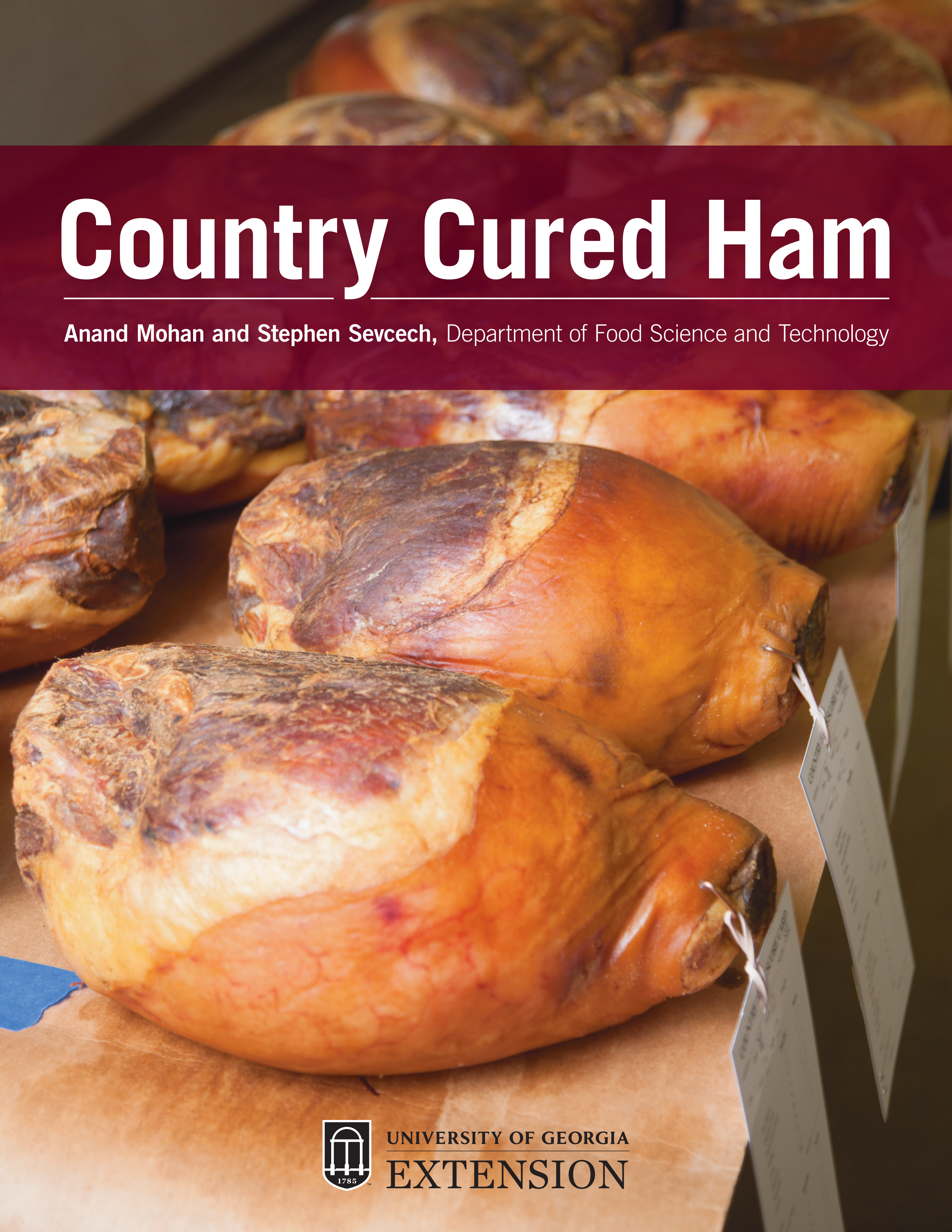
Country Cured Ham

Anand Mohan and Stephen Sevcech, Department of Food Science and Technology



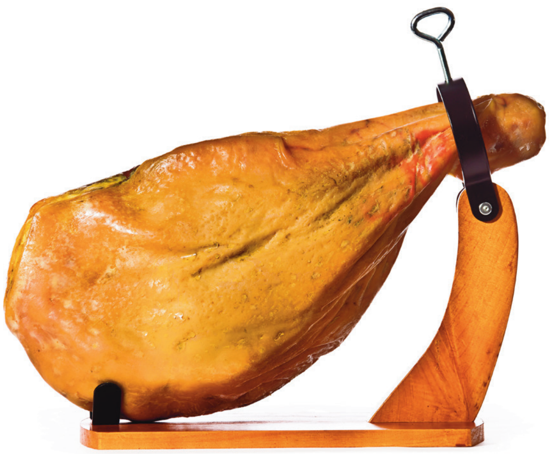
UNIVERSITY OF GEORGIA
EXTENSION

Introduction

Although humans have raised animals for food for centuries, there were limited preservation techniques before the modern era of technology. Most methods involved salting, sawdust, fermentation, or other methods. One common method was dry curing with or without cold smoking. Dry curing used the natural environment and salt to allow for long-term storage of the carcasses. The process of dry curing hams originated in Asia and then moved to Europe, where different groups created slightly different methods to process cured meat. Each region now has a distinct method to produce cured hams.

