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BACON
101



BACON TECHNOLOGY JOURNAL

A supplement to The National Provisioner

BACON TECHNOLOGY 101

Creating bacon from pork bellies is an old story that has evolved into a modern rendition, thanks to the evolution of food science and equipment automation.

A NATIONAL PROVISIONER RESEARCH PROJECT
BY BARBARA YOUNG, EDITOR-IN-CHIEF
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PART ONE: OVERVIEW

Bacon has given birth to the development of sophisticated technology featuring such innovations as high-speed, high-volume slicing equipment, curing and injection systems, smokehouses, chilling and packaging improvements.

Current capabilities concerning slicing equipment, for example, include advanced computer and vision technology enabling the bacon industry to view and measure a cross section of a slab of bacon to produce a more accurate and efficient slice. An additional benefit is the machine's ability to produce greater volumes of more accurate slices to a closer tolerance with consistent thicknesses. Such systems also ensure a reduction in front-end trim waste, less butt-end waste and the elimination of poorly produced thick and thin slices.

To be sure, technology is a key driver behind efficiency and growth in the food-production realm.

The National Provisioner is producing a series of technology journals covering various aspects of the processing side of the industry. These in-depth reports delve into the science and technology that support the business foundation of meat- and poultry-processing programs.

This Bacon Journal is the first in the series. It is a study of the science behind bacon production along

with the invaluable tools that have evolved over the years. As a source guide, the bacon technology journal is designed to assist bacon processors maximize their production potential, especially with tips concerning best practices from their industry counterparts.

Bacon primer

Human consumption of pork including cured meat, meaning primarily a salted product, reportedly began centuries ago in England, France and Germany with bacon as the favorite, especially among the working classes of those early days. Bacon's historical connection as a staple food is understandable since pigs were cheap and easy to breed, given that their diets included virtually anything.

Broadly defined, bacon refers to a category of cured and processed pork bellies that end up in strips or else formed into circular patterns. Bacon varieties include middle bacon or rashers in the familiar shape of a thin strip of belly pork with a lean round piece of loin at one end. Streaky bacon is the same cut, minus the round loin end. Pork pressed into a pseudo-bacon shape is known as picnic or café bacon. Gammon is a specialty of the United Kingdom that is a joint of

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pork, not the belly, and is cured and prepared in the same manner as regular bacon. Bacon grease, the fat rendered from cooked bacon, is a useful byproduct as a cooking oil, particularly in the southern United States. Cracklings, also popular in the South, is produced from diced and fried bits of bacon rind. Canned bacon is precooked, needs no refrigeration and is popular with campers. Bacon bits are crisp pieces of bacon that are preserved and dried, and must be refrigerated. Vegetable-based imitation “bacon-flavored” bits, may be stored at room temperature.

Roger Mandigo, professor of meat science at the University of Nebraska in Lincoln, identifies two kinds of systems for producing bacon in the United States — dry cure or pickle cure. A mixture of curing ingredients is rubbed on all surfaces of the green bellies to produce the dry-cure effect. Most commercially processed bacon is pickle-cured, which involves injected bellies with a brine solution made up of salt and water.

“These two systems go back hundreds of years,” Mandigo confirms.

USDA generally defines bacon as the cured belly of a swine carcass. Certain cuts and characteristics are more narrowly defined, however, such as smoked pork loin bacon. USDA-certified bacon means that it has been treated for *Trichinella*

spiralis, a zoonotic agent. Zoonosis is a disease passed from animals to humans. *Trichinella spiralis* is an intestinal worm producing larvae that migrate to and encyst in muscles of a number of animals, particularly swine. Humans sicken from consuming infected pork that is undercooked. The culprit cysts then live in the muscles of the human hosts. Tapeworms and roundworms generally are readily destroyed at cooking temperature and time combinations less rigorous than the combinations

NATURAL BACON FORMULATION

Water	66.38%
Sea salt	22.00
Cane sugar	10.40
Celery powder	1.20
Starter culture	0.02

Source: The American Meat Science Association (AMSA) White Paper Series, Number 1, March, 2007, p. 10)

NATURAL BACON PROCESS

1. Trim pork bellies.
2. Prepare pickle prior to use.
3. Dissolve the following in water: sea salt, cane sugar, celery powder and starter culture.
4. Pump pork bellies to 115% of green weight.
5. Place the pumped pork bellies on bacon hooks and smokehouse process.
6. Chill and slice.

Source: The American Meat Science Association (AMSA) White Paper Series, Number 1, March, 2007, p. 10)

BACON PROCESS

1. Grade and sort - some grade manually and sort automatically by weight
2. Dump and convey bellies to injector
3. Some companies trim bellies
4. Mix pickle
5. Inject bellies
6. Check pump percentage
7. Hang on bacon combs important
8. Smoke
9. Chill
10. Slice
11. Package

Source: Robert J. Delmore Jr., Ph.D., Associate Professor, Animal Science Department, California Polytechnic State University, San Luis Obispo, Calif.

necessary to destroy pathogenic bacteria.

Bacon weight and yields are also governed by federal regulations. Weight of cured pork bellies labeled as “uncooked” must not exceed the weight of uncured pork bellies. For labeling purposes, cooked or precooked bacon produced from cured pork bellies must show a yield factor of not more than 40 percent the weight of uncured pork bellies. Translated this means a requirement of 60-percent shrinkage from the green weight or the initial pork belly weight.

Ed Woods, owner and operator of Woods’ Smoked Meats Inc., Bowling Green, Mo., discusses the uses of lightweight and heavyweight bacon in the following dialogue.

During 55 years as a smoked meats processor, Woods’ company has won numerous national and international awards for its branded Sweet Betsy from Pike products including its line of smoked cured bacon. Before owning his business, Woods headed the bacon department of the defunct Oklahoma City, Okla.-based Wilson Foods Corp. In those days lightweight bacon slabs were used for lean, premium-grade bacon, and cheaper grades were produced from heavier slabs, he reports. Pork processors operated with three grades of bacon in 1970: 10-14 pound-slabs comprised the top grade, 14-20 pounds represented the middle

grade and 20 pounds and above indicated the cheap grade.

