pepper is the major spice flavor in smoked sausage. Red Pepper is used at very low levels. Coriander is sometimes used. Smoke and the sweet burnt flavor of dextrose are the major flavors of smoked sausage.

### ***Polish Sausage (kielbasa)***

The same rules as smoked sausage, except garlic is added for typical flavor.

### ***Fresh Pork Sausage***

Black pepper and sage are dominate flavors with red pepper used for "hot" varieties. Dextrose is added for browning characteristics.

### ***Italian Sausage***

Black pepper and fennel (licorice flavor) are the flavors in Italian sausage. Red pepper is added for hot Italian sausage.

### ***Liverwurst (braunschweiger)***

Onion and nutmeg provide spice flavor for this product. Smoked bacon provides additional flavor, particularly to braunschweiger. This is one product where the sweet flavor of nonfat dry milk helps product flavor.

### ***Salami***

Black pepper, particularly in the form of whole pepper corns, creates flavor of cotto (cooked) salami. Nutmeg is used at low levels. Heavy mustard usage is common.

### ***Pepperoni***

Paprika, red pepper, black pepper, garlic, and fennel are spices used for pepperoni or sausage for pizza.

### ***Summer Sausage (beef stick)***

Black pepper is usually only spice used for flavor. Heavy mustard usage is common.

### ***Dry Sausage***

Most other dry sausages use black pepper for major flavor, and may include garlic, coriander, and nutmeg for other spice flavors.

### ***Cured Products (Ham and Bacon)***

These products use no spices. Some processors use California ham spice, Western ham spice, or Virginia ham spice. All these are a mixture of cinnamon and clove in a soluble seasoning. Corned beef uses garlic.

In review, meat products use mustard (which does not contribute to flavor), black pepper, nutmeg, coriander, red pepper, garlic, and paprika as major spices. Minor spices include onion, fennel, ginger, cardamom, cinnamon, cloves, and cumin. All traditional meat products use the seasonings listed or modified forms.

Tex-Mex products are providing new areas for increased spice usage in meat products. These products use red pepper, chili pepper, cumin and garlic at greater usage levels than traditional products.

Notes:

- Black Pepper - Taste on tip of tongue
- Nutmeg - Taste on front side of tongue
- Ginger - Taste on middle side of tongue
- Coriander - Flower type taste felt on roof of mouth
- Garlic - Hearty taste that fills mouth
- Onion - compliments garlic flavor with sweetness
- Red Pepper - Tickles throat at low levels
- HVP / HPP - Increases meat type flavor.

## References:

- Briskey, E. J. (1964) Etiological status and associated studies of pale, soft, exudative porcine musculature. *Adv. Food Res.* 13, 89.
- Hamm, R. (1960) Biochemistry of meat hydration. *Adv. Food Res.* 10:355.
- Hedrick, H.B., E.D. Aberle, J.C. Forrest, M.D. Judge and R.A. Merkel. (1994). *Principles of Meat Science*, 3<sup>rd</sup> ed., Kendall/Hunt Publishing Company, Dubuque, Iowa.
- Jay, J.J. (1986) *Modern Food Microbiology*, 4<sup>th</sup> ed., Van Nostrand Reinhold, AVI, New York, New York.
- Kierant, B.H., J.A. Johnson and A.J. Siedler (1964). A summary of nutrient content of meat. *Am. Meat Inst. Found. Bull.* No. 47.
- Newbold, R.P. (1966) Changes associated with rigor mortis. In "The Physiology and Biochemistry of Muscle as Food" (E.J. Briskey, R.G. Cassens and J.C. Trautman, eds.), pp. 213-224. Univ. of Wisconsin Press, Madison.