

The Porcine Carcass: Anatomical Fabrication and Biochemical Dynamics of Salt-Cured Pork

The conversion of the domestic swine (*Sus scrofa domesticus*) from a live biological organism into a series of highly valued, shelf-stable cured meat products requires an exceptional synergy of anatomy, thermodynamics, and biochemistry. Unlike the processing of bovine or ovine species, where the hide is entirely removed during the initial slaughter cascade, porcine processing frequently prioritizes the preservation of the skin and its underlying thick layer of subcutaneous fat¹. This structural matrix is indispensable; the commercial viability of premium cuts—such as bone-in bellies, dry-cured hams, and preserved fatbacks—is highly dependent on the integrity of the dermal collagen and the adipocyte architecture¹. To achieve mastery over the curing process, one must first possess an exhaustive understanding of the skeletal and muscular topography of the carcass. This foundational anatomical knowledge must be followed closely by a nuanced comprehension of the physical and chemical principles that govern mass transfer, lipid oxidation, and microbial fermentation during maturation. The overarching objective is to manipulate post-mortem muscle and adipose tissue to ensure absolute microbiological safety while maximizing organoleptic development and slicing yields.

Pre-Slaughter Biochemistry: Adipose Genesis and Lipid Profiling

The physical properties of salt-cured pork are pre-determined long before the animal enters the abattoir. Because swine possess a monogastric gastrointestinal tract, they exhibit minimal biohydrogenation of ingested fats¹. Consequently, dietary fatty acids are deposited directly into porcine adipocytes with minimal structural alteration, making the biochemical profile of the resulting carcass highly susceptible to nutritional manipulation¹. Understanding the precise morphology and chemical composition of these lipid depots is a prerequisite for successful charcuterie fabrication.

Subcutaneous Stratification and Adipocyte Morphology

Porcine adipose tissue is not a homogenous mass; rather, it is a highly organized, temperature-dependent closed-cell foam where liquid and crystalline triglycerides are compartmentalized within individual adipocytes, structurally bound by an extracellular collagen fiber network³. The subcutaneous backfat, which runs along the dorsal ridge of the animal, is structurally separated by distinct connective tissue fasciae into three highly differentiated layers: the outer, middle, and inner layers⁵. These layers exhibit diverse developmental chronologies and diametrically opposed biochemical profiles.

The outer layer of subcutaneous fat develops earliest during the animal's ontogeny and is in closest proximity to the epidermis⁵. This layer possesses the highest concentration of

polyunsaturated fatty acids (PUFAs), such as linoleic acid ($C_{18:2\ n-6}$), and monounsaturated fatty acids (MUFAs), rendering it significantly softer and endowing it with a lower melting point⁵. Beneath this lies the middle layer, which develops later but at a highly accelerated rate. The middle layer is the thickest of the three and exhibits the highest overall lipogenic activity, acting as the primary energetic storage depot for the animal⁵. Finally, the inner layer rests directly adjacent to the epimysium of the underlying longissimus musculature. The inner layer typically contains the highest proportion of saturated fatty acids (SFAs), most notably palmitic acid ($C_{16:0}$) and stearic acid ($C_{18:0}$)⁶. Consequently, this layer is the firmest, exhibits the highest thermal stability, and presents the most rigid structure during mechanical slicing⁶. The adipocytes themselves also display locational variance; research comparing different swine breeds indicates a biphasic distribution of fat cells, with structural hypertrophy being dependent on the anatomical location, further influencing the ultimate texture of the fatback¹¹.

Subcutaneous Fat Layer	Developmental Sequence	Dominant Fatty Acid Profile	Physical Characteristics
Outer Layer	Early (Primary)	High PUFA / MUFA (Linoleic, Oleic)	Softest texture, lowest melting point, high susceptibility to oxidation ⁵
Middle Layer	Late (Accelerated)	Mixed (High lipogenic activity)	Thickest layer, high overall triglyceride storage ⁵
Inner Layer	Late (Secondary)	High SFA (Palmitic, Stearic)	Firmest texture, highest thermal stability, dense crystal structure ⁶

Nutritional Interventions and Iodine Value (IV) Predictive Modeling

The overarching metric utilized by the commercial swine industry to quantify fat firmness and predict processing behavior is the Iodine Value (IV)¹³. The IV measures the degree of unsaturation within the lipid matrix, calculating the mass of iodine in grams that is consumed by the double bonds in 100 grams of fat¹⁴. The recent integration of agro-industrial coproducts, specifically Distillers Dried Grains with Solubles (DDGS) derived from the ethanol industry, into swine finishing diets has introduced a severe technological challenge for meat processors¹. DDGS contains high fractions of corn oil, which is exceptionally rich in polyunsaturated fatty acids, predominantly linoleic acid¹.

When fed at high concentrations, these dietary PUFAs drive the IV of the belly and fatback well above the preferred industry threshold of 70 to 74 g/100g¹. Bellies exhibiting elevated IVs suffer from "soft fat" syndrome. Such bellies are structurally compromised; the intermuscular fat layers lack the rigidity required for high-speed mechanical slicing¹. Consequently, soft bellies yield a higher percentage of shattered slices, drastically reducing commercial bacon yields and creating separation between the lean and fat strata during thermal processing¹⁹. Furthermore, the high concentration of double bonds in PUFAs renders the fat highly susceptible to oxidative rancidity during long-term storage, fundamentally limiting the shelf life of the cured product⁴. To combat this, the industry relies on predictive regression models. Advanced multi-variate linear regression equations can forecast the final backfat and belly IV based on the dietary intake of essential fatty acids during the initial (INT) and final (FIN) feeding phases, combined with carcass parameters like backfat thickness and hot carcass weight¹⁸. Furthermore, modern abattoirs deploy Rapid Evaporative Ionization Mass Spectrometry (REIMS) and near-infrared (NIR) spectroscopy (e.g., the NitFom™ probe) directly on the slaughter line to non-destructively predict the IV of hot carcasses, permitting the immediate segregation of soft bellies away from premium curing lines¹⁷.

Thermal Transitions: Differential Scanning Calorimetry (DSC)

The physical properties of the porcine fat and skin matrix are frequently evaluated using Differential Scanning Calorimetry (DSC) to detect thermal phase transitions at the molecular level²⁵. For the dermal and epimysial collagen network, structural integrity relies entirely on the hydrogen bonding stabilizing the triple-helix conformation¹. As heat is applied, thermal energy disrupts these hydrogen bonds, causing the triple helix to unfold into a disordered, random coil—a phase transition known as thermal denaturation¹. DSC thermograms of porcine tissues

identify critical endothermic peaks; myosin denatures between $50^{\circ}C$ and $65^{\circ}C$, while the major collagen denaturation (shrinkage) occurs sharply around $60^{\circ}C$ to $65^{\circ}C$ ¹.