“Hogs have changed over the years and are leaner than in the past, so standards have changed,” says Woods, noting that slabs can now be purchased derinded or with skins attached (see “Breeding quality pigs”).

Bacon history

The 17th century gave birth to the American pork

industry thanks to Hernando Cortez' introduction of hogs to New Mexico coupled with sows Sir Walter Raleigh brought to Jamestown Colony in 1607. As the 17th century closed, the typical farmer owned four or five pigs, supplying salt pork and bacon for his table with surpluses sold as barreled pork. Frank Preston Johnson of Kewanee, Ill., in Henry County and a state representative in his day, succeeded in winning approval for his hometown's designation as "Hog Capital of the World" in 1948. His argument included the fact that babies were weaned on bacon rind in a neighboring county and the daily breakfast of athletes in his hometown included "Henry County bacon."

In 1924, Oscar Mayer introduced the first packaged sliced bacon, for which it received a U.S. government patent. That innovation brought bacon out of the meat case where it was in the hands of butchers, who sliced and wrapped it for customers. The self-serve bacon package featured shingled slices wrapped in cellophane and placed in a cardboard frame.

The Romans recognized ham (perna) and shoulder bacon (petaso) as two separate meats, and devised different recipes for their preparation. Reportedly, both were to be first boiled with dried figs, but ham would then be baked in a flour paste, while bacon was to be browned and served with a wine and pepper sauce. Bacon fat or lard was a particular favorite among the Anglo-Saxons who used it for cooking and also as a dressing for vegetables.

Based on an Oxford University Press account, the word bacon dates back to prehistoric times when the Germanic base of bakkon originated. The English version is derived from bakko, the Old French word

TROUBLE-SHOOTING GUIDE

Smoking: Not usually a problem for companies with established processes but over- or under-smoking related to color can be an issue.

Dirty smoke house: Smokehouse must be cleaned regularly (depending on the plant and the system several times a week to weekly). This is important to avoid soot on the bacon.

Hanging: Bacon must be hung properly to maximize the slice yield.

Chilling: Bacon can be under-chilled and therefore very hard to slice and can be over-chilled and then shatter when sliced.

Leakers: Bacon can be a challenge to package due to leakers.

Metal from broken bacon combs: Part of the bacon comb can break off and, if not found manually or with metal detection, can cause serious problems with slicing.

Source: Robert J. Delmore Jr., Ph.D., Associate Professor, Animal Science Department, California Polytechnic State University, San Luis Obispo, Calif.

PRE-COOKED BACON

USDA defines pre-cooked bacon as having been cooked to a finished yield of 40 percent or less. When a 1-pound package of raw bacon is cooked to 0.4 pounds or less, it may be labeled as fully cooked bacon. Most pre-cooked bacon is considered shelf stable (may be stored safely at room temperature) because it is vacuum-sealed, has a high-brine concentration, and the water activity is low enough to prevent the outgrowth of pathogenic organisms.

GLOSSARY

Bacon: back and sides of a hog salted and dried or smoked; usually sliced thinly and fried

Cut of pork: cut of meat from a hog or pig

Side of bacon, fitch: salted and cured abdominal wall of a side of pork

Gammon: hind portion of a side of bacon

Bacon strip: a slice of bacon

Bacon rind: the rind of bacon

Canadian bacon: from a boned strip of cured loin

meaning ham. The modern French word for bacon means any cut of pork, usually salted. The French took their bacon seriously, to be sure.

Consider that Repas Baconique was a French festival at which pork was the exclusive menu item.

Notably, the English perfected the technique of salt curing and smoking belly pork. In 12th century England, bacon was used as a synonym for the native term fitch, meaning side of cured pig meat. By the 14th century, however, it applied to cured meat.

To be sure, preserved pork, including sides salted to make bacon, was an important source of food in the diets of early British citizens. British pigs for both fresh and salted meat improved significantly in the 18th century. The first large-scale bacon curing business was set up in the 1770s by John Harris in Wiltshire, which continues as the main bacon-producing area of Britain.

In northern England, thousands of families mostly ate bacon as their primary meat. Bacon or "pickled pork" gained favor in southern England. Some fitches of bacon were salted and then plain-dried. Meanwhile the best bacon was hung in the chimney breast to smoke. Sliced bacon collops were a special English cut of bacon that was fried with eggs. Most home-cured bacon was cooked into a pease or bean pottage.

Along with the introduction of the bacon-curing process, commercial bacon production reportedly started as early as 1770 in England. John Harris of Clane in Wiltshire, while watching pigs at rest during a break on their travel from Ireland to London, came up with the idea of curing them on the spot. Huge, fat pigs were bred to be killed at any time of year. The meat was cured quickly, which meant that it also tainted quickly. As the quality

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NATURAL BACON SMOKEHOUSE SCHEDULE

Dry Bulb (°F)	Wet bulb (°F)	RH (%)	Time (minutes)
110 (42°C)	92 (35°C)	70	75
145 (63°C)	—	—	60
145 (63°C)	—	—	15
134 (57°)	—	—	90
140 (60°C)	120 (49°C)	55	Core temperature 128°F (53°C) Estimated 180 minutes

Source: The American Meat Science Association (AMSA White Paper Series, Number 1, March, 2007, p. 10)

was poor, this bacon was sold immediately and cheaply in country markets to the impoverished class. In spite of this, William Ellis considered bacon a “serviceable, palatable, profitable, and clean meat, for ready use in a country house.”

Bacon could also be spiced. An 1864 recipe, in “The Art and Mystery of Curing, Preserving, and Potting all kinds of Meats, Game and Fish” suggested taking some pieces of pork “suitable for your salting tub,”

rubbing them well with warmed treacle, and adding salt, saltpeter, ground allspice, and pepper. They also were to be rubbed and turned every day for a week. The meat was then suspended in a current of air and later coated with bran or pollard and smoked.