It is illegal to sell uninspected home cured hams.

The curing process creates a unique cured flavor using intentional mold growth, and this cured flavor now represents a niche market in that has led to more modern advancements in dry curing. The creation of refrigeration and the development of nitrates revolutionized curing meat so that it is now safe and effectively produced year-round and widely considered delicious.



History

Dry aging ham processes originated throughout Asia and Europe. These types of dry aged hams include China's Jinhua and Yunnan hams, Italian prosciutto, Spanish Serrano and Iberian hams, and German Black Forest ham (8). Pigs were originally introduced to the U.S. by Hernando de Soto when he landed in Florida (7). The pigs left in Florida learned to live and thrive in the environment, and later pigs became a common food source for the early colonialist.

The later coined "country cured" hams came about when Europeans settled in Virginia with imported pigs or possibly native pigs. The country curing process came about when the new settlers combined the German, Spanish, and Italian methods of dry curing. Today, country cured hams are primarily produced in Kentucky, Tennessee, North Carolina, and Virginia (7) with brands such as Smithfield, Johnston County Hams, Browning's Country Cured Ham, Benton's Hams, and many others.

Production

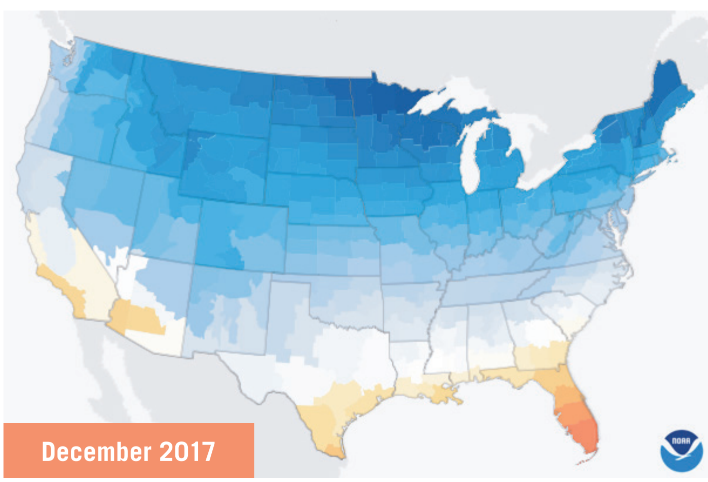
Curing country hams in natural or artificial storehouse environments

Before the curing process, secure a properly sealed building that can reach the correct temperatures required for dry curing hams. For production outside, the hams need to cure between December to February when the average daily temperature stays between 36 to 40 °F (2 to 4 °C) (1). Over 40 °F (4 °C) may result in excess mold or bacteria growth.

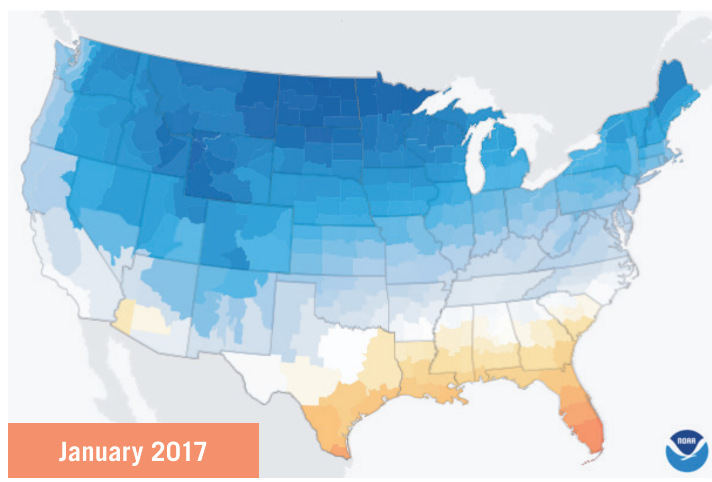
The hams will absorb the smells of the surrounding environment, so a sealed building keeps out undesirable flavors such as garbage (8). In addition to quality issues, any area with strong undesirable odors should be kept away from the storehouse for sanitary purposes. The shelves used to store the ham should drain well and not have a strong odor. Pine, for example, may create an undesirable, bitter, sap flavor in the ham. Plastic or synthetic shelving is ideal as long as the shelves drain away fluids (3).

A controlled, refrigerated room with temperate and humidity control is used by producers interested in year-round production. This type of refrigerator room will maintain all of the control points more precisely, but temperatures and humidity should still be checked regularly. A refrigerated room also provides control not influenced by the weather and make it easier to fix problems with the ham if they arise (7). Either way, the two methods will result in quality hams if conditions are maintained at proper levels throughout the whole curing process.