Simultaneously, the melting profiles of the lipids within the adipocytes are dictated by their specific fatty acid chain length and degree of unsaturation²⁶. DSC curves reveal that high proportions of stearic and palmitic acids drive endothermic melting peaks upward, ensuring the fat remains structurally solid at ambient curing temperatures, whereas high concentrations

of linoleic acid ($C_{18:2}$) drastically depress the melting point²⁶. This complex interplay of lipid phase transitions dictates the physical behavior of the pork backfat during the subsequent chilling and curing protocols.

The Initial Slaughter Cascade and Thermodynamic Tissue Preservation

The conversion of the live animal into a pristine carcass requires tightly calibrated interventions to preserve the biochemical potential of the meat while absolutely mitigating microbiological hazards. The physiological stress experienced by swine during transport and lairage directly influences post-mortem muscle glycolysis. Acute stress triggers rapid glycogen depletion and

an accelerated drop in muscle pH while the carcass temperature remains high, leading to the denaturation of myofibrillar proteins and the development of pale, soft, and exudative (PSE) meat, which exhibits catastrophic drip loss and poor salt uptake¹.

Scalding Thermodynamics and Dermal Collagen Integrity

Because porcine processing retains the skin, the deep bristles must be removed via thermal scalding. This is a precision thermodynamic process designed to denature the proteinaceous anchors of the hair follicles without cooking the underlying dermal collagen¹. If the scalding

temperature is too high (exceeding $62^{\circ}C$ to $63^{\circ}C$), the dermal collagen crosses its phase transition threshold as identified by DSC analysis; it undergoes severe denaturation, coagulates, and physically shrinks around the base of the bristles, permanently trapping them in the skin and destroying the tensile strength of the hide¹. Conversely, under-scalding (below $58^{\circ}C$) fails to disrupt the follicular keratin network, forcing operators to use excessive mechanical scraping that damages the epidermis¹.

Commercial swine scalding therefore adheres strictly to a time-temperature matrix of $58^{\circ}C$ to $62^{\circ}C$ for an exposure duration of 4 to 6 minutes¹. Deep muscle tissues remain thermally protected by the insulating subcutaneous fat layer; thermocouple measurements demonstrate that deep muscle temperatures remain stable at approximately $40.6^{\circ}C$ during the scald, ensuring the process does not artificially accelerate post-mortem glycolysis¹. Following scalding, the carcass undergoes mechanical dehairing and intense flame singeing (at approximately $1200^{\circ}C$ for 10 to 15 seconds) to incinerate residual keratin and thermally sanitize the epidermis, delivering a substantial log reduction in superficial bacterial counts¹.

Evisceration, Splitting, and Neurological Hazard Mitigation

Following exterior decontamination, the carcass undergoes safe evisceration. Because the gastrointestinal tract contains billions of colony-forming units of enteric pathogens, operators must execute a circum-anal incision (bunging) to physically isolate and seal the rectum¹. The viscera are carefully extracted using a "finger guide" technique along the *linea alba* to prevent accidental perforation¹. Any visible fecal contamination incurs a strict zero-tolerance regulatory response, mandating physical excision of the tissue rather than washing, which would merely drive pathogens deeper into the porous muscle¹.

To facilitate rapid heat dissipation during chilling and prepare the carcass for primal fabrication, the intact eviscerated carcass is split symmetrically down the sagittal plane into two halves¹. Splitting requires immense mechanical torque and extreme precision. Advanced robotic systems map the exact dimensions of the carcass, driving a saw blade perpendicularly to the skin surface to bisect the vertebral bodies and cleanly open the neural canal¹. Because the splitting saw fragments the spinal cord, a specialized vacuum removal system immediately tracks the open spinal canal, aspirating the highly potent slurry of cerebrospinal fluid and central nervous system (CNS) tissue to eliminate cross-contamination hazards before the

carcass enters the ultra-rapid blast chillers¹.

Anatomical Topography: Breakdown of Primal and Subprimal Cuts

Following ultra-rapid blast chilling (which drops surface temperatures to -4°C to -6°C to arrest microbial proliferation and instantly solidify liquid lipids within the adipocytes), the chilled porcine carcass is systematically fabricated¹. The primary division separates the carcass into four major primal cuts: the shoulder, the loin, the belly, and the ham³⁶. These primals are subsequently deconstructed into subprimal and retail cuts, guided strictly by standardized frameworks such as the Institutional Meat Purchase Specifications (IMPS) utilized across North America³⁸.

The Shoulder Primal (Anterior Quarter)

The shoulder comprises the anterior quarter of the carcass, encompassing the cervical and cranial thoracic regions, extending posteriorly to a straight cut passing between the second and third rib³⁷. As the primary locomotive center of the pig, the shoulder muscles are subjected to continuous mechanical load during the animal's life. Consequently, the musculature here is characterized by a high concentration of connective tissue, dense epimysial collagen networks, and significant intramuscular lipid deposition (marbling)³⁶. Under IMPS specifications, the shoulder is bisected into two distinct subprimals: the Boston butt and the picnic shoulder³⁶.

The Boston Butt (IMPS 406): Despite its colloquial nomenclature, the Boston butt represents the dorsal, upper extremity of the shoulder, terminating at the cervical and thoracic vertebrae². It houses powerful, highly oxidative muscles such as the *M. supraspinatus* and *M. serratus ventralis*. Because of its ideal lean-to-fat ratio (frequently standardized at 70/30) and rich myoglobin content, the Boston butt is optimal for prolonged thermal processing where extensive collagen gelatinization occurs, as well as for comminuted dry-cured sausage formulations (e.g., salami)³⁶. A highly prized extension of the upper neck musculature is the collar or *coppa* (*M. spinalis dorsi* and related cervical muscles). In traditional Italian charcuterie, this well-marbled subprimal is expertly isolated, dry-cured with spices, and aged into *capicola*².

The Picnic Shoulder (IMPS 405): The ventral half of the shoulder encompasses the foreleg down to the carpal joint (hock)³⁶. It contains the arm bone (humerus) and shank bones (radius and ulna). The musculature here, heavily reliant on the *M. triceps brachii*, is inherently tougher and more sinewy than the upper shoulder, featuring a thicker skin cap⁴¹. The picnic is frequently cured and smoked whole on the bone, functioning as a highly economical alternative to the hind leg ham, or it is boned to extract lean manufacturing trim for emulsion sausages².

