A Guide to Meat Processing for the Nutrition Community

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1. Introduction

Meat consumption has been a widely debated topic in the scientific community. The health benefits and potential adverse health outcomes of meat consumption are at the center of many scientific studies. Surrounding the meat consumption debate is confusion and misinformation on meat and processing nomenclature, product labeling claims, and ingredients, to name a few.

This white paper serves as a guide to nutrition experts and the scientific community. By reviewing existing published scientific information; this article assesses how meat is processed; common categories of processed meats and their characteristics; the meaning of different labeling claims; and an overview of the nutritional benefits of meat consumption and public health implications.

1.a. What is Meat?

According to the American Meat Science Association, meat is skeletal muscle and its associated tissues from mammalian, avian, reptilian, amphibian and aquatic species harvested for human consumption. Edible offal such as organs and non-skeletal muscle tissues also are meat.¹ Products within the meat category are often subdivided into numerous other categories recognizable by consumers. Some meat subcategories include red, white, game, fresh, poultry, processed, and more. These subcategories do not adequately describe the unique properties associated with the various products and species, such as visual and cooked color, myoglobin content, lipid content, and nutrient profile, and are inappropriate to classify meats for health and nutritional purposes broadly.² Among the numerous meat³ subcategories, there is an overlap of products that contribute to confusion among health professionals and consumers.

All meat is processed to varying levels. Meat processing is the conversion of a carcass into a final or finished product that is deemed desirable by consumers produced through various levels of physical or biochemical transformations. Meat is either minimally processed or further processed.⁴

Minimally Processed Meat (MPM): Raw, uncooked meat products have not been significantly transformed compositionally and contain no added ingredients. Products may be reduced in size by fabrication, mincing, grinding, and/ or a meat recovery system.

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² Id.
³ The term meat as used throughout the paper includes poultry.
Further Processed Meats (FPM): Products that undergo an alteration, beyond minimal processing. Products may contain approved ingredients and/or be subjected to preservation through salting, curing, drying, or fermentation; thermal processing; batter/breading; or other processes to enhance sensory, quality, and safety attributes. Products may include ready-to-cook or not ready-to-eat and ready-to-eat products.

2. Meat Processes

There are numerous ways meat can be prepared into minimally and further processed products for consumers. Meat is processed for many reasons, but often it is for sensory enhancement, storage extension, and, most importantly, food safety. Table 1: “Processes applied to meat to create minimally or further processed meat items,” outlines a few of the common meat processes, defines them, describes the function or purpose of that process, and gives examples of products that undergo that process and whether the result is a minimally or further processed product.

2.a. Sensory Enhancement

Providing consumers with a positive eating experience is essential to the success of the food industry by encouraging consumers to make repeat purchases, but it is also important for nutrition. People will not consume products they do not enjoy, and meat is a nutrient-dense product that provides essential nutrients as part of a healthy, balanced dietary pattern. Meat is an excellent source of many vitamins and minerals. People do not need to consume a lot of calories to get the essential nutrients that benefit them from having meat products in their diet.

Characteristics that enhance sensory and contribute to a positive eating experience include visual attributes, aroma, and palatability. Meat color has the greatest influence on consumer perception and visual acceptance of products. Consumers desire both raw and cooked products to have an acceptable color. The ideal color for raw beef is a bright cherry-red color, raw pork should be reddish-pink, lamb should be pinkish-red, and cured meat should have a bright pink color. When addressing the aroma characteristics of meat, the largest concern is off-odors. Over time, off-odors can develop and alter consumers' acceptance of meat items. The biggest off-odors of concern include rancid, oxidized, sour, and putrid. The palatability of meat is determined by the tenderness, juiciness, and flavor of products. In many cases, meat items are processed to improve one of these sensory characteristics, with the largest influence on improving tenderness and flavor.

Processing meat for sensory reasons includes everything from adding spices and seasonings to enhance and add flavor to curing products to get an attractive bright pink color. Many meat products are processed to add or enhance flavor beyond the natural flavor inherent to

meat products. For example, pork loin may be marinated with teriyaki seasoning and spices to create a more desirable flavor preferred by consumers. On the other hand, ham is often cured to create the traditional pink color desired by consumers.

2.b. Storage Extension

Storage extension relates to both food safety and sensory enhancement. When meat is processed for storage extension, the goal is to provide consumers with an attractive and palatable product for as long as possible. The most common way of extending the storage time of meat is to reduce bacterial growth and product oxidation.\(^6\) Products are processed multiple ways to slow or prevent the growth of spoilage microorganisms such as *Brochothrix thermosphacta*, *Carnobacterium* spp., *Enterobacteriaceae*, *Lactobacillus* spp., *Leuconostoc* spp., *Pseudomonas* spp. and *Shewanella putrefaciens*. Processing not only reduces the growth of spoilage bacteria but can reduce pathogen growth. Products are also processed to reduce lipid oxidization. Excessive spoilage bacterial growth and oxidation can lead to organoleptic deterioration resulting in discoloration, off-odors, and off-flavors.

Meat products are also regularly processed for storage extension purposes alone. For instance, drying (dried sausages or jerky) removes much of the water from meat, reducing the water activity and preventing the growth of numerous spoilage microorganisms. Reducing the growth of spoilage microorganisms and chemical reactions slows decomposition to extend storage length.

2.c. Food Safety

Food safety is the most important reason meat is processed. Numerous pathogens are inherent to meat products, including *Salmonella* spp., Shiga toxin-producing *Escherichia coli*, *Listeria monocytogenes*, *Clostridium perfringens*, and *Clostridium botulinum*. Processing meat can control, reduce, and/or eliminate some of these pathogens. Heat-treated meat items are a great example and reach temperatures high enough to kill or reduce pathogenic bacteria, which improves the safety, as well as, the storage life of the product. Other products have added ingredients that help control the growth of pathogenic microorganisms. For example, adding salt and nitrite to meat products inhibits the growth of numerous pathogens, such as *Listeria monocytogenes*, *Clostridium perfringens*, and *Clostridium botulinum*. Hot dogs have several added ingredients, such as nitrates and nitrites, and are also heat-treated to reduce bacterial growth. All ingredients are generally recognized as safe (GRAS) by the Food and Drug Administration and used within the USDA Food Safety and Inspection Service’s (FSIS) regulatory parameters.