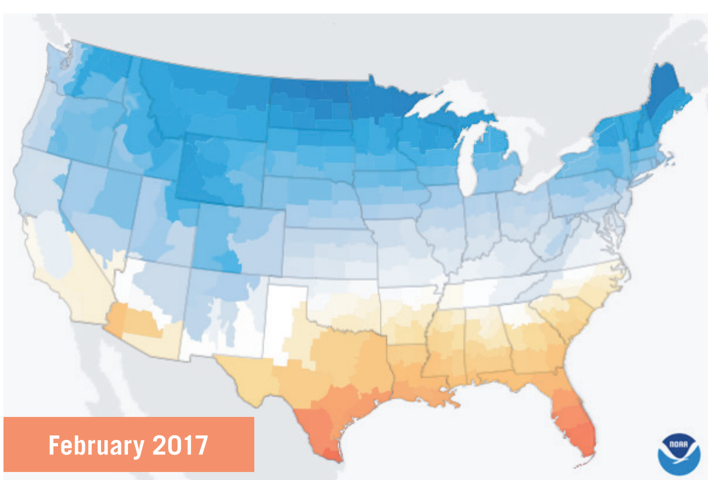
The images below show the average daily temperatures from the National Oceanic and Atmospheric Administration for December to February. The top left image depicts December 2017, the top right is January 2017, and the bottom is February 2017. **Any area above 36 to 40 °F during these months—Florida, for example—shouldn't produce country cured hams outside.**



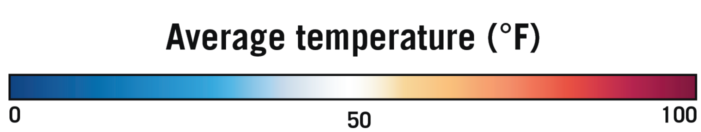
December 2017



January 2017



February 2017



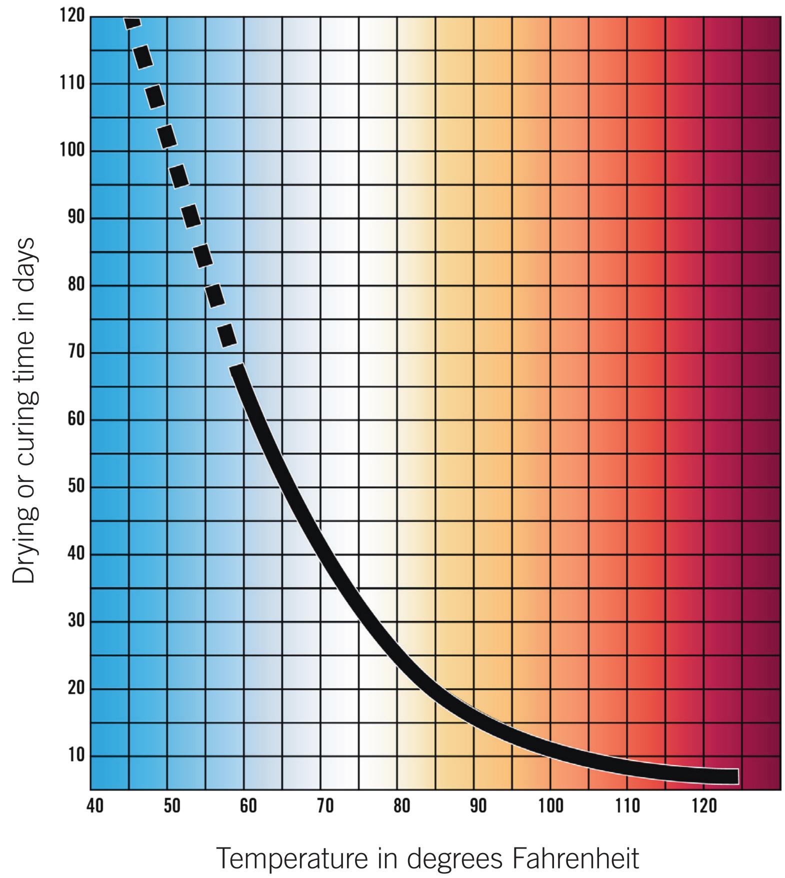
Temperatures between 36 and 40 °F are represented by the light blue sections.

Images retrieved from climate.gov

Hams cured under natural weather conditions should be cured for approximately six months. Hams cured under environmentally controlled conditions can be aged from three weeks to four months, depending on the aging temperature. Do not allow the internal temperature of the aging ham to exceed 95 °F because higher temperatures may cause many of the enzymes that cause aged flavors to be destroyed. During aging, a ham will lose 12-15% of its weight and take on a dark-colored appearance. When controlled conditions are not available, hams age best during the summer months as the inherent enzymes that produce the aged flavor are more active during increased temperatures.