The two large categories of bacon currently marketed in America, include minimally processed bacon stocked in stores primarily in 1-pound packages, and microwave bacon with a more extensive ingredient legend.

Noting that bacon now is a center-of-the-plate item, Mandigo traces its transformation from an accompaniment to eggs to an entrée.

“There is a significant shift in the way bacon is used,” he says. “It has changed from breakfast meat entrée to a condiment for almost anything — from toppings to an ingredient in casseroles and for sandwiches. Bacon is very different and we make different kinds of bacon for different applications, such as Arby’s pepper-coated bacon.” **NP**

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PART TWO: BACON PRODUCTION BASICS

Bacon is derived from hog flesh — especially the animal's sides, belly, or back. Meat from other animal species may also be cured or otherwise prepared to resemble bacon, such as chicken and turkey bacon. Beef bacon is also marketed, although to a lesser extent.

Notably, most cured-meat products are not necessarily also smoked and/or cooked, and more accurately should be included in a precise category of cured/and or smoked meats. Cured and smoked meat products are primarily made from the primal cuts of pork consisting mainly of ham and bacon.

Bacon refers to different cuts in different countries. In the United States it usually means the side between the fifth rib and the hipbone. In Europe, the word bacon generally refers to one half of a fattened pig. Bacon has one of the highest fat contents of any cut of meat. Fat gives bacon its sweet flavor and tender crispness, thus its proportion ideally should be $\frac{1}{2}$ to $\frac{2}{3}$ of the total weight. Sliced bacon generally has been trimmed of rind, sliced and packaged. It comes in thin slices (about 35 strips per pound), regular slices (16 to 20 per pound) or thick slices (12 to 16 per pound). Slab bacon comes in a chunk to be sliced and is less costly than pre-sliced bacon. Rinds usually remain intact on slabs, but are generally removed prior to slicing.

Chemistry of cured meat

Although bacon continues to be home cured in some rural communities, the bulk of its manufacture is in large industrial meat-processing plants equipped to slaughter, dress, cure, smoke, and sell on a large scale.

It is essential to note that differences exist between the way large and small bacon operations cure and

smoke hog bellies. Small processors rank among culinary artisans who prefer the dry-cure method that involves rubbing bacon slabs with a dry mixture of seasoning ingredients including salt and sugar.

Larger bacon manufacturers instead usually employ the injection technique involving penetrating slabs with a liquid brine mixture of salt, sugar and, perhaps liquid smoke for flavor. The ingredient recipe likely includes sodium phosphate for moisture retention during processing and cooking. Sodium ascorbate or sodium erythorbate is used to accelerate the curing process while also facilitating color retention. Curing salt, including sodium nitrite, inhibits bacteria, assists in setting flavor and acts as a color-enhancing agent.

Preserving meat using salt or curing techniques is the oldest known processing application. However, its historical origin is uncertain. History indicates that nitrate was determined a naturally occurring contaminant in salt, prompting chemists to isolate that compound and intentionally add it in the form of saltpeter (potassium nitrate). Chemists eventually recognized that nitrite (NO_2) and not nitrate (NO_3) was responsible for the beneficial color and flavor properties that enhance pork.

Nitrite

When nitrite (NO_2) is combined with meat, it eventually is reduced to nitric oxide (NO). Such reduction is often accelerated by the use of ascorbate or erythorbate. Nitrite is responsible for cured meat flavor characteristics. Flavor difference in part may be due to the suppression of lipid oxidation by nitrite. Other antioxidants, meanwhile, produce no cured meat flavor.

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OTHER BACON CATEGORIES

Beef bacon

Generally classified as breakfast bacon, beef bacon is made from boneless beef short plates, which are cured and processed much like pork bellies. Current beef bacon processors include the following:

Local Harvest, a CSA (Community Supported Agriculture) organization in Santa Cruz, Calif., offers hickory smoked grass-fed beef bacon, marketed as “smoked the old fashioned way in a real hickory smokehouse.” Ingredients include grass fed beef brisket, water, salt, honey and spices.

Monticello, Mo.-based U.S. Wellness Meats, markets beef bacon processed without adding sodium nitrite.

Porcino Foods Company, City of Industry, Calif., produces beef bacon “from trimmed domestic steer beef plates, cured and hickory smoked to produce a regular bacon flavor profile with 45-percent less fat than pork bacon.”

Canadian bacon

The boneless loin from large sows of a live weight of more than 360 pound is often cured and used as Canadian bacon. It is manufactured from the large muscle of pork loins, the strip or sirloin muscle. The extremely lean characteristic is accomplished by trimming most of the external fat and introducing minimum amounts of intramuscular fat. Stitch-pumped boneless loins spend two- to five-days in cover pickle to be washed in cold water after removal. The product next is stuffed into cellulosic casings or stockinettes. It is hung in a smokehouse and processed to an internal temperature of between 150°F and 155°F. Smokehouse schedules for Canadian bacon are similar to requirements for ham processing. Graduated or single-temperature schedules in either case are acceptable.

Jowl bacon

Considered a substitute of sorts for regular bacon, jowl bacon is fashioned from fresh, trimmed hog jowls using the same curing, cooking and smoking procedures for bacon made from bellies. Cuts range from 5-inch to 8-inch squares. Jowl bacon generally carries more fat.

USDA, which initially authorized the use of sodium nitrite in cured meat in 1925, continues to allow the restricted use of nitrite and sodium ascorbate or sodium erythorbate (isoascorbate) in bacon.

Addressing pumped bacon, meaning bacon injected with curing ingredients and massaged or tumbled, the regulation specifies the use of sodium nitrite at 120 parts per million (ppm) ingoing or an equivalent amount of potassium nitrite used at 148 ppm ingoing. Sodium ascorbate or sodium erythorbate (isoascorbate) “shall” be used at 550 ppm. The regulation notes that sodium ascorbate or sodium erythorbate carries a molecular weight of approximately 198. Hydrated forms of these substances should be adjusted to attain the equivalent of 550 ppm of sodium ascorbate or sodium erythorbate.