3. Common Minimally and Further Processed Meats

Meat packers and processors are constantly developing new products to meet consumer nutritional needs and changing preferences. As people grow, their nutritional needs evolve. Over time, a person may develop hypertension and require a low sodium dietary pattern. Some consumers have a soy allergy and need processed meat products without ingredients like hydrolyzed soy protein. Alongside changing nutritional needs, consumers often desire a variety of different flavors and products that can fulfill their adventurous eating habits. In response to consumer needs and preferences, the meat industry has developed thousands of items that meet a variety of nutritional needs while still providing palatable products. The broad array of minimally and further processed meat products available to consumers continues to grow to provide options to a diverse population.

3.a. Types of Minimally Processed Meat

Minimally processed meat (MPM) items are those that do not undergo any major transformation or have added ingredients. Steaks, chops, roasts, ground items (with no added ingredients, including spices and seasonings), and diced meat are all MPMs. These items vary in size, shape, and nutritional profile. There are thousands of different MPM products across the species (beef, pork, lamb, veal, chicken, and turkey) of products typically available to consumers today. Some common MPM products include beef strip steak, 90% lean ground beef, beef pot roast, chicken breast, chicken thigh, turkey drumstick, whole turkey, pork loin chop, pork tenderloin roast, lamb riblets, lamb stew meat, and many more. There are also a few sub categories of minimally processed meat items that are occasionally used in products, including advanced meat recovery items and lean finely textured meat.

3.a.1. Advanced Meat Recovery

Advanced meat recovery (AMR) is a lean meat product made by applying mechanical pressure to remove meat from bones. This process does not alter the composition of the meat. Products as a result of the AMR process cannot contain tissues from the central nervous system or bone. AMR products are produced with equipment that does not crush, grind, or pulverize bones. Following AMR processes, bones appear comparable to those that have been hand-deboned. To verify that bone is not introduced into the product, meat from advanced meat recovery systems must be tested regularly and cannot contain more than 0.15% (150 mg/100 g) of calcium.

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3.a.2. Lean Finely Textured Meat

Lean finely textured meat (LFTM) is lean meat derived from edible high fat trimmings that have been desinewed and subjected to a mild heat treatment to melt and separate the fat and allow recovery of the lean meat portion. LFTM gets its fine texture from the process to remove the lean from the high-fat trimmings. The lean becomes very finely ground during the process of removing it from fat using a centrifuge, similar to the way milk is separated from cream. The resulting LFTM product is 94-97 percent lean meat.

3.b. Types of Further Processed Meat

Building on the range of MPM, many items can be further processed for specific food safety, sensory enhancement, and storage extension purposes. The further processing of meat products enhances sustainability. Further processing products can lengthen the storage life of products and reduce food waste. Less palatable meat items can be further processed into products consumers enjoy. Without further processing, there would be an enormous amount of food waste. Examples of further processed meat (FPM) products, including their description, processing methods, and common ingredients, can be found in Table 2. In addition to Table 2, there are other generalized categories further processed meat items fit into, including delicatessen meats (deli meat) and ready-to-eat (RTE) meats.

3.b.1. Delicatessen Meats

Delicatesen meats have numerous synonyms, including deli, luncheon, and lunch meat. Many deli meat items overlap with FPM items in Table 2. Deli meat refers to RTE items that are typically sliced and assembled in a sandwich for consumption. Deli meats can be in the FPM ham category, sausage category, or others. There is an wide array of deli meat products that can meet almost every dietary requirement. Deli meat can be formulated to meet the food labeling regulations for low fat, reduced fat, low sodium, and reduced sodium, as well as the American Heart Association (AHA) certification, meeting AHA’s Heart-Check program requirements. Additionally, deli meats come in a variety of different flavors like oven roasted, smoked, mesquite, cajun-style, or honey-flavored. Deli meat includes items like oven roasted turkey, black forest ham, mesquite chicken, roast beef, corned beef, pastrami, bologna, olive loaf, and many more.

3.b.2. Ready-To-Eat Meats

Ready-to-eat meats are items that are safe to eat without additional preparations, although some RTE meats may receive additional preparation for palatability or aesthetic, epicurean, gastronomic, or culinary purposes. Most RTE meat items are thermally processed to achieve the lethality of pathogenic microorganisms. Many of the FPM items in Table 2 can be RTE or non-RTE including bacon, bologna, Canadian bacon, corned beef,
smoked ham, dry-cured ham\textsuperscript{13}, hot dogs, jerky, pastrami, cooked and smoked sausage, dry and semi-dry sausage, and some specialty meats.

### 4. Common Meat Processing Ingredients

Further processed meat items can have a variety of ingredients. Ingredients may provide key functions during and after processing and affect product safety, storage life, and sensory characteristics. Some products require specific ingredients and processes. For example, bacon must be cured using salt, nitrate or nitrite, added water, and a cure accelerator (ascorbate or erythorbate). Cure accelerators (along with other ingredients) are often used in many cured meat products other than bacon but are only required in bacon. Bacon is often cooked at extremely high temperatures in a frying pan, and cure accelerators inhibit the formation of nitrosamines during high-temperature cooking.\textsuperscript{14}

There are strict labeling requirements for all meat products. Any meat product with two or more ingredients must comply with FSIS' ingredient labeling regulations.\textsuperscript{15} All ingredients must be included on the product label in descending order of predominance. A list of ingredients commonly used to further process meat is found in Table 3. Table 3 includes the ingredient name, description, function/use, regulatory level, and examples of when the ingredient is used.

#### 4.a. Spices and seasonings

In addition to the ingredients found in Table 3, spices and seasoning are commonly used in further processed meat products. Spices are aromatic substances of plant origin and seasonings are any ingredient added to improve or modify flavor.\textsuperscript{16} There are limitless combinations that give further processed meat items distinct sensory profiles formulated to meet consumer preferences. Some spices have natural antimicrobial and antioxidant properties that need to be considered during formulation and further processing.