The Loin Primal (Dorsal Trunk)

The loin (IMPS 410) represents the dorsal trunk of the carcass, extending from the posterior edge of the shoulder to the anterior edge of the pelvic girdle (hip bone)³⁶. It contains the greatest continuous mass of high-value lean tissue in the entire animal. The skeletal infrastructure includes the thoracic and lumbar vertebrae, as well as the superior aspects of the ribs⁴¹.

The Longissimus Dorsi: The primary muscle of the loin is the *M. longissimus dorsi*, which forms the iconic "pork chop" or loin eye⁴³. Because this muscle primarily serves an architectural role—maintaining posture and structural rigidity rather than facilitating acute locomotion—it is pale in color, exceptionally tender, and contains vastly less connective tissue than the shoulder musculature⁴². In Spanish and Portuguese Iberian butchery traditions, highly specialized transitionary muscles are extracted from the junction between the shoulder and loin, namely the *presa* (an oval-shaped, heavily marbled muscle) and the *pluma* (a feather-shaped extension taken from just beneath the *presa*)².

The Tenderloin (IMPS 415): Nestled securely beneath the lumbar vertebrae on the ventral aspect of the spine lies the *M. psoas major*, or tenderloin³⁸. As the absolute least exercised muscle in the porcine anatomy, it represents the apex of tenderness but is almost entirely devoid of intramuscular fat⁴³.

Fatback: Superior to the loin eye lies the fatback, a thick, dense cap of subcutaneous adipose tissue bounded by the epidermis². It is critical in charcuterie for barding, larding, and direct curing². European butchery traditions, such as the German DLG (Deutsche Landwirtschafts-Gesellschaft) guidelines, formally stratify the loin further into the *Stielkotelett* (the anterior rib chop) and the *Lendenkotelett* (the posterior lumbar chop)⁴⁴.

The Belly Primal (Ventral Trunk)

The pork belly (IMPS 408) is the ventral portion of the carcass, separated from the loin via a longitudinal cut that traverses the ribs³⁶. It spans horizontally from the posterior edge of the shoulder to the anterior edge of the ham³⁶. Anatomically, the intact belly contains the distal portions of the ribs (spare ribs, IMPS 416) connected to the costal cartilage and the sternum³⁷. Once the spare ribs and the heavy sternum cartilage are surgically excised, the remaining boneless tissue constitutes the commercial belly³⁷. The belly is distinguished by its pronounced stratification, featuring alternating layers of lean muscle (such as the *M. rectus abdominis* and *M. transversus abdominis*) interspersed with substantial intermuscular fat layers, all capped by a resilient layer of subcutaneous fat and skin³⁵. The ratio of lean-to-fat within the belly has shifted dramatically over the past century; where mid-20th-century bellies exhibited 68% to 75% separable fat, modern precision breeding and high-protein nutritional regimes have driven contemporary bellies to a much leaner 45% to 55% fat content²⁰. Despite this radical reduction, the belly remains the highest-fat primal on the carcass, ensuring its absolute supremacy for bacon and pancetta fabrication²⁰.

The Ham Primal (Posterior Quarter)

The ham primal (IMPS 401) consists of the entire hind leg, separated from the loin and belly by a transverse cut passing through the narrow part of the hip bone (shaft of the ilium) just anterior to the aitch bone³⁵. The ham is a massive, complex muscular cluster responsible for propelling the animal forward.

Its sheer volume is dominated by four major functional muscle groups: the *M. biceps femoris* (the outside round), the *M. semimembranosus* (the inside round), the *M. semitendinosus* (the eye), and the *M. quadriceps femoris* (the knuckle or tip)³⁵. These muscles exhibit varying

physiological fiber type compositions. For instance, the *M. biceps femoris* contains a relatively high proportion of highly oxidative Type I fibers, contrasting sharply with the more glycolytic Type IIB fibers prevalent in the *M. longissimus dorsi*⁴⁸. This histological variance dictates the post-mortem pH decline and ultimately affects moisture retention, texture, and salt diffusion rates during curing⁴⁹. The vast majority of hams are preserved—either through wet-curing and thermal smoking to produce city hams, or through painstaking, long-term dry-curing regimens to yield highly valued artisanal products like Italian *prosciutto*, Spanish *jamón ibérico*, and American country hams⁴⁵.

Primal Cut	Associated IMPS Series	Principal Osteology	Primary Musculature	Optimal Cured Applications
Shoulder	403–406	Scapula, Humerus, Radius, Ulna	<i>M. supraspinatus</i> , <i>M. triceps brachii</i>	Coppa (Collar), Salami, Picnic Ham
Loin	410–415	Thoracic & Lumbar Vertebrae, Ribs	<i>M. longissimus dorsi</i> , <i>M. psoas major</i>	Kassler, Canadian Bacon, Lonzino
Belly	408–409	Distal Ribs, Costal Cartilage	<i>M. rectus abdominis</i>	Bacon, Pancetta (<i>tesa & arrotoleta</i>)
Ham	401–402	Femur, Ilium, Ischium (Aitch Bone)	<i>M. biceps femoris</i> , <i>M. semimembranosus</i>	Prosciutto, Jamón, Country Ham

Optimal Anatomical Selections for Salt-Cured Pork Production

The art of charcuterie is fundamentally predicated on the anatomical selection of cuts that possess optimal lipid-to-protein ratios, specific structural densities, and appropriate morphological configurations to endure the rigorous dehydration and extreme mass transfer inherent to salt curing. Different cuts react vastly differently to osmotic pressure and enzymatic aging.

The Pork Belly: Bacon and Pancetta Fabrication

The belly is unequivocally the most globally dominant cut for salt-curing, serving as the foundational substrate for Anglo-American bacon and Italian *pancetta*⁴⁵. Its superiority stems directly from its anatomical stratification; the alternating striations of lean and fat provide a harmonious balance of texture and flavor release⁵². During curing and subsequent thermal processing (hot smoking or high-heat rendering), the thick intermuscular lipid layers baste the adjacent *M. rectus abdominis* fibers, preventing the severe desiccation that would ruin a leaner cut²⁰.

In Italian traditions, the belly is processed into *pancetta*. It may be left flat, salted, and dry-cured (*pancetta tesa*) or aggressively seasoned with aromatics, rolled into a tight cylinder, and surgically bound with twine (*pancetta arrotolata*)⁵¹. The physical rolling process protects the inner lean tissue from extreme oxidation and rapid dehydration, while allowing the exterior fat cap to undergo slow, controlled lipolysis, developing profound aromatic complexity over several months of hanging⁵¹. The high fat content (frequently exceeding 30%) in premium bellies results in significantly higher eating quality scores for juiciness, flavor, and overall acceptance compared to low-fat bellies⁵².