According to state and federal meat inspection regulations, a procedure during aging is necessary for destruction of trichina, a parasitic nematode worm. The following chart is an indication of time-temperature relationships necessary for the destruction of trichina. Each procedure for trichina destruction must be approved by state or federal meat inspection personnel.

Suggested time-temperature requirement for control of trichina in country cured ham and shoulders



The internal temperature of a ham is usually 5 °F below the room temperature. The following is a time-temperature relationship that might be used to age hams.

Time-temperature relationship for aging hams		
Aging room temperature	**Approximate internal temperature of ham**	**Days of aging**
100 °F	95 °F	12-15 days
95 °F	90 °F	20-25 days
85 °F	80 °F	40-45 days
75 °F	70 °F	70-80 days

Curing methods

Uncured ham is referred to as “green ham” by the meat industry. Fresher green hams produce the best country cured hams, and a preferred ham is slaughtered within 24 to 36 hours of processing. The green ham should have the flank fat and excess skin removed before the curing process.

Preparing and applying the cure

Hams can be cured either by wrapping them in a waxless butcher paper layer and hung up (bagged) or by being placed in a well-draining box (boxed). Regardless of the method, the cure ratio is 4 kilograms (kg) of salt to 1 kg of sugar with some optional seasoning such as black or red pepper. Nitrates are not required to be added to the cure but are suggested to ensure that all pathogens are killed.

Nitrates or nitrites have a maximum limit of 200 parts per million (ppm) in finished whole meat products and 156 ppm for chopped meat (13). When adding nitrates, the largest permitted amount for dry-cured products is 3.5 ounces for 100 pounds of meat (4). Excess nitrates/nitrites result in the formation of a carcinogen. Celery powder or seed can be used as "natural" curing agent as well. This method allows the final product to be organic or to have a clean label.

An example of what a good ham should look like after removing the flank fat and skin.

Photo: Gregg Rentfrow, University of Kentucky

The mixture ratio for the ham is 1:10 (mixture to ham). This means a 100 kg ham gets a 10 kg rub, a 50 kg gets a 5 kg rub, and so on. The U.S. Department of Agriculture recommends that a 100 kg ham is covered with at least 6 kg of salt per 100 kg and "a salt box cure mixture contains at least 70% salt" (USDA FSIS 9 CFR 318.10) (7, 8).

Bag curing

For the bag curing method, all of the required mixture should be applied on the surface of the pig and in the hock (cut part of leg) before curing. Gently pull back the surface fat and apply some seasoning around the inside of the hock and all around the hock. Then, rub the whole ham with the mixture, focusing more of the mixture on the meat not coated in fat. Add enough water to the mix to make the mixture feel cool to ensure that the mixture absorbs into the ham. The mixture should slightly adhere together and clump up some. If water is not added to the cure mixture, wrap the ham and lay it out for 24 hours to make sure the cure mixture is absorbed. (8).

A ham completely coated with a cure mixture.

Photo: Gregg Rentfrow, University of Kentucky

Next, gently wrap the ham with unwaxed butcher paper to ensure that the cure mixture remains on the surface. Place the ham in a ham sock with the ham hock facing down, and hang up the ham. If water was not added to the mixture, lay the ham flat for 24 hours first (8). Cure the ham from 36 °F to 40 °F (2 °C to 4 °C). The USDA suggests a minimum of four days of curing per kg of ham with a minimum of 40 days or two days per pound (7) (USDA 9 CFR 318.10). Another source determines that curing should last at least 60 days or two days per pound. Anything less than the 40 days or 2 days per pound determined by the USDA could result in pathogen growth in ham and may make the consumer sick. Bag curing works better than box curing for ovular or larger hams (8).

Box curing

Box curing involves putting multiple hams in a well-draining box. This method is preferred by professional ham producers. After measuring the necessary amount of cure in the ratio mentioned earlier, one third of the cure will be applied to the hams with the same application technique mentioned for bag curing. Stack the hams in a box and rotate on a weekly basis. The other two-thirds of the cure mixture will be applied to the ham over two more weeks. One third will be applied on day seven and again on day 14, rotating the hams every time. The hams should still be cured from 36 °F to 40 °F (2 °C to 4 °C).

The cure penetrates the hams at about an inch per week, so longer times will be needed for thicker hams. Cure long enough that the thickest part of the ham is penetrated. Shortening the curing process could result in bacterial or parasite growth, so the time suggested should be considered the minimum requirement. After the hams have finished curing, suspend them in a ham sock with the ham hock downward (8).