Specific ingredients are required or prohibited in the formulation of certain products. These products must also follow specific processes to bear that specific product name, e.g., meet a standard of identity. For example, pepperoni must be a dry sausage comprised of pork or pork and beef. Pepperoni can also have antioxidants present and may be dipped in a potassium sorbate solution to control mold growth. Additionally, extenders and binders, hearts, tongues, and other byproducts are not permitted ingredients in pepperoni.\textsuperscript{17}

\textsuperscript{13} Dry cured hams do not undergo thermal processing but meet pathogen control through added ingredients, aging and water activity
\textsuperscript{14} “A potentially carcinogenic compound formed from the reaction of nitrous acid and secondary amines in foods exposed to high heat treatment. Nitrosamine formation in cured meats is minimized through proper processing techniques and adherence to current production regulations including the use of antioxidants especially sodium ascorbate/erythorbate.” (Seman et al. 2018).
\textsuperscript{15} 9 CFR 317.2(f) and 381.118
\textsuperscript{17} United States Department of Agriculture. Food Safety and Inspection Service. (August 2005). Food Standards and Labeling Policy Book.
Common spices used in further processed meat products include all spice, anise, bay leaves, cardamom, cassia, celery seed, cinnamon, clove, coriander, cumin, garlic, ginger, mace, marjoram, mustard, onion, paprika, pepper, sage, and thyme.\textsuperscript{18}

4.b. Binders, Extenders and Fillers

Some of the non-meat ingredients in further processed meats are classified as binders, extenders, and fillers (BEFs). Binders, extenders, and fillers are non-meat ingredients that can be incorporated into comminuted and cured items. These ingredients have numerous functions, including improving batter stability, water binding capacity, texture and flavor, yield, slicing characteristics, and reducing formulation costs.\textsuperscript{19} Binders, extenders, and fillers are characterized by high-protein content, as well as their ability to bind water and fat. Many BEFs have a meat-like texture, hydrate rapidly, and have an affinity for juice retention.

Common BEFs include hydrolyzed vegetable proteins (see Table 3) from soy, wheat, or peas. Dairy can also be used to make BEFs. For example, nonfat dried milk solids, calcium-reduced nonfat dried milk, dried whey, and reduced whey are BEFs derived from milk. Other BEFs include sodium caseinate, carrageenan, modified food starch, and textured vegetable proteins.

4.c. Efforts to reduce sodium

Adding sodium to muscle tissues can improve the quality of the meat and poultry products. Sodium chloride, sodium phosphates, sodium nitrite, and sodium lactate are all commonly used compounds. Compounds such as sodium chloride have important quality, shelf-life, myofibrillar functionality, and food safety properties. However, there are numerous concerns with high levels of sodium in the diet. Consumer health is a driving force in producing meat. The meat industry offers nutrient dense protein food products while continuously improving and maintaining safety. In response to public requests, the industry has been and remains actively involved in efforts to reduce sodium in meat products. The meat industry is constantly undergoing product reformulation to reduce the level of sodium and offer numerous products that meet the low and lower sodium labeling claims.

5. Nutritional Benefits of Minimally and Further Processed Meats

Minimally and further processed meat products provide consumers with a convenient and balanced dietary source of all essential amino acids. These products are important sources of micronutrients, such as iron, selenium, vitamins B\textsubscript{12}, B\textsubscript{6}, thiamin, riboflavin, niacin, and potassium. Per serving, meat provides more protein than dairy, eggs, legumes, cereals, vegetables, or nuts. The iron and zinc in MPM and FPM is also more bioavailable than

\textsuperscript{19} Id.
from other sources; meaning these minerals are more easily absorbed and utilized by the body. Both MPM and FPM are excellent sources of protein and micronutrients, especially to vulnerable populations.

5.a. Protein

Protein is an important macronutrient that supports various metabolic and physiologic functions, including the regulation of appetite, food intake, body weight, and body composition. Protein is critical for developing, maintaining, and repairing muscles. In children, protein is key for growth and brain development. In aged populations, protein is essential in preventing muscle loss. Research has also highlighted meat’s high protein and low carbohydrate content provides both weight control benefits and diabetes management. Scientific literature demonstrates the importance of protein in the diet and that not all proteins are created equal. Dietary protein supplies the body with nitrogen and amino acids. There are nine amino acids that are essential and classified as indispensable in the diet including histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Protein is found in all living things, but is present in different proportions and varies in total amino acid composition, including the number and levels of indispensable amino acids. Of the indispensable amino acids, some are limiting including leucine, lysine, methionine, and tryptophan. These limited indispensable amino acids play important roles in different metabolic functions. For example, leucine activates the mammalian target of the rapamycin (mTOR) pathway which signals protein synthesis in human skeletal muscle. Leucine also stimulates insulin secretion from pancreatic β cells. Lysine can synthesize carnitine, and carnitine deficiencies are associated with fatty acid oxidation and metabolic disorders. Tryptophan plays a key role in the production of the neurotransmitter, serotonin. Deficiencies in tryptophan can result in lower serotonin levels, which can lead to mood disorders like anxiety and depression. Because meat has


greater amounts of limited indispensable amino acids than other foods, it is the best source of high quality protein. Minimally and further processed meats also have a higher protein to energy ratio and are more digestible than other foods.

5.b. Micronutrients

Minimally and further processed meat products contribute more zinc, vitamin B_{12}, phosphorus, and iron than plant foods.\(^{27}\) For example, a three-ounce serving of a lean beef item like a top sirloin steak typically has less than 120 calories and is an excellent source of six nutrients, including protein, zinc, vitamin B_{12}, vitamin B_{6}, niacin, and selenium; and is a good source of four nutrients—phosphorous, choline, iron, and riboflavin.\(^{28}\) In addition, more than 65 percent of beef cuts sold at retail meet government standards for “lean,” including 17 of the 25 most popular cuts, while seven pork cuts meet USDA “lean” guidelines.\(^{29}\) Pork is also lean and nutrient-rich. A three-ounce serving of pork tenderloin is a source of nine key essential nutrients—an excellent source of thiamin, selenium, protein, niacin, vitamin B_{6}, and phosphorus; and a good source of riboflavin, zinc, and potassium in less than 125 calories.\(^{30}\) Among pork consumers, fresh lean pork accounts for 23 percent of total protein intake, 25 percent or more of total intakes of selenium and thiamin, and 10 percent or more of total intakes of phosphorus, potassium, zinc, and B vitamins.\(^{31}\) Lamb is also nutrient dense and, on average, a 3-ounce cooked portion provides greater than 20 percent of the daily value of zinc, vitamin B_{12}, niacin, and protein in about 175 calories.\(^{32}\)

5.c. Consumption Importance in Vulnerable Populations.