The Fatback: Monolithic Adipose Preservation in Salo and Lardo

The fatback is a monolithic block of pure subcutaneous adipose tissue harvested directly from the dorsal aspect of the loin². It is composed of roughly 80% to 82% lipids and only 13% to 17% water, encased entirely within a highly stable collagenous network⁵⁵. The density of the fatback, heavily driven by higher concentrations of stearic and palmitic acids (especially in the inner layers closest to the loin), makes it exceptionally suitable for direct curing without the need for any underlying lean muscle⁶.

In Eastern European culinary traditions, the raw fatback is dry-salted with coarse salt, crushed garlic, and peppercorns to produce *saló*⁵⁷. In Italy, it is famously cured in porous marble basins with rosemary and spices to yield *lardo di Colonnata*. The dense lipid matrix, practically devoid of the high moisture content found in lean muscle, effectively limits rapid bacterial spoilage, allowing the fat to safely age at cellar temperatures. Over time, the fat develops a silky, buttery texture through slow, endogenous enzymatic breakdown, transforming into a highly prized delicacy².

The Jowl: Structural Integrity in Guanciale

The pork jowl (cheek) is a highly specialized anatomical cut containing alternating layers of fat and heavily exercised masticatory muscles². Because the jaw is constantly in motion throughout the animal's life, the collagen network within the jowl is intensely cross-linked, yielding an adipose matrix that is significantly firmer and more structurally sound than the fat found in the belly⁶⁰.

When dry-cured with salt, black pepper, and occasionally thyme or garlic, the jowl becomes *guanciale*. The high collagen content and dense fat structure give *guanciale* a much higher physical resistance to rapid rendering at low temperatures compared to standard bacon. This slow-melting characteristic makes it the superior, traditional choice for emulsified Roman pasta sauces such as *carbonara* and *amatriciana*, where the rendered lipids must gradually emulsify with starch and cheese without rapidly crisping or burning⁶⁰.

The Loin: Wet-Curing and Hot-Smoking in Kassler

While the loin is typically consumed fresh, it features prominently in specific Northern European curing traditions, most notably the German *Kassler* (or *Kasseler*)⁶¹. Named, according to popular culinary lore, after a 19th-century Berlin butcher named Cassel (though historical records remain highly contested), *Kassler* consists of a pork loin or neck that is lightly subjected to a wet brine and subsequently hot-smoked with beechwood or alder⁶¹.

Because the *Longissimus dorsi* is exceptionally lean and lacks the protective intermuscular fat of the belly, the *Kassler* process relies heavily on exact equilibrium wet-brining to prevent moisture loss⁶⁴. The salt chemically swells the myofibrillar proteins, forcing the lattice to expand and trap water within the cellular matrix prior to smoking, ensuring the resulting roast remains succulent and juicy⁶⁴.

Thermodynamics and Mass Transfer in Salt-Curing Kinetics

The preservation of pork via salt curing is fundamentally a rigorous thermodynamic exercise in mass transfer and osmotic pressure. When sodium chloride (NaCl) is introduced to the surface of the meat, an extreme concentration gradient is established between the hypertonic exterior and the hypotonic interior of the muscle cells.

Fickian Diffusion and Effective Diffusion Coefficients

The physical migration of salt into the porcine tissue and the simultaneous exudation of cellular water are mathematically governed by Fick's Second Law of Diffusion, expressed as:

$$\frac{\partial C}{\partial t} = \nabla \cdot (D_{eff} \nabla C)$$

where C is the concentration of the solute (salt) and D_{eff} is the effective diffusion coefficient³¹.

Empirical studies utilizing proton and ^{23}Na Magnetic Resonance Imaging (MRI) have determined that the apparent diffusion coefficient of NaCl in porcine *Longissimus dorsi* ranges between $3.0 \times 10^{-10} \text{ m}^2/\text{s}$ and $7.0 \times 10^{-10} \text{ m}^2/\text{s}$ ⁵⁰. The velocity of this diffusion is highly dependent on the anatomical structure of the tissue. Salt migrates through pure myofibrillar tissue much faster than through dense connective tissue or adipose matrices⁵⁰. In fatback and intermuscular fat, the extreme hydrophobic nature of the adipocytes acts as a resistive barrier, severely depressing the diffusion coefficient⁵⁰.

Furthermore, D_{eff} is profoundly temperature-dependent, increasing as thermodynamic energy rises. For instance, curing at 15°C accelerates penetration compared to 4°C ,

though higher temperatures simultaneously elevate the risk of microbial spoilage before the salt has fully penetrated the core³¹. The type of salt utilized also alters kinetics; potassium chloride (KCl) exhibits faster mass transfer rates than NaCl, while divalent salts like calcium chloride ($CaCl_2$) exhibit stronger interactions with muscle proteins, altering equilibrium states⁶⁹.

Solute / Tissue Type	Approximation of Deff (m2/s)	Physiological Modifiers
NaCl in Lean Muscle	$3.0 \times$ to $7.0 \times$	Increases with lower pH (e.g., PSE meat); increases with temperature ³¹ .
NaCl in Adipose Tissue	Significantly depressed	Hydrophobic lipid matrix acts as a physical and chemical barrier to aqueous diffusion ⁵⁰ .
Water (Desorption)	$2.42 \times$ (Dry Salting)	Strongly influenced by ambient relative humidity and the state of protein denaturation ³¹ .

Osmotic Swelling, Isoelectric Shifts, and Equilibrium Brining

As NaCl penetrates the lean tissue, it fundamentally alters the ionic strength of the aqueous phase. At moderate concentrations (e.g., 2% to 6%), the chloride ions selectively bind to the protein filaments (actin and myosin), increasing the net negative electrostatic repulsion between the myofibrils. This electrostatic repulsion expands the myofibrillar lattice, allowing the meat to physically trap and retain more water—a critical mechanism for maintaining juiciness in wet-cured products like Kassler or injected bacon⁵⁰. Conversely, if the salt concentration becomes exceedingly high (approaching or exceeding 10%), the proteins cross their isoelectric threshold and undergo severe "salting out" (denaturation), which collapses the lattice and rapidly expels water, a phenomenon deliberately leveraged in dry-cured products like prosciutto to ensure maximum dehydration and microbiological stability⁵⁰.