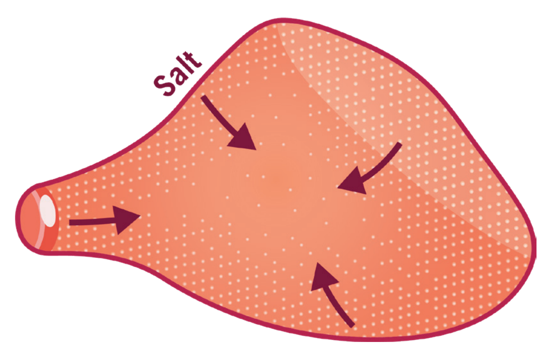
Salt equalization

Salt equalization occurs during springtime for people curing hams using storerooms. Salt equalization should be applied to the ham whether it's being box- or bag-cured. The temperature for the hams should be 50 °F to 60 °F (12.8 °C to 15.6 °C), and the ham should be shucked or removed from the old paper and sock. For the box method, there is no sock to remove. Remove excess cure from the ham. If desired, rinse and brush off the surface of the ham to ensure that the remaining salt equally absorbs in the ham. Then add the ham into a fresh ham sock and rehang for two days per kilogram of ham according to the USDA (USDA FSIS 9 CFR 318.10) (3, 7, 8).

Average curing time for country ham		
Weight of ham	**Approximate thickness of ham**	**Approximate curing time**
14-16 lb ham in cure	4-5 inches	28-35 days
18-20 lb ham in cure	5-6 inches	35-42 days
22-24 lb ham in cure	6-7 inches	42-49 days

The ham is finished after the salt content has reached 4% throughout the ham. This is the minimum percentage of salt required from the USDA for food safety. The salt percentage is not easy to measure at home, so strict adherence to at least the minimum requirements will allow at least 4% overall salt content. Additionally, the ham must lose 18% of its mass for the ham to be labeled "country ham." Further aging or smoking can reduce mass more, if needed. At around 4% salt most bacteria will die (3, 7, 8) and the ham is safe from most bacterial growth.

Legally, the ham can be sold or eaten at the end of this stage, but some producers still smoke or age the ham for further assurance of food safety or to add more flavor. Smoking helps to reduce the risk of pathogens that may have survived to this point. If you choose to sell the ham, you must get it inspected by the USDA, or legal or criminal action can be taken against you.



The rub penetrates the ham and equalizes at a minimum of 4% salt content.

Smoked hams (cold smoking)

Producers prefer cold smoking over aging for cured hams due to its flavor and shorter processing time. The exact temperature for cold smoking can vary, but ham should not be heated above 110 °F (43

°C) because high heat destroys the desired flavors and aromas. Smithfield Hams, for example, only uses smoke at 90 °F (32 °C) (3, 8). Hams only need to smoke for one to three days or until the outside turns a chestnut brown. Smoking not only provides flavor, but also kills *Trichinella spiralis*, a pork parasite (3, 7).

The wood chosen for smoking is very important, as soft woods with sap or tar such as pines or conifers give the meat a bitter taste. Hardwoods like oak or maple are the best choice of wood (3, 7, 8).

Unsmoked hams

Aging hams is the lesser use method of post-curing processing because the flavor is distasteful to the average "novice" ham eater. Aging normally occur in the summertime when temperatures reach above 75 °F (28 °C), with humidity below 65%, to achieve the desired slow mold growth on the surface of the ham. This mold on the ham provides a unique aged flavor and will be removed before consumption. The normal aging time varies from 1.5 months (45 days) to 6 months. The longer aging time creates a stronger aged flavor in the meat (3, 7, 8).

Storage

Finished hams can be stored without refrigeration due to the low water content (water activity) and high salt levels (8). Bacteria are unlikely to be able to grow on the surface of the ham, but rodents and possible insects could be an issue. Keep the hams stored in a location away from insects, rodents, or any other potential pests just like other dry foods.

Preparing and cooking

After almost a year of curing and aging, it is time to prepare and eat the country cured ham. A country ham doesn't require refrigeration because the 4% salt content creates an unlivable condition for most bacteria (8). Wash the ham to remove residual mold or salt remains on the surface (3, 7, 8). From here the ham can be cooked a few different ways.

Whole ham

Before baking or boiling the whole ham, the ham should be washed and soaked in water for eight to 12 hours prior to cooking. If desired, glaze the ham before cooking or covering. Cover the ham and bake it at 350 °F (177 °C) for 30 minutes with 1 to 2 inches of water in the pan. Reduce the heat to 300 °F (150 °C) for another 1.5 hours. Next, turn over the ham and cook for 1.5 hours until the internal temperature hit 140 °F (60 °C). Let the ham cool and slice the ham.

When boiling the ham, use the same eight- to 12-hour soak before cooking, submerge the ham in water, and bring it to a boil. Reduce the water to a simmer and cook for 20 minutes per pound. Let the water and ham cool to the touch before removing the ham from the pot. Once the ham is removed from the pot, slice the ham and serve (8).

Sliced ham

Country hams can be sliced and fried in a pan. Cut the slices about a quarter of an inch thick or ask a grocer willing to slice it. Trim off the skin of the ham, fry it with some fat for about 10 minutes, and enjoy. Gravy or seasoning can be added to the ham to preference (3).