Since under certain conditions nitrite in cured meat product contribute to the formation of nitrosamines, a known carcinogenic, the USDA in-plant inspection system calls for pulling samples of pumped bacon. Such samples are analyzed to determine the level of nitrosamines using a Thermal Energy Analyzer (TEA). If TEA confirms a positive level of nitrosamines, additional samples are collected and subjected to analysis using gas chromatography. Presumptive positive must be confirmed by mass spectrometry before actually deemed positive. If any one of the original samples collected by USDA for confirmation is found to contain confirmable levels of nitrosamines, all pumped bacon in the producing establishment and all future production will be retained. USDA will then sample and analyze such retained pumped bacon for nitrosamines on a lot-by-lot basis.

According to the American Meat Science Association, even though nitrite is recognized as a potentially toxic compound, its controlled use in processed meats does not represent a toxicity risk under normal circumstances.

Processing methods

Bacon processors continuously seek ways to help improve product yield, which is accomplished through automation. New and innovative technology is a key driver in this regard. Today’s systems not only offer high efficiencies but also come in stand-alone machines or fully-integrated programs.

“To make high-quality retail bacon you need a belly injector, a smoke house, bacon press, slicer and a packaging machine,” summarizes Robert Delmore Jr., Ph.D. Delmore is an associate professor in the animal science department at California Polytechnic State

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University in San Luis Obispo. Although he offers this simple and direct answer to the question concerning what equipment is absolutely necessary to produce quality bacon, he knows that bacon equipment manufacturers must meet processors' demands for innovation and automation.

Consider vision technology that employs a high-speed camera to scan the face of the product before slicing. It not only measures the area to determine fat-to-lean ratio, but also makes adjustments to ensure the ideal thickness. A vision slicer can be integrated into automated lines handling fixed-weight retail and bulk packaging.

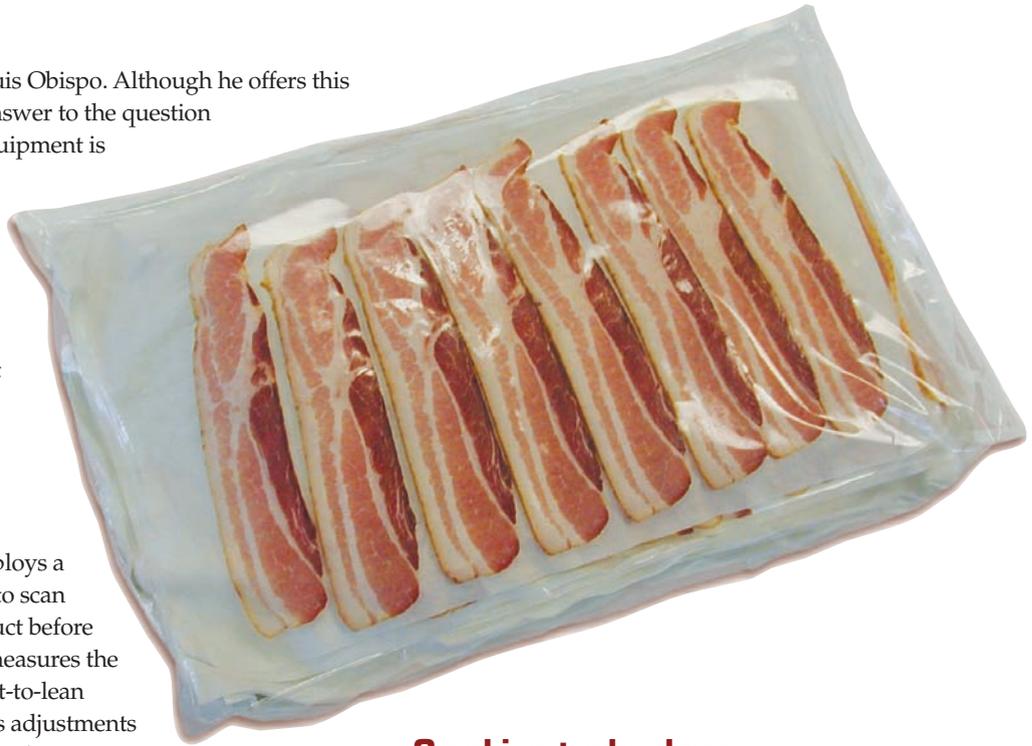
Natural and organic cured bacon: scientific and regulatory components

Bacon qualifying as natural and organic must conform to USDA regulations prohibiting the addition of nitrite or nitrate as ingredients.

"Natural and organic must carry the claim assuring no added nitrites, but in looks this bacon has the same color as [regular] cured bacon," offers Roger Mandigo, professor animal science, University of Nebraska. "In most cases, other ingredients are added to help it cure, such as vegetable powder, turbonado sugar and sea salt with small amounts of nitrite. The result is the cured color and eating texture [expected] of bacon."

Although "natural" and "organic" are separate and distinct categories, neither is allowed to be manufactured with added sodium (or potassium) nitrite or nitrate. Moreover, the definitions of natural and organic require that "Uncured" be included for products labeled with a standardized cured product name, such as bacon. Not all products labeled "Uncured" are natural or organic, however.

"Extensive new regulations are being worked through USDA now, so the whole discussion of natural and organic is best left alone until these new regulations are in place," Mandigo advises.



Smoking technology: from the smokehouse to the plant

Wood smoke has been used to preserve food while also providing flavor, aroma, and color, no doubt since the discovery of fire. For centuries, moreover, wood smoke has been used as an agent to treat products in traditional smokehouses. In the late 1800s, E. H. Wright, a Kansas City pharmacist, developed and patented a crude method for distilling vaporous smoke. He sold the "liquid smoke" to farmers through his apothecary and small brokers as a product for the home curing of hams and bacon, as well as a flavor ingredient for other food products. Smoked meat flavor comes from phenolic compounds in the vapor phase. The bactericidal benefit in smoking meat is due to the combined effects of heating, drying and the chemical components in smoke. Such smoke components as acetic acid, formaldehyde and creosote prevent microbial growth when present on the surface of the meat.