Meat consumption is beneficial to numerous at-risk populations. Up to 16 percent of adults in the U.S. and over 20 percent of individuals over age 60 are marginally depleted in vitamin B_{12}. B_{12} deficiencies increase with age, resulting in six percent of adults age 70 and older being vitamin B_{12}-deficient.\(^{33}\) Several studies demonstrate meat intake decreases bone fracture risk, which is crucial to the aging population because bone fractures can be a critical life event.\(^{34}\) Meat plays an integral role in ensuring adequate vitamin and mineral

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\(^{31}\) Murphy MM, Spungen JH, Bi X, Barraj LM. Fresh and fresh lean pork are substantial sources of key nutrients when these products are consumed by adults in the United States. Nutrition Research. 2011; 31: 776-783.


intake.\textsuperscript{35} The preponderance of scientific evidence affirms the healthful role lean meat products, including minimally and further processed meats, play in dietary patterns. Moreover, numerous randomized, controlled trials illustrate that meat is a valuable component of a healthy dietary pattern. Other studies demonstrate that meat when consumed in combination with vegetables, helps the body absorb more nutrients from those vegetables.\textsuperscript{36}

The high iron content in meat is particularly important to certain vulnerable populations, including the 1.2 million children in the U.S. with anemia. Meat's importance also holds true for teenage girls and pregnant women who are at a higher risk of anemia.\textsuperscript{37} Although iron supplementation is an option, it is not as bioavailable as iron in meat. The heme iron present in meat is the most absorbable form of iron, and a prolonged deficiency could lead to negative long-term health outcomes, including decreased mood, shortness of breath, dizziness, headaches, and more.\textsuperscript{38} The natural presence of heme iron also aids the absorption of non-heme iron.\textsuperscript{39}

Throughout the life span, various subpopulations, such as children and pregnant women, have increased protein needs during growth and development, and meat is a logical choice. Per serving, meat provides more protein than most other foods. Protein is critical for developing, maintaining, and repairing strong muscles and vital for reducing the muscle loss that occurs with aging.\textsuperscript{40} Finally, research shows that meat's high protein and low carbohydrate content translates into a low glycemic index, which offers benefits for both weight and diabetes control.\textsuperscript{41} The high protein quality in MPM and FPM is vital in maintaining autonomy and musculoskeletal health in older adults by helping prevent frailty, disability, falls, and sarcopenia. A review in the journal Applied Physiology,
Nutrition, and Metabolism stated that the growing body of evidence indicates that protein intake well above the current Recommended Dietary Allowance helps promote healthy aging.\textsuperscript{42}

6. Perceived Public Health Concerns

Over the past decade, consumption of MPM and FPM has been at the center of many scientific studies and news stories. Evaluating and addressing potential public health concerns associated with meat consumption is necessary and must continue. Processing meat is one of the oldest forms of food preservation dating back to as early as 3,000 B.C.\textsuperscript{43} The use of ingredients and different processes to preserve meat is thoroughly studied both for its effectiveness and, more importantly, for its impact on public health. These ingredients and processes are utilized to mitigate public health hazards. Regardless, some concerns associated with MPM and FPM consumption remain at the center of scientific evaluation, including nitrosamine formation, heterocyclic amines, and health outcomes.

6.a. Nitrosamine Formation

When exposed to specific conditions, a class of carcinogens known as nitrosamines can be formed in foods. Nitrosamines are formed by a reaction between nitric oxide and secondary or tertiary amines. Secondary and tertiary amines are present in all foods. These compounds are a part of all proteins as side chains of proline, hydroxyproline, histidine, arginine, and tryptophan. Nitrosamine formation occurs when nitric oxide and secondary or tertiary amines in foods are exposed to very high temperatures. Forms of nitric oxide are present in many foods. All cured FPMs, contain nitrates and nitrites which are precursors to nitric oxide and, therefore, have the potential to form nitrosamines. However, the levels of nitrates and nitrites are closely regulated by USDA and nitrosamines are rarely formed in many FPM.\textsuperscript{44} Bacon is an item that has a higher risk of nitrosamine formation, because it is cured and cooked at very high temperatures, often in a frying pan. As a result of this increased risk, there is a lower level of nitrites allowed by USDA and cure accelerators must be used to mitigate risk. With the addition of cure accelerators such as ascorbate (a form of vitamin C) and erythorbate (a similar compound to vitamin C), nitrosamine formation is prevented.

\textsuperscript{44}Table 3. Common ingredients used in meat processing.
6.b. Heterocyclic Amines

Heterocyclic amines (HCA) are compounds that can form during high temperature cooking like grilling. Together, when amino acids and creatine are put under high heat, the Maillard reaction occurs and can form HCAs. The formation of HCAs can be reduced or prevented by trimming away excess fat before grilling to reduce high heat flare-ups. Additionally, using lower temperatures when grilling, indirect heat, and turning meat frequently can reduce HCA formation. Additionally, using different marinades, spices, and seasonings can almost eliminate HCA formation. Research shows marinating or seasoning meat with rosemary, onion, garlic, lemon juice, and others can greatly reduce HCA formation.46

6.c. The Effect of Meat Consumption on Cancer Outcomes

The potential role that MPM and FPM may have on cancer outcomes is a widely debated topic. Scientific evaluations continue to explore high consumption of processed meat and any relation with colorectal cancer in both the general population and specific sub-groups. In 2018, the International Agency for Research on Cancer (IARC) released a Monograph addressing red and processed meat consumption and cancer. IARC concluded processed meat is a Group 1 carcinogen, meaning there was sufficient evidence in humans that intake causes colorectal cancer. IARC also concluded that red meat is a Group 2A carcinogen, meaning it is probably carcinogenic based on limited evidence that intake of red meat causes colorectal cancer in humans.47 Many of the observed associations are weak in magnitude and may be due to methodological challenges and limitations. It has been shown repetitively across varying worldwide study populations that, on average, those who consume high levels of processed meat have demographic, lifestyle, other dietary, and clinical factors that are associated with an increased risk of chronic disease and cancer.48 These other factors have demonstrated an increased cancer risk independently of processed

45 Maillard reaction – a form of non-enzymatic browning similar to caramelization; a chemical reaction between an amino acid and a reducing sugar, usually requiring heat
meat consumption. In the Monograph, IARC noted that “Chance, bias, and confounding could not be ruled out with the same degree of confidence for the data on red meat consumption since no clear association was seen in several of the high-quality studies and residual confounding from other diet and lifestyle risk is difficult to exclude.”\textsuperscript{49} Cancer is complex. There are numerous known and suspected factors that contribute to cancer incidence, but separating one factor from another can be challenging. Research needs to continue to evaluate the effect of MPM and FPM on cancer outcomes, including mechanistic evaluations of exactly how meat may be linked to cancer.