A ham being aged and sweated.

Photo: Gregg Rentfrow, University of Kentucky

Quality attributes of dry-cured ham

Dry cured hams such as country cured hams, prosciutto, Jinhua ham, and Iberian hams use precise techniques to achieve specific quality attributes, like texture and flavor. These properties are controlled by the ham's composition, ingredient levels, and treatments.

Texture

Textural properties play an essential role during eating; we naturally notice textural qualities whether or not we think about them. Dry cured hams are nothing like conventionally cooked meat. A normal pork roast cooked on the grill or in an oven should be juicy with a balance of tough and tender to create the right amount of chewiness. This is largely due to water content and water activity (available water) in the meat.

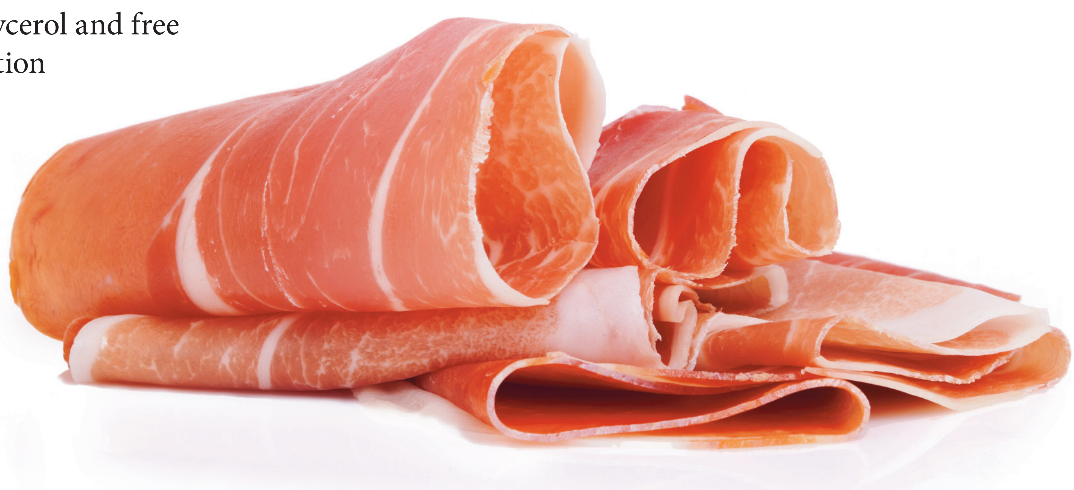
One experiment looked at how water content and water activity correlated to texture by testing six trials of dry cured ham by curing each set of two hams and monitoring the dryness at different times. The experiment showed that the water activity decreased as hardness and chewiness increased. Each trial showed that the drier products produced a harder and chewier final product (10). This means that meat dried or cured longer result in more water removal and significant textural changes. Depending on the consumers of the dry cured ham, some hams will be dried or aged longer to optimize hardness and chewiness. For that reason, producers control their processing methods precisely for texture.

Flavor

The aged flavor in cured meat makes it unique to other products. The flavor can be intensified by increasing the aging time. The aged flavor is caused by proteases and lipases, which are natural enzymes in the hams. Proteases and lipases break down the long chain protein and fat molecules into smaller chains, even down to single units (monomers). Of the many dry cured hams worldwide, country cured hams are aged the shortest. Processing time normally varies from 85 to 145 days with an average aging time of 30 to 90 days. Country cured hams are one of the few dry cured hams that use cold smoking as part of the curing process. Cold smoking provides a charred, smoky flavor and requires comparably less time (one to three days) (3, 7, 8). Other dry cured hams (prosciutto, Jinhua, Iberian) don't smoke the hams, but instead age the hams for long periods of time, starting at 155 days up to 330 days (11).

Proteins are broken up from full polypeptides (proteins) to smaller chains, tripeptides, dipeptides, and even free amino acids; some of the proteases include cathepsins, calpains, and aminopeptidases. The broken-down proteins may interact with other full or broken proteins and form new structures given the right conditions. Protein degradation is the main factor that contributes to the aged flavor.

Lipids are broken down in glycerol and free fatty acids; heavy fat degradation is not desired for flavor. Free fatty acids oxidize to create off-flavored compounds such as aldehydes, ketones, esters, and alcohols. Fortunately, muscle fat (marbling) is minimally degraded and excess outer fat is mostly trimmed off (11).



Steps to quality control

1. Use hams from meat-type hogs.
2. Chill hams to 40 °F, internal temperature.
3. Do not pump or stitch country cured hams.
4. Cure immediately after cutting.
5. Apply exact amount of cure and rub three times at proper intervals.
6. Cure according to size.
7. Keep temperature in curing 30 to 40 °F and **do not** stack hams over five high.
8. Remove excess cure after curing schedule is complete.
9. Allow for salt equalization.
10. Smoke at a low temperature and allow for air circulation of hams in aging room.
11. Do not put hams in air-tight bags.
12. Control humidity in aging rooms to reduce mold growth.
13. Age long enough for trichina control and for a cured color to develop.
14. Control for total shrink of no less than 18% from green weight.
15. Control insects, especially mites and skipper flies.
16. Sell a high-quality, good-flavored, neatly packaged ham.