Smokehouse types include those with natural air circulation, air-conditioned or forced air and continuous. Cooking often is a simultaneous process when smoking meat. For best results, cooking requires careful control of the smoking and heating process to achieve high yields.

Liquid smoke is preferred by some processors due to some benefits not offered by wood smoke. The common preparation of liquid smoke involves using heat to break down complex chemical substances into

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simpler substances. The process begins as sawdust, is further dried and then burned in specifically designed rotary or multiple-hearth furnaces to control oxygen, moisture, time and temperature.

Bacon processing primer

Bacon slabs are cured using a salting or pickling mixture, and then dried with or without wood smoke. Traditionally, the process consisted of soaking the pork in brine or rubbing it in a salt mixture by hand, then smoking the sides in smoke from an open chimney — sometimes for three or four months. The smokehouse timetable is based on belly size, smokehouse air velocity, facility temperature and internal temperature. Ideal temperatures for smokehouses range between 115°F and 125°F. Smokehouse dampers are open during the drying process, which could last up to two hours. Dampers are closed in the second phase, of about two hours, and the temperature increased by 5°F-10°F.

The belly is prepared from the side after removal of the leg, shoulder, loin, fat back, and spareribs. All bones and cartilages should be excluded, as well as practically all leaf fat. The fat back should also be excluded by a straight cut not more than 1.5 inches (3.8 cm) from the outermost dorsal curvature of scribe line. The anterior (shoulder) and posterior (leg) ends of the belly must be reasonably straight and parallel. No side of the belly should be more than 2.0 inches (5.0 cm) longer than its opposing side. The width of the flank muscle (rectus abdominis) ideally should be at least 25 percent of the width of the belly on the leg end. The fat on the ventral side of the belly and adjacent to the flank should be trimmed to within 0.75 inches (19 mm) from the lean. The area ventral to the scribe line must be free

of scores and “snowballs” (exposed areas of fat) that measure 3.0 square inches.

Grading and preparation

In the absence of standardized regulatory quality grades for bacon, grading generally is done in-plant on the basis of green-belly weights. Heavier cured bellies result in fatter, less tender and darker colored bacon.

Bellies must be correctly graded by weight,” advises Robert J. Delmore Jr., Ph.D., an associate professor in the Animal Science Department of California Polytechnic State University. “We pump bellies at a fixed percentage and if the bellies are not sorted properly the pump percentage will be wrong.”

The belly comprises 9 percent of live weight and approximately 13 percent of the carcass weight. The initial preparation phase for bellies involves removing spareribs, a function of separation from the loin. The flank end is squared by cutting through the center of the length of the flank pocket. The flank side can be cut 1 inch longer than the loin side, due to differential shrinkage that impacts the smoking process in the rectus abdominis muscle — a long, flat muscle in the flank side of the belly. The loin side is trimmed. The teat line removal ensures that no rudimentary mammary glands remain in the bacon slab. Less expensive bacon, which is not trimmed as closely, contain “mammary seeds,” resulting in seedy bacon.

Breeding quality pigs

Today’s pigs are bred and fed for leaner meat than in past years. Consider that pigs averaged 2.86 inches of backfat compared with less than 0.75 inches currently. More than 70 percent of the pigs produced in

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the United States now are sold on a "carcass merit" pricing systems, whereby a portion of the price is determined by certain characteristics of the animal. Current systems pay premiums for pigs with low amounts of fat and high amounts of muscle. Producers and processors are currently engaged in research seeking advanced measurements systems that will allow premium payments for carcasses with better-flavored, juicier and more-tender meat.

One such research project by The National Pork Board (NPB) in conjunction with Iowa State University resulted in the availability of genetic markers significantly associated with growth, leanness and meat quality. In line with this breakthrough, the Iowa State University Research Foundation signed a licensing agreement with GeneSeek Inc. of Lincoln, Neb., which permits the use of DNA markers in four genes. The markers were tested and commercially validated by a large pig breeding company. Based on reports, the first gene marker controls growth and leanness, allowing producers and breeders to choose from a "fast" growth form of the gene or a "lean/efficient" growth form of the gene. Basically, the technology allows breeders and producers to develop the best multi-gene combination for their lines.

Final processing phase

Once bacon is cooked and smoked, it is chilled and the rind is removed if necessary. Slabs are held in tempering coolers to reduce the internal temperature of the bacon to 26°F-28°F prior to slicing. Benefits of this step allow bacon to retain its shape in a bacon press and to facilitate slicing. Chilled bacon slabs are pressed or blocked by placing them in a large forming machine that compresses the bacon to a relatively uniform width and thickness — an essential step to achieve worthwhile slicing yields.

Finally, bacon slabs are sliced on high-speed machines to be automatically shingled into select weight units. Thin-sliced bacon, also known as hotel or restaurant sliced, is

approximately ½ inches, regular ⅓ and thick about ⅜ inch. Shingled bacon is either vacuum packed or not, but vacuum packaging assures a longer shelf life. **NP**

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PART THREE: BACON PRODUCTION: BEST PRACTICES

The top three bacon plants in the U.S. process 35 percent of bellies in the nation, with Smithfield, Va.-based Smithfield Foods claiming the highest share of market at 17 percent. Its branded lines of pork products include naturally hickory smoked uncured bacon and microwave bacon, among a large quantity of other types. Smithfield companies that specialize in bacon production use a variety of ingredient formulations. Category leader Oscar Mayer has contributed to revolutionizing the bacon industry beginning with its introduction of packaged, sliced bacon in 1924. Another category leader, Hormel Foods began curing bacon in the early 1900s. Today its bacon featuring natural hardwood smoke is a consumer favorite. Hormel added bacon pieces to its bacon portfolio in 1978.