\textit{6.d. The Effect of Meat Consumption on Heart Health}

For adults over 65, heart disease is the leading cause of death.\textsuperscript{50} Some studies determined a link between decreased heart health and meat consumption, but the evidence has not been consistent. Overall, the evidence implicating meat consumption in adverse cardiometabolic outcomes is of low quality. Therefore, the relationship between meat consumption and heart health is uncertain. Furthermore, evidence demonstrates if a causal relationship exists between meat consumption and heart health, the magnitude of association is very small.\textsuperscript{51} Research needs to continue to evaluate the effect of MPM and FPM on heart health outcomes.

\textit{7. Conclusion}

Minimally and further processed meat products play a significant role in a healthy, well-balanced diet. Animal-derived proteins are the only sources of all essential amino acids. By including meat in the diet, consumers can more easily fulfill their macronutrient requirements. Meat packers and processors are committed to providing consumers with a wide array of products so consumers can choose the foods that best fit their personal lifestyle and family dietary needs. The industry is dedicated to providing safe, wholesome, and nutritionally diverse products to meet a variety of consumer needs.

Table 1. Processes applied to meat to create minimally or further processed meat items.

<table>
<thead>
<tr>
<th>Process</th>
<th>Definition</th>
<th>Function</th>
<th>Product Examples</th>
<th>Minimal or Further Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batter/Breading</td>
<td>Items that are often coated with pre-dust, a seasoned batter consisting of a blend of flour, starches, and water, and/or a breading. Products may be uncooked but partially fried to set the batter or fully-cooked.</td>
<td>Sensory Enhancement – creates a specific flavor, texture, and/or mouthfeel</td>
<td>Chicken nuggets, chicken fingers, corn dogs, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Blending</td>
<td>Additional mixing of meat products to solubilizing and swelling meat proteins.</td>
<td>Sensory Enhancement – uniformly distributes ingredients throughout product</td>
<td>Sausage, hot dogs, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Co-Extruding</td>
<td>Extrusion of multiple layers of raw materials simultaneously. For example the process of forming sausage into a cylindrical shape while simultaneously coating the sausage with a layer of solubilized collagen or alginate.</td>
<td>Sensory Enhancement – adds value and increases functionality to create more palatable products</td>
<td>Hot dogs, mayonnaise, homogenized milk, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Curing</td>
<td>The inclusion of nitrate or nitrite salts. There are numerous curing methods: <em>Brine or Pickle</em>: a slow curing method where product is immersed in a solution of curing agents (nitrates, nitrites, and more) dissolved in water. <em>Dry Curing</em>: an older method in which curing ingredients are rubbed in dry form over the meat surface. <em>Traditional Curing</em>: the addition of traditional manmade salt and nitrate/nitrite to products. <em>Natural Curing</em>: the addition of natural sources of nitrates and nitrites from celery juice/salt, sea salt, turbinado sugar, and others.</td>
<td>Sensory enhancement, storage extension, and food safety – creates a unique appearance, flavor, and texture, while enhancing product safety by hindering bacterial growth and lengthens storage time</td>
<td>Ham, bacon, hot dogs, some sausages, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Dicing</td>
<td>Reducing size of product into smaller blocks or particles.</td>
<td>Sensory enhancement – increases ease and uniformity of cooking and handling</td>
<td>Stew meat</td>
<td>Minimally processed</td>
</tr>
<tr>
<td>Drying</td>
<td>Removing water from a meat product by evaporation or sublimation following lethality.</td>
<td>Sensory enhancement and storage extension – transforms meat into a shelf-stable form while increasing palatability</td>
<td>Jerky, dry sausages, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Emulsifying</td>
<td>A mixture of immiscible substances, one of which is dispersed in the form of droplets or globules within the other. When muscle, fat, water, and salt are subjected to high-speed cutting and shearing forming a meat batter.</td>
<td>Sensory enhancement – transforms meat items into more palatable forms</td>
<td>Hot dogs, some snack sticks, some sausages, and more</td>
<td>Further Processed</td>
</tr>
</tbody>
</table>
Table 1. Processes applied to meat to create minimally or further processed meat items. *Cont.*