Microbial validation

Microbial growth is a concern for food that's not heated to normal cooking temperatures, so country cured hams have been validated to show the log reductions of bacteria on inoculated hams. There are two different validations of inoculated fresh hams with *Salmonella* spp., *E. coli* O157:H7, *L. monocytogenes*, and staphylococcal enterotoxin. Each test has one trial with just salt and another with nitrates and salt. The test performed by Portocarrero also examined the effects of smoking versus an unsmoked process (4, 9).

Validation 1

Reynolds, Harrison, Rose-Morrow, and Lyon from the University of Georgia performed a validation where fresh hams were inoculated with *Salmonella* spp., *E. coli* O157:H7, *L. monocytogenes*, and *Staphylococcus* aureus processed as they would be commercially, based off of the bulletin "Curing Georgia Hams Country Style" written by Christian in 1982. Mix 1 sets received a cure of 3.36 kg salt, 454 g sugar, 14.2 g sodium nitrite, 56.7 g sodium nitrate and the cure mix 2 sets received 3.63 kg salt and 454 g sugar. The hams were tested on days 0, 49, 61, 69, 90, and 120. Two more sets were not inoculated controls and used with and without nitrates/nitrate.

Salmonella

Finished country cured hams were tested for *Salmonella* spp. For cure mix 1, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 3.03 ± 1.17, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively. The bacterial presence of the inoculated group with cure 1 on finished hams for days 0, 90, and 120 was 7.28 ± 1.28, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively (9).

Finished country cured hams were tested for *Salmonella* spp. For cure mix 2, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 3.18 ± 1.31, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively. The bacterial presence of the inoculated group with cure 2 on finished hams for days 0, 90, and 120 was 7.31 ±1.32, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively (9).

E. coli O157:H7

Finished country cured hams were tested for *E. coli* O157:H7. For cure mix 1, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 3.71 ± 1.20, 1.73 ± 0.00, < 1.57 ± 0.00 logs, respectively. The bacterial presence of the inoculated group with cure 1 on finished hams for days 0, 90, and 120 was 7.13 ± 0.87, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively (9).

Finished country cured hams were tested for *E. coli* O157:H7. For cure mix 2, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 3.84 ± 1.24, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively. The bacterial presence of the inoculated group with cure 2 on finished hams for days 0, 90, and 120 was 7.72 ±1.40, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively (9).

L. monocytogenes

Finished country cured hams were tested for *L. monocytogenes*. For cure mix 1, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 2.52 ± 1.33, 1.73 ± 0.00, < 1.57 ± 0.00 logs, respectively. The bacterial presence of the inoculated group with cure 1 on finished hams for days 0, 90, and 120 was 6.40 ± 1.18, 1.80 ± 0.53, and < 1.57 ± 0.00 logs, respectively (9).

Finished country cured hams were tested for *L. monocytogenes*. For cure mix 2, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 3.41 ± 1.63, < 1.57 ± 0.00, and < 1.57 ± 0.00 logs, respectively. The bacterial presence of the inoculated group with cure 2 on finished hams for days 0, 90, and 120 was 6.59 ±1.39, 1.75 ± 0.56, and 1.57 ± 0.00 logs, respectively (9).

Staphylococcus spp.

Finished country cured hams were tested for *Staphylococcus* spp. For cure mix 1, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 4.53 ± 1.20, 4.83 ± 2.43, 5.14 ± 1.77 logs, respectively. The bacterial presence of the inoculated group with cure 1 on finished hams for days 0, 90, and 120 was 6.55 ± 1.34, 4.91 ± 2.62, and 5.29 ± 1.65 logs, respectively (9).

Finished country cured hams were tested for *Staphylococcus* spp. For the cure mix, the bacterial presence on the finished, uninoculated ham for days 0, 90, and 120 was 4.84 ± 0.92, 5.41 ± 1.90, and 5.37 ± 1.61 logs, respectively. The bacterial presence of the inoculated group with cure 1 on finished hams for days 0, 90, and 120 was 6.81 ±1.95, 4.98 ± 2.25, and 5.52 ± 1.67 logs, respectively (9).

Validation 2

Another validation was performed on country cured hams by Portocarrero, Newman, and Mikel ,which tested the growth of *Salmonella* spp., *E. coli* O157:H7, and *L. monocytogenes*. This test used a trial with and without nitrates was well as with or without smoking. 348 hams were separated to each respective group including control groups and inoculated groups with or without nitrates and with or without smoking; triplicate trials were used for inoculated groups. The two rubs were composed of 7.5 g salt and 2.5 g sugar or 7.5 g salt, 2.5 g sugar and 0.28 g nitrite per kilogram of ham. The smoking process was applied for 8 hours to two groups after equalization. Dry curing occurred for 234 days.