As bacon consumption continues to increase,

processors in this category also continue to capitalize on this marketplace opportunity with innovative approaches in style and substance. Production techniques are somewhat standard, however, whether for retail and foodservice products or cooked and precooked bacon. Moreover, processing equipment may be identical in large measure, but end-product variations exist in terms of research and development. To remain competitive, bacon manufacturers and their equipment supplier partners continue to press forward to bring distinction to products in this category.

To bring an inside view to the matter, seven progressive bacon processing manufacturers participated in the following discussion concerning their “best practices.” They include **Oscar Mayer**, **Coleman Natural Foods**, **Hatfield Quality Meats**, **Applegate Farms**, **Pederson’s Natural Farms**, **Kunzler & Co.** and **Leidy’s Inc.**

Oscar Mayer, Kraft Foods Inc., Madison, Wis.

BY BETH GOEDEL, SENIOR BRAND MANAGER

Products: Oscar Mayer is the bacon category leader, producing traditional, ready-to-serve, natural, Canadian, turkey and premium-flavored bacons.

Processing: To make bacon, you need the following: a method for curing, a device, such as a smokehouse, for converting the cured belly into a smoked bacon product; a device, such as a chill cell, for making the belly firm

and cold for slicing operations; and appropriate equipment to slice and package.

At the plant, we receive pork bellies that are skinless and trimmed to our exacting purchase specifications.

Once inside our facility, we cure, smoke, and chill the bellies to meet our stringent quality and food-safety specifications. After chilling bellies to a very cold temperature, we slice and package them to meet our customers' expectations.

Raw material: We have exacting purchase and production specifications that we rigorously uphold. Our raw material is held under very cold conditions to maintain quality. Specifics are proprietary. Suppliers must meet very rigid requirements before we will accept and use them. For example, the bellies must be skinless and trimmed to specific dimensions, as well as meet a number of specific quality specifications related to fat and lean prior to use.

Curing: Our curing processes are proprietary. Delivering a particular end product through processing is accomplished during our cure process, specifically with our formulations. For example, we use a maple flavoring for producing maple bacon and we use a mixture of salts for our low-sodium product.

Packaging: The ideal package is easy to open and close and keeps the last slice of bacon as fresh as the first. Our new *Oscar Mayer Stay Fresh Reclosable* bacon package is an example.



Food safety: We are always diligent about meeting the time and temperature requirements in our process as part of our food-safety program to deliver a safe product to our consumer.

Coleman Natural Foods LLC, Golden, Colo.

BY DEE MCLAUGHLIN, VICE PRESIDENT, PORK OPERATIONS, AND DENNIS STIFFLER, EXECUTIVE VICE PRESIDENT, FOOD SAFETY QUALITY MANAGEMENT

Products: All natural hickory bacon (perfect thickness and blend of hickory flavor and spices, with half the sodium of leading brands)

Overview: We produce branded premium bacon so it's important that flavor profiles perform; that we deliver on a clean label; that uniformity is there, along with a quality-management process and auditing of finished product. With our co-packer, we want to take advantage of innovative technology and their processes for efficiency, to control costs and ensure delivery of a high-quality product. It is all about tying to a "Never Ever" philosophy concerning no antibiotics, no added growth promotants and all-vegetarian fed.

It also means not using artificial preservatives and chemical curing aids with our bacon.

Packaging: From the retail perspective, a 16-ounce package is best to give consumers the ability to see the product. It also gives us a method to communicate our story from a brand perspective. Foodservice requires different packaging because it is a ready-to-cook and not a ready-to-eat-product.

Raw material: We're not about the process but starting with right type of raw materials. We spend a

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lot of time on the live side so we have the best genetics best in terms of matching our production system with genetics for high-quality uniform products.

Coleman has an exclusive arrangement to market a breed of animals called Hampshire, known for meat-quality characteristics. The old adage is true that not all bacon is created equal. Due to genetics, the bacon you get on sandwich at Wendy's is not same bacon or from the same process involved in a package of Coleman's natural bacon. Belly sizes within the industry are also different. As far as the process to differentiate ourselves, we go within the breed to pick highest quality animals. We designate subprimals for our further-processing program along with our "Never Ever" cured protocol for finished product whether bacon, ham or hot dogs.

Raw material specifications: In a typical plant no matter what size, bellies arrive sorted by size in 2-pound weight increments. Each increment may have a different application when it gets to consumer. Larger bellies by weight are used for foodservice or precooked

applications, smaller bellies for retail bacon. Inside the plant, bellies are segregated. Product is pumped and every brand has its own secret recipe, whether brown sugar or maple flavoring. USDA regulates how much products can be pumped.

Processing: Bellies are hung on a rack, and moved from the pumping area to a smokehouse. Bacon is not fully cooked, and only has to be cooked to an internal temperature of 135°F, that's where you get most differentiation. Some processors use liquid smoke by spraying the product to give it an atomized smoked flavor. Liquid smoke application is typically two-to-three hours less than the typical smoke cycle. Starting with smoke enables the flavor to set in bellies before raising the temperature. Finish with heat. Long smoke cycle produce darker mahogany color while lighter smoke delivers a lighter cherry color. Once the heat process ends, bacon bellies are chilled to 26°F-28°F, depending on finished product. Bellies are pressed because muscles contort when chilled, and pressing produces a nice rectangular shape that improves slicing

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BACON PRESSES

- High speed 16 cycles each minute – increases the capacity
- Large press chamber – no trim, eliminate waste
- Three dimensional pressing – exact shape, no trim
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- Auto in-feed and discharge – reduce labor, set the pace

yield. Bacon is either in bulk or net-weight sizes. Sliced bacon goes into packages of 12 ounces and 24 ounces or a 34-pound box. Making consistent bacon depends upon how well individual slices are sorted after slicing before packaging.