To achieve exact flavor profiles without inducing severe salting out, modern artisanal charcuterie heavily relies on Equilibrium Curing (EQ). Rather than immersing the belly in a hypertonic gradient brine (which risks oversaturation of the exterior while leaving the core raw), EQ precisely calculates the salt as a percentage of the total mass (meat plus water). The Water Phase Salt Percentage (WPSP) is utilized to ensure microbiological safety while maintaining palatability. A typical WPSP for dry-cured bacon or pancetta is precisely calibrated to 2.25% to 2.75% of the meat's mass⁷¹. Over the course of 7 to 14 days, the solute concentration reaches

absolute equilibrium throughout the intra- and extracellular fluid, completely eliminating the risk of a highly hypertonic, overly salty crust⁷².

Water Activity (a_w) Depression and Moisture Sorption Isotherms

The ultimate objective of the mass transfer of salt is the depression of the meat's water activity

(a_w). Raw pork exhibits a remarkably high a_w of 0.98 to 0.99, providing a perfect solvent matrix for the rapid proliferation of pathogenic and spoilage microorganisms⁷⁴.

The dissolution of NaCl binds free water molecules, rendering them thermodynamically

unavailable for biological metabolism⁷⁴. Bacterial hurdles are established at specific a_w thresholds: most vegetative pathogens (e.g., *Salmonella*, *Listeria*) are effectively inhibited

below an a_w of 0.92, whereas extreme halophilic bacteria and xerophilic molds require depression below 0.80 or 0.75⁷⁴. The physical chemistry of this dehydration is mapped using moisture sorption isotherms, which plot the relationship between total moisture content and

a_w at a constant temperature. For salted pork, these isotherms demonstrate a severe

hysteresis drop exactly at a_w 0.75, which directly corresponds to the saturation limit of an aqueous NaCl solution⁷⁰. Below this 0.75 threshold, sodium chloride crystallizes within the meat matrix, physically ceasing to bind additional water, which dramatically shifts the drying kinetics during the final maturation phases of dry-cured hams and hard salamis⁷⁰.

Biochemical Maturation: Microbial Fermentation, Lipolysis, and Colorimetric Pathways

While salt provides the primary osmotic barrier against spoilage, the unique organoleptic profile of cured pork—its distinctive pink coloration, tangy flavor, and resistance to rapid

rancidity—is driven by the deliberate addition of nitrite (NO_2^-) and nitrate (NO_3^-) salts, and their subsequent complex biochemical interactions with the native or inoculated meat microbiome.

Nitrate Reductase and Nitric Oxide Synthase Activity

In long-term dry-cured products (like pancetta or traditional salami), nitrates must be enzymatically reduced to nitrites to become chemically active. This reduction is facilitated by the endogenous or inoculated microbiota, primarily coagulase-negative staphylococci (CNS) such as *Staphylococcus carnosus* and *Staphylococcus xylosus*⁷⁹. These highly halotolerant bacteria possess robust nitrate reductase activity, functioning as the biochemical engine that continuously and slowly supplies nitrite over months of aging⁷⁹. Emerging research also indicates that strains like *S. xylosus* possess Nitric Oxide Synthase (NOS) activity, capable of producing nitric oxide directly from amino acid precursors even in the absence of added nitrates, providing a secondary pathway for color formation⁸¹.

Controlled Lipid Oxidation and Volatile Organic Compound

Generation

Beyond their role in color formation, *S. xylosus* and *S. carnosus* excrete powerful endogenous lipases and esterases directly into the adipose tissue⁸³. These enzymes cleave the ester bonds of the triglycerides within the pork belly and fatback, releasing free fatty acids (FFAs) into the matrix⁸³.

Simultaneously, during prolonged exposure to oxygen and salt (which acts as a potent pro-oxidant), the unsaturated fatty acids (e.g., oleic and linoleic acid) undergo autoxidation⁸⁵. The initiation phase involves the abstraction of a hydrogen atom from the lipid chain, yielding an unstable alkyl radical⁸⁵. This radical rapidly reacts with molecular oxygen to form lipid hydroperoxides⁸⁵. Because hydroperoxides are odorless and highly unstable, they immediately undergo secondary degradation via β -scission to form a myriad of highly aromatic secondary metabolites, including aldehydes, ketones, and alcohols⁸⁵.

Hexanal (derived specifically from the oxidation of linoleic acid) and pentanal are primary markers of this oxidation. Measured via Thiobarbituric Acid Reactive Substances (TBARS) assays, a controlled, low level of hexanal imparts the characteristic "cured" and "nutty" aroma essential to aged pancetta and bacon, whereas runaway oxidation leads to catastrophic rancidity⁸⁶. Thus, the lower the initial Iodine Value of the pork fat (i.e., fewer PUFAs), the more controlled and manageable this oxidative cascade remains during extended curing¹⁷.

The Nitrosylmyoglobin Color Phenomenon

The reduced nitrite molecule undergoes further chemical dismutation in the mildly acidic

environment of post-mortem muscle to form nitric oxide (NO) gas⁹⁰. The nitric oxide molecule exhibits a profound, highly specific chemical affinity for the iron atom centered within the porphyrin ring of myoglobin (the primary oxygen-carrying pigment in muscle)⁹⁰.

When NO binds to the iron (Fe^{2+}) in myoglobin, it forms nitrosomyoglobin, which imparts a dark, vibrant red color to the raw cured meat³². Upon the application of heat (e.g., pan-frying bacon or hot-smoking Kassler), the globin protein fraction denatures, permanently detaching from the porphyrin ring³². The remaining complex, nitrosohemochrome, stabilizes into the iconic, permanent bright pink color universally associated with cooked ham and bacon³².

Toxicological Control: Mitigating Nitrosamine

Synthesis

Despite its absolute indispensability for color, flavor, and the critical inhibition of *Clostridium botulinum*, the use of nitrites carries severe and heavily regulated toxicological parameters⁹¹.

High-Temperature Kinetics and Amine Reactions

In high-heat environments, residual nitrites can react violently with the secondary and tertiary amines present in degrading muscle proteins to synthesize *N*-nitrosamines (e.g., *N*-nitrosopyrrolidine and *N*-nitrosodimethylamine)⁹¹. Nitrosamines are heavily documented, potent human carcinogens⁹¹. Because pork belly bacon is routinely subjected to

high-temperature pan-frying—frequently reaching 190°C to 200°C —it represents the highest risk vector for nitrosamine formation among all commercial meat products⁹⁵.

The Biochemical Role of Sodium Ascorbate and Erythorbate

To chemically blockade this carcinogenic reaction, global regulatory agencies (such as the USDA FSIS) strictly cap the ingoing sodium nitrite levels for pumped bacon at a maximum of 120 ppm⁹⁴. More critically, commercial processors are legally mandated to incorporate exactly 550 ppm of sodium ascorbate or sodium erythorbate (stereoisomers of Vitamin C) directly into the curing brine⁹⁴.