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
<th>Sensory enhancement and storage extension</th>
<th>Food safety, sensory enhancement, and storage extension</th>
<th>Minimally Processed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabricating</td>
<td>Disassembly of a carcass by separating it into smaller primal, subprimal, and/or retail cuts.</td>
<td><em>Sensory enhancement</em> and <em>storage extension</em> – reducing the size of the carcass into smaller pieces so multiple carcasses can be differentiated into homogeneous groups, and then cooked and stored more efficiently than an intact carcass.</td>
<td>Summer sausage, pepperoni, salami, snack sticks, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Fermenting</td>
<td>Bacterial metabolism of carbohydrates to an organic acid, typically lactic acid, under low heat conditions.</td>
<td><em>Sensory enhancement, storage extension, and food safety</em> – as the conversion of sugars to organic acids takes place, food is preserved and unique flavors formed.</td>
<td>Ground meat, meatballs, patties, and more</td>
<td>Minimally Processed</td>
</tr>
<tr>
<td>Grinding/Comminuting</td>
<td>A process of reducing meat particle size by cutting and pressing through specifically sized orifices in a grinder plate.</td>
<td><em>Sensory enhancement</em> – changes the product size into a palatable form that is easily handled by consumers and in a state that allows for ease of mixing and forming.</td>
<td>Bacon, ham, some roasts, chops, and many more.</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Injecting</td>
<td>The process of inserting solutions into meat products using needles.</td>
<td><em>Food safety, sensory enhancement, and storage extension</em> – injected solutions carry spices and seasonings equally throughout products. Solutions may also contain antimicrobials, which control pathogen and spoilage bacteria growth.</td>
<td>Fajita meat, enhanced pork loin, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Marinating</td>
<td>Delivering ingredients to products by saturating them in a water-based solution for a length of time.</td>
<td><em>Sensory enhancement</em> – adds flavor to product.</td>
<td>Steak, chops, and more</td>
<td>Minimally Processed</td>
</tr>
<tr>
<td>Tenderizing</td>
<td>Subjecting products to a physical, chemical, or enzymatic processes to improve texture.</td>
<td><em>Sensory enhancement</em> – makes whole muscle items more tender.</td>
<td>Some hams, hot dogs, corned beef, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Pasteurizing</td>
<td>Applying heat to a product as a means of destroying some spoilage and all pathogenic bacteria, excluding spores.</td>
<td><em>Food safety and storage extension</em> – eliminates pathogen and spoilage bacteria.</td>
<td>Patties, nuggets, meat fingers, and more</td>
<td>Minimally Processed</td>
</tr>
<tr>
<td>Restructuring/Forming</td>
<td>The forming of some steaks, roasts, nuggets, patties or other shapes following particle reduction via fabrication, chopping, chunking, slicing, flaking, comminuting or others.</td>
<td><em>Sensory enhancement</em> – can alter tenderness, and mouthfeel of products while making them into a product shape with more consumer appeal.</td>
<td>Canned stew, chili, corned beef, chicken, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Retorting</td>
<td>Using temperature (116 and 121°C) and pressure to cook meat in a sealed package.</td>
<td><em>Food safety, sensory enhancement, and storage extension</em> – reduces bacterial growth, results in shelf stable products, and creates a convenient, palatable item for consumers.</td>
<td>Canned stew, chili, corned beef, chicken, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td>Processes</td>
<td>Description</td>
<td>Sensory Enhancement</td>
<td>Examples</td>
<td>Further Processed</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>---------------------</td>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Smoking</strong></td>
<td>Applying the smoke during thermal heat treatment. Smoking can be achieved through the burning of logs, woodchips, and sawdust, or by drenching the product in a liquid smoke concentrate, or exposure to an atomized cloud of distilled liquid smoke.</td>
<td><em>Sensory Enhancement</em> – creates a unique smoke flavor, aroma, and surface color</td>
<td>Bacon, ham, jerky, pastrami, some ham, some sausages, and more</td>
<td>Further Processed</td>
</tr>
<tr>
<td><strong>Sterilizing</strong></td>
<td>Killing all microorganisms, spores, and pathogens by heating meat products in hermetically sealed containers (exceeding 121°C) and high-pressure (at least 0.082 MPa).</td>
<td><em>Food safety and storage extension</em> – eliminates all microorganisms and spores</td>
<td>Some RTE lunch meat, ham, sausage, and more.</td>
<td>Further Processed</td>
</tr>
<tr>
<td><strong>Thermal Processing</strong></td>
<td>Subjecting product to heat processing to achieve a specified level of safety, prolong shelf-life, and enhance sensory characteristics.</td>
<td><em>Sensory enhancement, storage extension, and food safety</em> – reduces or kills microorganisms (spoilage and pathogenic) while transforming the product into a palatable state</td>
<td>Hot dogs, ham, salami, bacon, lunch meat, and more</td>
<td>Further Processed</td>
</tr>
</tbody>
</table>

**Sources:**
<table>
<thead>
<tr>
<th>Meat Item(s)</th>
<th>Description</th>
<th>Process</th>
<th>Common Ingredients</th>
<th>Example Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacon</td>
<td>Cured pork belly.</td>
<td>Smoking, curing, thermal processing, and injecting.</td>
<td>Salt, sugar, sodium erythorbate, or ascorbate, sodium nitrite, and water. Can have other spices and seasonings.</td>
<td>Maple Bacon, Hickory Smoked Bacon, Peppered Bacon, Thick Cut Bacon, Lower Sodium Bacon, Turkey Bacon Made with Turkey Leg Meat, and many more.</td>
</tr>
<tr>
<td>Bologna</td>
<td>Comminuted semisolid sausages in large diameter casings that have not more than 30% fat or 40% fat and added water. A popular type of sausage.</td>
<td>Comminuted, emulsified, blended, cured, thermally processed, and can be smoked or unsmoked.</td>
<td>Salt, nitrite, added water and can have phosphates, sugar and other spices and seasonings.</td>
<td>Bologna, Beef Bologna, Turkey Bologna, German Bologna, and more.</td>
</tr>
<tr>
<td>Canadian Bacon</td>
<td>Cured pork from a trimmed boneless pork loin.</td>
<td>Can be cured, smoked or unsmoked, and thermally processed.</td>
<td>Can have salt, sugar, nitrate/nitrite, and water, as well as other spices and seasonings.</td>
<td>Cherrywood Smoked Canadian Bacon, back bacon, and more.</td>
</tr>
<tr>
<td>Corned Beef</td>
<td>Cured beef from the brisket, navel, clod, middle ribs, round, rump, or similar cut.</td>
<td>Fabricated, cured, can be injected, and heat treated.</td>
<td>Salt, nitrite, peppercorns, bay leaves, mustard, dill seeds, and more.</td>
<td>Corned beef brisket, Corned Beef Top Round, Delicatessen Corned Beef, and more.</td>
</tr>
<tr>
<td>Ham (General Category)</td>
<td>A large category of further processed meat items from the leg of a pork carcass. Hams may be fresh, cured, or cured-and-smoked. Generally, ham is the cured leg of pork. Fresh ham is an uncured leg of pork. Products can be bone-in or boneless</td>
<td>Can be blended, thermally processed, cured, uncured, diced, fabricated, restructured, comminuted, injected, or smoked or unsmoked.</td>
<td>Ingredients vary widely based on the type of ham.</td>
<td>Deli Ham, Honey Cured Ham, Spiral Sliced Ham, Fresh Ham, Lean Ham, Low Sodium Ham, Ham Center-Cut Slice, and many more.</td>
</tr>
<tr>
<td>Fresh Ham</td>
<td>The only type of ham that is not cured. The term “fresh” must be on the label.</td>
<td>Fabricated and can be diced or thermally processed.</td>
<td>Typically, none or just spices and seasonings.</td>
<td>Fresh Ham Uncooked, Fresh Ham Cooked, and more.</td>
</tr>
<tr>
<td>Smoked Ham</td>
<td>Hams that are cured and smoked. Products can be bone-in or boneless and cooked or uncooked prior to sale.</td>
<td>Cured, injected, smoked, and can be thermally processed.</td>
<td>Salt, nitrite, added water and can have phosphates, sugar, and other spices and seasonings.</td>
<td>Hickory Smoked Ham, Cured and Smoked Spiral Sliced Ham, Smokehouse Ham, Black Forest Ham, Honey Ham, Honey-Cured Ham, and more.</td>
</tr>
<tr>
<td>Dry Cured Ham</td>
<td>Fresh hams rubbed with a dry-cure mixture and aged. Six months is the traditional aging process but may be shortened according to aging temperature or lengthened to over a year for flavor development. Dry curing produces a salty product that is shelf stable with very low water activity.</td>
<td>Cured, dried, and can be smoked.</td>
<td>Salt, nitrate, or nitrite and can have other spices and seasonings added.</td>
<td>Country Cured Ham, Westphalian Ham, Prosciutto, Serrano Ham, and more.</td>
</tr>
<tr>
<td>Hot Dogs (Frankfurters)</td>
<td>Comminuted semisolid sausages in small diameter synthetic casings that do not have more than 30% fat or 40% fat and added water. Can be made from beef, pork, turkey, chicken, or a combination. A popular type of sausage.</td>
<td>Comminuted, emulsified, blended, cured, thermally processed, and can be smoked or unsmoked.</td>
<td>Salt, sodium nitrite, added water (ice) and can have phosphates, hydrolyzed vegetable protein, and more.</td>
<td>All Beef Franks, Reduced Sodium Frankfurters, Skinless Bun Length Beef Franks, Turkey Hot Dogs and more.</td>
</tr>
<tr>
<td>Jerky</td>
<td>A nutrient dense meat product that has been made shelf stable through drying.</td>
<td>Thermally processed, dried, and can be marinated, and smoked.</td>
<td>Salt, sugar, seasonings, and spices.</td>
<td>Beef jerky, teriyaki beef jerky, peppered beef jerky, turkey jerky, bacon jerky, and many more.</td>
</tr>
</tbody>
</table>