Food safety: From a shelf life and USDA regulatory standpoint the issues come down to whether your product is free of contamination. Is it in good microbiological condition not too old or with slime? What is the specification, and will your raw material allow you to generate that specification? That's the key. Center cut and ends of belly go into different products. So once you cook and press and slice, within each belly there is some sizing and sorting going on.

Hatfield Quality Meats Inc., Hatfield, Pa.

BY DENNIS BOWER

Products: Line includes a wide variety of traditional hardwood smoked bacon styles (retail

and foodservice applications) and the traditional 1-pound package in regular, thick sliced, reduced sodium and Applewood for retail. An 8-ounce unit and a 3-pound package target club stores. Seasoning bacon

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frozen block to separator



separator meat block



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using ends and pieces come in a 1-pound unit. Hatfield's focus is on branded sales, although private label represents a small part of the total business. Several traditional bacon styles target foodservice. Laid flat is the most popular and convenient style. Other offerings include hotel style (shingles) and sliced slab style. Multiple-slice-count options come in various styles.

Packaging: Hatfield uses the traditional L-board packaging format for retail. A convenient E-Z open feature with a corner tab opening adds value.

Hatfield's foodservice bacon packaging is all about fresh, thus it features controlled atmosphere packaging. ExtenServ packaging uses nitrogen to deliver a 120-day fresh shelf life.

Beyond the traditional retail and foodservice formats, Hatfield offers various bacon styles for business-to-business usage, including diced, strips and ground bacon. Consistent quality continues to be the expectation that many customers expect from *Hatfield* bacon. A unique "family recipe" flavor profile lasting for generations continues to be the preferred taste among discriminating consumers.

Processing: First steps involve cure making and the injection process. It is important to have the correct balance of ingredients, level, and temperature for a high-quality finished product.

Certain undesirable conditions could occur in bacon processing. Time and temperature are important factors in bacon processing. It begins with raw material age and temperature. There are also time-and-temperature relationships, which include the cure, smokehouse, chilling, and tempering."

Every piece of equipment is necessary to produce high-quality bacon. It would be quite difficult to produce high-quality bacon without all the equipment operating properly at each step throughout the system. That includes cure-making equipment, cure injectors, smokehouse, chilling coolers and slicing equipment.

Applegate Farms, Bridgewater, NJ

CHRISTOPHER ELY, CO-FOUNDER

Products: Traditional dry-cured pork bacon, Canadian-style bacon, Pancetta (Italian style) and turkey bacon (traditional-style bacon made with whole muscle thigh meat).

Processing: We start with pre-selected and closely trimmed bellies that will be either antibiotic free or organic. A minimal amount of a solution comprised of



water, salt and sugar is injected in the bellies. They rest for a period, then are hung and slowly smoked for at least eight hours. After smoking, the slabs again rest and equalize for a period before pressing and slicing.

Raw material: All incoming raw material undergoes a quality-control check to make sure the product is in spec. We use two types of specs for our bellies. A multi-point spec is for our regular bellies designated for traditional American-style bacons. A much tighter set of specs give us an extremely lean belly for our dry-cured Pancetta. In general, bacon is considered a raw product, hence the safe-handling instructions on every package of bacon. Regardless, we employ the same strict HACCP (Hazard Analysis and Critical Control Point) and sanitation standards with our bacons as we would with a ready-to-eat product.

Undesirable conditions to avoid:

- **Low-quality Raw material:** The quality of raw material is inextricably tied to the way an animal was raised. Animals reared humanely, with plenty of space and the ability to exercise their natural behaviors and instincts produce better quality meat than animals raised in stressful environments.
- **Incorrectly hung bellies:** Hanging bacon from the wrong end and/or not uniformly attaching it to the bacon comb during processing can lead to inconsistencies during processing that ultimately affect flavor.

- **Smoking:** Batch smokers produce a better-smoked flavor than the more commonly used conveyer belt smokers. The proper smoker is the most important piece of equipment in the production of bacon. However, the method and amount of time used during the smoking process is equally important. Our

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bacon is gently smoked for several hours in a batch smoker to provide a more complex flavor profile.

• **Curing:** Our bacon-curing ingredients include only salt, sugar, celery juice and starter cultures. This process is more complex than conventional-curing methods and therefore requires more management and a high-skill level to ensure that a product is correctly cured. Another difference between natural and conventional curing processes is the time it takes to produce a product like bacon. Bellies arrive in the morning and ship out as bacon in the evening at some commercial bacon operations. In contrast, our bacon takes more than a week to produce to achieve a fully developed product flavor. Thus, it is not surprising to us when customers describe our bacon as having an “old-fashioned” flavor, since they are describing a flavor that is the result of a more slowed-down process.

Packaging: There is no question that the typical-style bacon board and vacuum packaging are the most widely used. They are the highest consumer accepted packaging for bacon. When done right, the presentation on the shelf can be very good. However, I would argue that for specialized bacons such as high-end, dry-cured smoked bacons and Italian-style Pancetta, a MAP (Modified Atmosphere Packaging) pack not only gives a better presentation, but also provides the consumer with a better-tasting product than a vacuum pack.

Pederson's Natural Farms, Hamilton, Texas

BY CHAD ONDRUSEK, PLANT MANAGER

Products: Primarily natural bacon approved for sale at Whole Foods and Wild Oats (uncured pork and turkey bacon) retail food stores. Some Canadian bacon, but 98 percent involves traditional bacon.

Processing: Our process is a little different, as most places inject the belly and we vacuum tumble ours. We restrict the ingredients we use. We get better pickup and distribution of solution through the tumbling process. After that, the process is the same. Temperature control is the biggest factor after the cooking process, which means making sure the temperature is correct. The proper temperature also is critical concerning preparing product for consistent slicing and consistent yields.

Packaging: The 12-ounce retail packaging on an outboard (laminated cardboard) is ideal. When bacon comes out of the slicer, it goes on an outboard and we fit that inside a plastic film and package it around that. A machine does the work.