Ascorbate acts as an exceptionally potent reducing agent. It forcefully and rapidly reduces the residual nitrite (specifically via the intermediate N_2O_3) directly into nitric oxide (NO) before the meat is ever subjected to thermal frying¹⁰⁰. By totally exhausting the available nitrite reservoir within the cold cellular matrix, ascorbates entirely strip the nitrosation pathway of its primary reactant. This effectively suppresses the synthesis of carcinogenic nitrosamines when the bacon is later subjected to extreme thermal loads in the consumer's skillet, ensuring the safety of the final product⁹⁴.

Conclusion

The successful execution of salt-cured pork is an intricate dance of applied physiology, thermodynamics, and biomolecular chemistry. It begins with the precise anatomical deconstruction of the porcine carcass, identifying cuts where the lipid-to-lean ratios are uniquely optimized for moisture retention and flavor development. The belly, with its alternating strata of *M. rectus abdominis* and highly stable subcutaneous fat layers, reigns supreme for bacon and pancetta. The monolithic, highly saturated lipid architecture of the fatback and jowl yields exceptional lardo and guanciale, while the pristine, lean structure of the *Longissimus dorsi* provides the ideal canvas for equilibrium-brined Kassler.

Ultimately, however, anatomical selection is entirely reliant on the mastery of the underlying biochemical variables. Producers must actively monitor the structural integrity of the fat by controlling Iodine Values starting at the nutritional phase. They must manipulate thermodynamic variables to preserve the dermal collagen during scalding, calculate precise diffusion kinetics to lower water activity effectively, and expertly balance the microbial reduction of nitrates against the dual threats of lipid autoxidation and nitrosamine generation. It is only through the absolute, uncompromising synthesis of these disciplines that the pork industry continues to safely and consistently produce the world's most highly sought-after cured meats.

Works cited

1. 52 Swine Slaughter and Processing Steps.pdf
2. Cut of pork - Wikipedia, https://en.wikipedia.org/wiki/Cut_of_pork
3. Temperature-dependent properties of fat in adipose tissue from pork, <https://pubmed.ncbi.nlm.nih.gov/35698889/>

4. The Impact of Added Diet Fat on Carcass Fat Quality | The Pig Site,
<https://www.thepigsite.com/articles/the-impact-of-added-diet-fat-on-carcass-fat-quality>
5. Dietary lipid sources on the fatty acid profile of swine fat: a review,
<https://www.scielo.br/j/cr/a/hSLCGwgRSFJz4nGr4LpMH3L/?lang=en>
6. (PDF) Fatty Acids Profile of the Subcutaneous Backfat Layers from,
https://www.researchgate.net/publication/220036714_Fatty_Acids_Profile_of_the_Subcutaneous_Backfat_Layers_from_Iberian_Pigs_Raised_Under_Free-range_Conditions
7. Comparison of the lipid content and fatty acid composition ... - PubMed,
<https://pubmed.ncbi.nlm.nih.gov/22064191/>
8. FATTY ACID COMPOSITION OF DIFFERENT ADIPOSE TISSUES IN,
<https://www.itjfs.com/index.php/ijfs/article/view/676>
9. Relationship Between Backfat Depth and its Individual Layers and,
<https://dr.lib.iastate.edu/bitstreams/3562c83f-4bc0-4379-88d3-42c3541f2251/download>
10. Fatty acid profile of the backfat layers in four pig breeds,
<https://www.ijfsab.com/index.php/fsab/article/view/66>
11. (PDF) Pig adipose tissue of two different breeds and locations,
https://www.researchgate.net/publication/364405957_Pig_adipose_tissue_of_two_different_breeds_and_locations_morphology_and_Raman_studies
12. Comparative Transcriptomic Profiles of Differentiated Adipocytes,
<https://pmc.ncbi.nlm.nih.gov/articles/PMC8834144/>
13. Using clean label, natural antioxidants to prevent lipid oxidation in,
<https://dr.lib.iastate.edu/bitstreams/eb98bd99-14d8-4074-8a2b-f00e13926dd1/download>
14. Iodine Value and its Impact on Pork Quality | The Pig Site,
<https://www.thepigsite.com/articles/iodine-value-and-its-impact-on-pork-quality>
15. LSDDG | PDF | Pork | Fat - Scribd,
<https://www.scribd.com/document/1028829320/lsddg>
16. Fat Hardness in Swine Products, Dietary Challenges and,
<https://www.cabidigitallibrary.org/doi/pdf/10.5555/20143091289>
17. Quantifying the influence of iodine value on pork quality,
<https://ttu-ir.tdl.org/items/04567982-072d-430a-b281-1eba0c7e9bc2>
18. Equations generated to predict iodine value of pork carcass back,
<https://www.asi.k-state.edu/extension/swine/peer-review-publications-pdfs/2015/Paulk%20Equations%20generated%20to%20predict%20iodine%20value.pdf>
19. Evaluating the ability to measure pork fat quality for the production of,
<https://pubmed.ncbi.nlm.nih.gov/23507493/>
20. Composition and value of belly primal - Pork Information Gateway,
<https://porkgateway.org/resource/composition-and-value-of-belly-primal/>
21. (PDF) Use of Iodine Value to Predict Commercial Slicing Yield and,
https://www.researchgate.net/publication/340151269_Use_of_Iodine_Value_to_Predict_Commercial_Slicing_Yield_and_Shelf-Life_of_Bacon
22. Visual, Sensory, and Oxidative Stability of Bacon Manufactured from,