1. Table 2. Common further processed meat products.
Table 2. Common further processed meat products. Cont.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Preparation</th>
<th>Ingredients</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastrami</td>
<td>Beef plate or thin meats that are prepared and often served as deli meat. Other meat items and species can be used but must be identified on the label.</td>
<td>Smoked, cured, and heat treated.</td>
<td>Salt, sodium nitrite, added water, and can have other spices and seasonings.</td>
<td>Delicatessen Pastrami, Pastrami, Smoked Pastrami, Top Round Pastrami, Turkey Pastrami, and more.</td>
</tr>
<tr>
<td>Roast Beef</td>
<td>Large ready-to-eat beef items.</td>
<td>Thermally processed and injected.</td>
<td>Added water and often contains phosphates, salt, sugar, and other seasonings and spices.</td>
<td>Roast Beef Premium Deli Ultra Thin, Roast Beef Deli Style, Medium Cooked Roast Beef, Lower Sodium Roast Beef, and more.</td>
</tr>
<tr>
<td>Sausage (General Category)</td>
<td>Coarse or finely comminuted meat from various species containing various ingredients, moisture levels, and under gone various processes. Numerous classes of sausage are recognized by the United States Department of Agriculture (see below).</td>
<td>Blending, thermal processing, curing, emulsifying, fermenting, grinding, and smoking.</td>
<td>Salt, nitrite, added water, and can have phosphates, sugar, and other spices and seasonings.</td>
<td>Sopressata, Pepperoni, Salami, Breakfast Sausage, Italian Sausage, and more.</td>
</tr>
<tr>
<td>Fresh Sausage</td>
<td>Coarse or finely comminuted sausages that must be refrigerated and cooked.</td>
<td>Grinding.</td>
<td>Salt, added water, and numerous spices and seasonings.</td>
<td>Bratwurst, Italian Sausage, Whole Hog Sausage, Breakfast Sausage, and more.</td>
</tr>
<tr>
<td>Uncooked Smoked Sausage</td>
<td>Uncommon sausage type. Similar to fresh sausage but have a different color and flavor profile.</td>
<td>Grinding and smoking.</td>
<td>Salt, added water, and numerous spices and seasonings.</td>
<td>Fresh Smoked Pork Sausage, Kielbasa, and Linguica.</td>
</tr>
<tr>
<td>Cooked and/or Smoked Sausage</td>
<td>Comminuted semisolid sausages.</td>
<td>Grinding, blending, smoking, thermally processed, and can be emulsified and cured.</td>
<td>Salt, sodium nitrite, added water (ice) and can have phosphates, other spices and seasonings.</td>
<td>Frankfurters, bologna, knockwurst, braunschweiger, Smoked Hot Beef Sausage, and more.</td>
</tr>
<tr>
<td>Dry and Semidry Sausages</td>
<td>Comminuted sausage that is fermented by bacterial growth. They are often cultured with lactic acid, similar to cheese, pickles, and yogurt.</td>
<td>Grinding, blending, curing, fermenting, and drying.</td>
<td>Salt, sodium nitrite, and numerous spices and seasonings.</td>
<td>Sopressata, Pepperoni, Salami, Summer Sausage, Lebanon Bologna, and more.</td>
</tr>
<tr>
<td>Specialty Meat, Loaves and Jellied</td>
<td>Typically, ready-to-eat sausage like products made from comminuted meats that are seasoned and usually thermally processed rather than smoked. They are usually sliced and served cold.</td>
<td>Can be ground, blended, thermally processed, and emulsified.</td>
<td>Salt, added water, and numerous spices and seasonings.</td>
<td>Head Cheese, Jellied Corned Beef, Ham and Cheese Loaf, Olive Loaf, Scrapple, and more.</td>
</tr>
</tbody>
</table>