Curing: We use different ingredients, no nitrites or phosphates, sea salts are common with natural bacon.

Slicing depends upon customer specifications. We supply several private-label customers according to customized specifications. We have our own spec for our branded line. We often run 12-ounce packages, and a lot of regular commodity bacon in 1-pound packages, or greater.

Kunzler & Co. Inc., Lancaster, Pa.

BY RON FINK, VICE PRESIDENT, OPERATIONS

Products include traditional hardwood smoked bacons (retail and foodservice); vacuum packages in both L-Board (12-ounce, 1-pound, 1.25-pound, 1.5-pound and 2.5-pound) and tux carton; and sliced-slab-style packages (retail); vacuum and non-vacuum sliced slab product in 5- and 10-pound packages (foodservice package); a value-added Quick and Easy™ line of individually sliced product laid-out on bacon paper (foodservice).

We offer our unique traditionally hardwood smoked bacon in all of these categories. We also produce low-sodium honey, maple, and five pepper product lines.

Processing: Bacon processing begins with a synchronous supply chain schedule developed with a seven-to-10-day operations scope.

Traditionally bacon processing includes a belly injector (pump), combs and carts, smokehouses, chilling coolers, a belly press, and slicing/packaging lines.

We feel our bacon processing plant is ideal for each of these categories, as we have invested in and positioned capacity appropriately. We have attentively invested in each category over the past several years creating a unique line of retail and foodservice packaging configurations. We've always put significant importance of the entire planning process as the critical path to desired results. Establishing an inventory plan and delivering predicted service levels, prescribes the entire supply-chain plan by igniting the delivery of bellies for the throughput process.

This mentality somewhat rigidly allocates all classes of resources to specifically planned production runs resulting in meeting the end-in-mind inventory position. All of this aside, the first step to execute perfectly, upon belly delivery, is establishing a synchronous flow diagram (or plan) guaranteeing the time/temperature sensitivity of bacon processing will be met through each processing step.



We procure bellies skinned and trimmed to meet our finished products specification; the delivery of the bellies triggers the throughput process based upon planned finished goods inventory positions. Bellies also are injected with pickle, combed and hung for the cooking phase. We cook/smoke our bellies with real hardwood smoke in 10,000-pound batch houses. Smoked bellies chill in batch tempering cells, systemically reducing the belly temperatures from our targeted cooking temperature to our desired chilled temperature over a time/temperature, stepped-down cycle lasting upwards of 36 hours. Although we can bring the temperature down to our ideal temperature faster, we need the additional time to allow the bellies to equilibrate™ providing our maximum slicing and yield performance. The bellies are pressed according to specifications designed to meet finished product standards. They remain in a cooler and maintained at a specific temperature.

Temperature deviations from specification are a major concern in our process. We strive to maintain and measure temperature consistency ensuring

desired results.

Finally, the prepared bellies go to specific slicing and packaging lines to build the planned inventory. Ultimately, the throughput process serves as our function of maximizing product yield, while providing maximum economic utility of the purchased bellies. We do change our pressing specifications based upon finished good specs, but our value stream remains consistent.

Packaging: Maintaining specific time and temperature relationships throughout the production cycle is critical in building safety into our products and processes. Further diligent maintenance of flexible packaging lines ensure product integrity and consumer protection. We are extremely successful in managing made-to-order, made-to-stock, and contract packaging relationships encompassing a wide array of slice specifications.

Leidy's Inc., Souderton, Pa.

BY TERRY LEIDY, VICE PRESIDENT OF PURCHASING

Products: We produce retail and foodservice

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bacon. We only produce traditional bacon. When you get into smaller operations like us, our niche is more toward making better bacon. Besides the eyes, taste buds and aroma have a lot to do with it. We do things differently because we seek a different niche of business.

Products of distinction: We have to cook bacon to a finished product. There is precooked bacon on the market, but we don't do that. We make natural-cured bacon, which is antibiotic free. No added nitrates, sea salt is used instead to cure bacon. Other than that, the process is almost the same. Concerning the slicing, consumers want a number of slices per pound.

Raw materials are not all the same. Its origin is important, as pork bellies are different, although a natural part of the hog. The way the hog is reared, fed and its genetic ancestry affect the pork belly quality. Once slaughtered, the animal goes to a processing facility where primal cuts are separated. About 90 percent of bacon produced has the rind or skin removed. After that, the belly is trimmed to specification in preparation of the curing process. Bellies are hung up or combed (one end of belly is hung from trees that go into smoking process) before heading to the smoking cycle. The chilling or cooling process is next, followed by the forming or pressing done by equipment that squares the belly. The bellies end up on the slicing line, and finally the packaging section.

Processing: Bacon looks and sounds simple to

make, but it is not as simple as one might think. For one thing, leanness of belly or fat ratio makes a difference. Some bacon looks leaner than others, that has to do with the natural composition of bacon, using up-to-date equipment, the injecting or curing process. It is important that each belly is uniformly cured, that flavors are uniform and the proper process for cooking or smoking product in an oven is precise. Some don't use smoke or else use very little, others use it in the curing process depending on flavor and type of bacon produced. The first step involves making sure raw material is received at the proper temperature in line with a HACCP program. Weight classification of bellies need to be confirmed as well as the trim and techniques in belly processing. A small amount of dry-cured bacon is produced in the country — it is very rare and you don't see much of it because naturally absorbs salt and flavors but is hard to control and therefore narrowly used.

After [traditional] bacon is injected or cured, there is a dwell time. We like to see it have time to absorb flavors, almost like aging beef, for about 24 hours. Then it goes into the heat-processing stage. Some manufacturers inject it, hang it and smoke it within hours. We feel dwell time helps enhance flavors, like in wine.

Packaging: For household use, ideally it is a vacuum pack with a long shelf life. For foodservice, atmosphere packed bacon or bulk pack is best, differences are in the size of the package. **NP**