- <https://www.iastatedigitalpress.com/mmb/article/id/24727/download/pdf/>
23. Relationship between porcine carcass grades and estimated traits,
https://www.ejast.org/archive/view_article?doi=10.5187/jast.2021.e133
 24. Can In-Line Iodine Value Predictions (NitFom TM) Be Used for Early,
<https://www.mdpi.com/2304-8158/11/2/148>
 25. THE STUDY OF THERMAL DENATURATION OF BEEF, PORK,
<https://www.meatjournal.ru/jour/article/view/120>
 26. Crude Fat Analysis from Some Meat Products by Differential,
https://ijiaar.penpublishing.net/makale_indir/666
 27. Influence of collagen denaturation on the chemorheological,
<https://pubmed.ncbi.nlm.nih.gov/7115770/>
 28. THE STUDY OF THERMAL DENATURATION OF BEEF, PORK,
<https://www.meatjournal.ru/jour/article/download/120/188>
 29. Determination of melting point of vegetable oils and fats by,
<https://grasasyaceites.revistas.csic.es/index.php/grasasyaceites/article/download/630/641/641>
 30. Comparative Study of Porcine Mesenchymal Stem Cells Behavior,
<https://repo.uni-hannover.de/bitstreams/842f5d70-54df-4c63-85b1-40118b1f1661/download>
 31. Diffusion of curing salts in meat: effect of sodium chloride on tissue,
https://www.researchgate.net/publication/283814632_Diffusion_of_curing_salts_in_meat_effect_of_sodium_chloride_on_tissue_microstructure
 32. Clean Label Meat Technology: Pre-Converted Nitrite as a Natural,
<https://pmc.ncbi.nlm.nih.gov/articles/PMC8115001/>
 33. Schweinefleisch Teilstücke: Der komplette Guide für Kenner,
<https://natuerlich-boehm.de/schweinefleisch-teilstuecke-butchers-cut/>
 34. Schweinefleisch Cuts - Die wichtigsten Teilstücke vom Schwein,
<https://www.grillfuerst.de/magazin/fleischguide/schwein/>
 35. Pork wholesale nomenclature - 400 series - Canada.ca,
<https://inspection.canada.ca/en/food-labels/labelling/industry/meat-and-poultry-products/wholesale-meat/pork>
 36. Primal Cuts of Pork: A Butcher's Complete Guide to Every Section,
<https://butchershandbook.com/guides/primal-cuts-of-pork/>
 37. Pork Carcass Fabrication: Primal and Retail Cuts - SDSU Extension,
<https://extension.sdstate.edu/pork-carcass-fabrication-primal-and-retail-cuts>
 38. Subprimal Descriptions - Porcine Myology, <https://porcine.unl.edu/subprimals>
 39. Institutional Meat Purchase Specifications,
<https://www.ams.usda.gov/grades-standards/imps>
 40. INSTITUTIONAL MEAT PURCHASE SPECIFICATIONS - USDA,
<https://www.ams.usda.gov/sites/default/files/media/IMPS500SeriesDraft2020.pdf>
 41. Pork – Meat cuts manual - inspection.canada.ca,
<https://inspection.canada.ca/en/food-labels/labelling/industry/meat-and-poultry-products/meat-cuts/pork>
 42. Meat Cuts and Carcass Breakdown - The Curesmith,
<https://www.thecuresmith.com/codex/meat-cuts-and-carcass-breakdown/>

43. 6.1: Primal And Subprimal Cuts of Pork - Workforce LibreTexts,
[https://workforce.libretexts.org/Bookshelves/Food_Production_Service_and_Culinary_Arts/Meat_Identification_and_Fabrication_\(Welsch_and_Thibodeaux\)/06%3APork_Identification_and_Fabrication/6.01%3A_Primal_And_Subprimal_Cuts_of_Pork](https://workforce.libretexts.org/Bookshelves/Food_Production_Service_and_Culinary_Arts/Meat_Identification_and_Fabrication_(Welsch_and_Thibodeaux)/06%3APork_Identification_and_Fabrication/6.01%3A_Primal_And_Subprimal_Cuts_of_Pork)
44. Teilstücke des Schweinefleischs - Wikipedia,
https://de.wikipedia.org/wiki/Teilst%C3%BCcke_des_Schweinefleischs
45. The Different Cuts of Pork | S. Clyde Weaver,
<https://sclydeweaver.com/blog/the-different-cuts-of-pork/>
46. Review: Pork belly quality, bacon properties and recent consumer,
<https://cdnsiencepub.com/doi/10.4141/cjas-2014-121>
47. All Wholesale Beef and Pork Cuts - Meat Read, <https://meatread.com/learn/cuts>
48. Mechanical properties of type I and type IIB single porcine muscle,
https://www.researchgate.net/publication/51776658_Mechanical_properties_of_type_I_and_type_IIB_single_porcine_muscle_fibers
49. Changes in Biceps femoris Transcriptome along Growth in Iberian,
<https://www.mdpi.com/2076-2615/11/12/3505>
50. Diffusion of NaCl in meat studied by ¹H and ²³Na magnetic,
https://www.researchgate.net/publication/229399895_Diffusion_of_NaCl_in_meat_studied_by_1H_and_23Na_magnetic_resonance_imaging
51. Recipe: How to Make Pancetta Arrotoleta - Our Daily Brine,
<https://ourdailybrine.com/how-to-make-rolled-pancetta-recipe/>
52. Meat quality characteristics of pork bellies in relation to fat level - PMC,
<https://pmc.ncbi.nlm.nih.gov/articles/PMC8495343/>
53. How to Cure Bacon - Taste of Artisan,
<https://tasteofartisan.com/how-to-cure-bacon/>
54. Pancetta Tesa Vs Arrotoleta Drying Calculator - True Nature Meats,
<https://www.truenaturemeats.com/pages/pancetta-tesa-vs-arrotoleta-drying-calculator>
55. chemical and fatty acid composition of poultry meat and pork fatback,
https://www.researchgate.net/publication/353363304_CHEMICAL_AND_FATTY_ACID_COMPOSITION_OF_POULTRY_MEAT_AND_PORK_FATBACK_AS_A_RAW_MATERIAL_FOR_THE_PRODUCTION_OF_FRANKFURTERS
56. Total Fat and Water Content and Fatty Acid Composition in Pork,
https://www.researchgate.net/figure/Total-Fat-and-Water-Content-and-Fatty-Acid-Composition-in-Pork-Back-Fat-and-Mechanically_tbl1_8074115
57. Dry Salting for Salo and Pork: Step-by-Step Curing Guide,
<https://www.kelownapicklesmoke.ca/smoked-meat/dry-salting-for-salo-and-pork.php>
58. Cured Pork Fat (Salo) - GastroSenses,
<https://www.gastrosenses.com/blog/cured-pork-fat-salo/>
59. Elucidating the interplay between lipases and lipid metabolites,
https://www.sciopen.com/local/article_pdf/10.26599/FSAP.2025.9240137.pdf
60. Techniques - Pancetta/Guanciale | Page 4 - Kitchen Knife Forums,
<https://www.kitchenknifeforums.com/threads/pancetta-guanciale.64366/page-4>