1. This is not an all-encompassing list. There are thousands of different further processed meat products.
2. Not all ingredients are listed. There are unlimited combinations of ingredients for each product.
Source: United States Department of Agriculture Food Safety and Inspection Service.
Table 3. Common ingredients used in meat processing.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Description</th>
<th>Function/Use</th>
<th>Regulatory Level</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Added Water (Added Solution)</strong></td>
<td>Water is the most abundant component of muscle/meat. However, added water is a necessary functional component in many further processed meat products. Added water is the amount of water added to meat products, not the water that is already a component of muscle. Added water is also often referred to as the amount of water added in excess of the moisture to protein ratio.</td>
<td>Added water is a solvent used to dissolve, carry, and disperse substances, including ingredients. Without added water to dissolve and disperse small quantities, it would be very difficult to achieve uniform distribution of ingredients during mixing.</td>
<td>Any added water must be included in the ingredient statement. USDA FSIS(^1) limits the amount of added solution (added water with dissolved ingredients). Numerous products can have added solution, and that must align with the standard of identity(^2) found in 9 CFR 319. For products with added solutions that do not have a standard of identity, the calculation for the percentage of added solution is found in 9 CFR 317.2(e)(2)(i). The percentage of added solution must be on the label.</td>
<td>Delicatessen Lower Sodium Cooked Ham; Carne Asada Seasoned, Beef Skirt Steak Marinated; 15 Percent Water Added Turkey Ham; Carne Asada; and more.</td>
</tr>
<tr>
<td><strong>Hydrolyzed Vegetable Protein</strong></td>
<td>A type of flavoring to give meat-like flavor to food products. The hydrolysis of the protein in vegetables results in high levels of free glutamic acid. There are two possible types, acid or enzyme hydrolyzed.</td>
<td>Flavor enhancement. Used to increase protein content, cooking yield, or alter sensory and slicing characteristics.</td>
<td>Generally, no USDA regulated limit. Required to be included on the product label.</td>
<td>Not required in products but can be used in sausages, bologna, patties, and more with added soy, bologna, and more.</td>
</tr>
</tbody>
</table>
| **Nitrite** | NO\(_2\). The main curing agent that is often incorporated into meat in the form of salt (sodium nitrite). | Responsible for the distinctive properties that characterize cured meat products. It stabilizes the color of lean tissue, provides flavor, inhibits the growth of a number of pathogens and spoilage bacteria, and slows down rancidity. | USDA FSIS\(^4\) closely regulates the allowable levels of ingoing sodium nitrite found in 9 CFR 424.22.  
- Bacon: 120 ppm + 550 ppm of sodium ascorbate or sodium erythorbate  
- Dry-cured bacon: 200 ppm  
- Frankfurters or cured sausages: 156 ppm  
- Brine cured of injected products like ham of pastrami: 200 ppm  
- Dry-cured meat items: 625 ppm | Used in all cured products such as ham, bacon, hot dogs, some sausages, corned beef, and many more. |
<p>| <strong>Nitrate</strong> | NO(_3). A curing agent that is often incorporated into the meat as a form salt (sodium nitrate). Sodium nitrate is transformed into nitrite through non-enzymatic processes and nitric oxide (NO) by bacteria during the curing process. | Nitrate is used for long cured items that continually need nitrate to produce nitrite throughout the curing process. | Nitrate is not permitted in bacon. The allowable level of sodium nitrate can be calculated based on the regulatory limit for allowable level of nitrite.(^5) | Used in slowly cured products such as dried sausages, dry-cured hams, and more. |
| <strong>Phosphates</strong> | A chemical compound that contains phosphorus. Phosphates are not necessary for cured products but are often used. | To increase water-holding capacity (the ability to bind and retain water), adjust pH, and ionic strength of meat mixtures. Using phosphates may allow processors to use less sodium nitrite. | Variable depending on the form of phosphate. Allowable levels can be found in 9 CFR 318.7. | Used in many further processed products but not required for curing. Often used in hams, sausage, bacon, and more. |</p>
<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Description</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Chloride (Salt)</td>
<td>Generally, a white crystalline solid. Sodium chloride is made up of roughly 40% sodium and 60% chloride. Salt is one of the oldest ingredients used in meat processing and is a critical ingredient to all cured meat products. Salt preserves through dehydration and alteration of the osmotic pressure of microorganisms, which inhibits growth. Salt is often used in combination with other ingredients for the desired antimicrobial effect and flavor development. Products will become unpalatable with high concentrations of salt, so it is self-limiting.</td>
<td>Salt is used in almost every minimally and further processed meats including, seasoned beef patties, hotdogs, bacon, and much more.</td>
</tr>
<tr>
<td>Sodium Ascorbate or Ascorbic Acid</td>
<td>The sodium salt of ascorbic acid, a refined food-grade chemical similar to vitamin C. Stabilizes the color of cured meats. Inhibits the formation of nitrosamines. Accelerates curing, which aids in controlling bacterial growth. Similar to sodium erythorbate or erythorbic acid.</td>
<td>Bacon must have 120 ppm of nitrite and 550 ppm of ascorbate or erythorbate. Required in bacon (or another cure accelerator) and often used in other further processed and cured items.</td>
</tr>
<tr>
<td>Sodium Erythorbate or Erythorbic Acid</td>
<td>The sodium salt of erythorbic acid, a refined food-grade chemical similar to vitamin C and made from sugar. Stabilizes the color of cured meats. Inhibits the formation of nitrosamines. Accelerates curing, which aids in controlling bacterial growth. Similar to sodium ascorbate or ascorbic acid.</td>
<td>Bacon must have 120 ppm of nitrite and 550 ppm of ascorbate or erythorbate. Required in bacon (or another cure accelerator) and often used in other further processed and cured items.</td>
</tr>
<tr>
<td>Sodium and Potassium Lactate</td>
<td>The sodium salt of lactic acid and the potassium salt of lactic acid. Added to processed meats to reduce pathogen growth. Ingredient manufacturer’s instructions can be referenced for allowable limits and in accordance with FSIS Directive 7120.1.</td>
<td>Not required in products but common in numerous ready-to-eat products like ham and some sausages.</td>
</tr>
<tr>
<td>Sugar</td>
<td>A sweetener used in meat products. A variety of sugars, including molasses and other sweeteners, are commonly used. Type of sugars used range from sucrose (cane or beet sugar) to dextrose (corn sugar). The dextrose group includes corn syrup, corn syrup solids, and sorbitol. Added for flavor. Counteracts harshness of salt by preventing moisture loss and directly diminishing the saltiness in products. Sugars also can interact with amino acids create browning during cooking.</td>
<td>No specific level regulated in meat. Used in many further processed meat products like dry and semi-dry sausages, marinated meat products, honey cured ham, and many more.</td>
</tr>
</tbody>
</table>

1 USDA FSIS: United States Department of Agriculture Food Safety and Inspection Service
2 Standard of identity – Determines what ingredients a product must contain, ingredients it may contain, and any requirements of manufacturing to be named certain products. All standards of identity for meat products can be found in 9 CFR Part 319.