61. Kassler | Traditional Pork Dish From Germany - TasteAtlas, <https://www.tasteatlas.com/kassler>
62. Kassler - Wikipedia, <https://en.wikipedia.org/wiki/Kassler>
63. What is Kassler? One of the must-try foods in Germany | FoodMap, <https://www.foodmap.in/germany/kassler>
64. What is Kasseler Rippchen?, <https://orlandogermanclub.com/what-is-kasseler-rippchen/>
65. Sodium Chloride Diffusion in Low-Acid Foods during Thermal, <https://wpcdn.web.wsu.edu/wp-labs/uploads/sites/1254/2016/09/Tang260.pdf>
66. Investigation of Salt and Water Diffusion During Dry Salting, Wet, <https://www.mdpi.com/2076-3417/15/11/5939>
67. The diffusion of salt in pork muscle and fat tissue - PubMed, <https://pubmed.ncbi.nlm.nih.gov/5934934/>
68. Na-23-MRI quantification of sodium and water mobility in pork, https://www.researchgate.net/publication/51777319_Na-23-MRI_quantification_of_sodium_and_water_mobility_in_pork_during_brine_curing
69. Chloride Salt Diffusion in Wet Salting Pork with NaCl-Substitute Salts, <https://pmc.ncbi.nlm.nih.gov/articles/PMC13114307/>
70. 4.1. WATER ACTIVITY, <https://www.tdx.cat/bitstream/10803/6675/24/24AwResultats.PDF>
71. Meat Curing Calculator for Curing Meat, <https://eatecuredmeat.com/calculator/meat-curing-salt-calculator/>
72. Bacon Equilibrium Curing Calculator - Eat Cured Meat, <https://eatecuredmeat.com/bacon-curing-calculator/>
73. 38. Curing Pork Belly for BACON! Recipe and instructions - YouTube, <https://www.youtube.com/watch?v=okWgNgJWPHM>
74. Water Activity & Its Impact on Pork & Perishable Foods, <https://www.apexinstrument.me/understanding-water-activity-and-its-impact-on-perishable-foods-especially-pork-meat/>
75. Curing and diffusion coefficient study in pastirma, a Turkish, https://www.academia.edu/90113944/Curing_and_diffusion_coefficient_study_in_past%C4%B1rma_a_Turkish_traditional_meat_product
76. Role of meat and meat products in human nutrition, <https://www.fao.org/4/t0562e/T0562E04.htm>
77. Water Activity and Moisture Sorption Isotherms - Earthworm Express, <https://earthwormexpress.com/the-meat-factory/microbiology/water-activity/>
78. Water Activity Prediction and Moisture Sorption Isotherms, https://www.researchgate.net/publication/341430477_Water_Activity_Prediction_and_Moisture_Sorption_Isotherms
79. Nitrate reductase activity of Staphylococcus carnosus affecting the, https://www.researchgate.net/publication/301742845_Nitrate_reductase_activity_of_Staphylococcus_carnosus_affecting_the_color_formation_in_cured_raw_ham
80. Obtaining nitrite from vegetables sources by fermentative process, <https://www.redalyc.org/journal/496/49662789033/html/>
81. Evidence for Nitric Oxide Synthase Activity in Staphylococcus,

- <https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2017.00598/full>
82. Process-driven bacterial community dynamics are key to cured meat, https://www.researchgate.net/publication/273911731_Process-driven_bacterial_community_dynamics_are_key_to_cured_meat_colour_formation_by_coagulase-negative_staphylococci_via_nitrate_reductase_or_nitric_oxide_synthase_activities
 83. Analysis of Lipolysis and Oxidation Ability of Fermentation Strains in, <https://www.sciopen.com/article/10.3864/j.issn.0578-1752.2022.09.013>
 84. An Investigation of Volatile Flavor Compounds and Lipolysis ... - PMC, <https://pmc.ncbi.nlm.nih.gov/articles/PMC11395480/>
 85. A Comprehensive Review on Lipid Oxidation in Meat and ... - PMC, <https://pmc.ncbi.nlm.nih.gov/articles/PMC6827023/>
 86. Predictive modelling of TBARS changes in the intramuscular lipid, <https://pmc.ncbi.nlm.nih.gov/articles/PMC9046486/>
 87. (PDF) Analysis of the Early Stages of Lipid Oxidation in Freeze, https://www.researchgate.net/publication/8074115_Analysis_of_the_Early_Stages_of_Lipid_Oxidation_in_Freeze-Stored_Pork_Back_Fat_and_Mechanically_Recovered_Poultry_Meat
 88. Effect of drying processes on the occurrence of lipid oxidation ... - PMC, <https://pmc.ncbi.nlm.nih.gov/articles/PMC9922132/>
 89. Influence of iodine value and packaging type on shelf life of HRI, <https://porkcheckoff.org/research/influence-of-iodine-value-and-packaging-type-on-shelf-life-of-hri-packaged-bacon-slices/>
 90. Understanding the Cured Meat reaction | The National Provisioner, <https://www.provisioneronline.com/articles/91144-understanding-the-cured-meat-reaction-1>
 91. N-Nitrosamines in Meat Products: Formation, Detection and ... - MDPI, <https://www.mdpi.com/2227-9717/13/5/1555>
 92. What's in My Food? Bacon Edition | Product Development, <https://sciencemeetsfood.org/whats-in-my-food-bacon/>
 93. How Cured Meat Achieves its Pink Color: The Science Behind It, <https://agriculture.institute/processed-meat-technology/cured-meat-pink-color-science/>
 94. Bacon and Food Safety, <https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/meat-catfish/bacon-and-food-safety>
 95. Also next paper: Summary of recent research in nitrosamine research, https://digicomst.ie/wp-content/uploads/2020/05/1975_00_10.pdf
 96. The Low Risk of Nitrosamine and Amine Formation in Bacon, <https://earthwormexpress.com/about-meat-curing/the-low-risk-of-nitrosamine-and-amine-formation-in-bacon/>
 97. Nitrosamines in Bacon - CDC Stacks, https://stacks.cdc.gov/view/cdc/66116/cdc_66116_DS1.pdf
 98. Bacon Curing Methods | Nitrites, Brines & "Natural" Labels, <https://resources.tierraverdefarms.com/blog/for-the-love-of-bacon-part-2/>

99. Food Safety and Inspection Service, USDA § 424.22 - GovInfo,
<https://www.govinfo.gov/content/pkg/CFR-2020-title9-vol2/pdf/CFR-2020-title9-vol2-sec424-22.pdf>
100. Use of ascorbic acid to inhibit nitrosation: kinetic and mass transfer,
<https://pubmed.ncbi.nlm.nih.gov/3345578/>
101. Nitrosamine formation mechanism from Nitrates and Amines,
<https://resolvemass.ca/nitrosamine-formation-mechanism-from-nitrates-and-amines/>
102. how can ascorbic acid help mitigate nitrosamine risk in drug products?,
<https://www.dsm-firmenich.com/en/businesses/health-nutrition-care/news/talking-nutrition/how-ascorbic-acid-helps-mitigate-nitrosamine-risk-in-drug-products.html>
103. N-nitrosamines in processed meat products,
<https://www.food.dtu.dk/english/-/media/16484c92e45b40c7928499f222a0b752.pdf>