Growth of bacteria wasn't tested until day 66. The data was inputted as positive growth of the three trials done; the uninoculated group wasn't inputted because all positive growth came back negative for every trial.

L. monocytogenes

For *L. monocytogenes*, the bacteria had positive growth for 3/3 trials for all tests on day 66, 206, and 234 for salt cure, salt + NO2, smoked or not smoked (5).

Concerning the *L. monocytogenes*, the article says, "Following 45 d of curing, the population increased 1.5 logs, decreasing 3 to 5 logs during the equalization period for all treatments. The population of *L. monocytogenes* continued declining during the aging process and was undetected in any treatment by enumeration methods after 206 d. However, there was considerable variation between treatments during the aging period (Figure 2). The smoked treatments generally had a lower count than non-smoked. There were significant differences in population reduction between smoked and non-smoked for salt-cured hams during the first month of aging (P < 0.05). The authors also said, "Although the enrichment procedure on Day 234 was positive for all samples and treatments, the overall effect of the process was a >6-log reduction in *L. monocytogenes* (Table 2)."

Salmonella

For *Salmonella* spp. at day 66, the inoculated tests had positive growth for 3/3 trials for salt only, with positive growth for nonsmoked hams and 1/3 with positive growth for smoked hams. The inoculated salt + NO2 test showed 3/3 trials for positive growth without smoking and 1/3 for positive growth with smoking. At days 206 and 234, all trials, regardless of the treatment, had 0/3 positive growth (5).

Concerning *Salmonella*, the article says, "In our study, the population means were 7.06 and 7.16 log10 CFU/cm2 for salt and salt + NO2, respectively, immediately following inoculation. After 45 d of the curing process, the population mean decreased 4 and 3 log units, respectively, and more than two additional logs after 66 d of equalization, eventually reaching levels below the limit of detection after 94 d (Figure 3). At 122 d of the salt cure and 66 d of the salt + NO2 cure, neither inoculated nor control hams had positive growth following enrichment (Table 2). The country curing process was effective in reducing the *Salmonella* spp. population."

E. coli O157:H7

For *E. coli* O157:H7, the bacteria had positive growth for 0/3 trials for all tests on days 66, 206, and 234 for salt cure, salt + NO2, smoked or not smoked (5).

Concerning *E. coli* O157:H7, the article says, "There were no significant differences in *E. coli* O157:H7 population reduction throughout the process by either the cure treatment (data not showed) or by the smoke or nonsmoker process (P > 0.05). *E. coli* O157:H7 was not detected on intact hams prior to inoculation."

Prosciutto (Italy)

Dry cured hams originated in Asia and the process was brought to Europe before people settled in the Americas; these regions all contributed to the country ham curing process. Prosciutto is a dry cured ham that originated from Italy. Parma ham is a regional type of Italian prosciutto. This method of dry curing uses the same traditional methods used well before the modern era. For this reason, Parma ham and prosciutto require specific processing methods (1).

Prosciutto is made with the heavy pig species that were traditionally used. These pig species are large white, Landrace, or Donroc. Postmortem, the legs of the pigs are cured with just salt, and they get rubbed with salt twice in the aging process. The leg receives a metallic seal to mark the starting date of the curing. The first thin layer of salt is left on the leg for a week during refrigeration and then the ham is pulled out and washed. The leg is salted again and refrigerated for a period of 15 to 18 days (1).

Next, the legs are moved to a room to air dry until the 80th day. This room is maintained at low moisture levels at a temperature of about 70 °F (21 °C). The legs are moved from there to the final room, which is dark, 70 °F (21 °C), and low in moisture. The legs will hang for a minimum of 12 months, and prosciutto is not smoked or processed any further (1, 6).

To be called "Parma ham," the prosciutto must be certified raised and made specifically in the Parma region of Italy. Additionally, the pigs must be born in and fed food solely from the Parma region. Any processing not acceptable for Parma ham such as the addition of nitrates or nitrites changes the status of the Parma ham to prosciutto (1). A downgrade to prosciutto results in a lower sale price.

Parma ham is air drying in a climate controlled room.

Controlled mold growth on exposed cuts of Parma ham during dry aging.

Jinhua ham (China)

Jinhua ham originates from China, and its date of origin is unknown. One early account of producing these hams dates back to around 618-907 A.D. during the Tang Dynasty, while another story relates it to the South Song Dynasty in 1127-1279 A.D. Either way, these hams have a long history starting back from ancient China when dry curing was considered the best way to preserve meat. Jinhua hams are only produced by Jinhua masters who often apprentice for as long as 15 years. The hams are strictly produced in the mountainous Jinhua district and can also be referred to as "southern hams." The mountains have four different seasons that offer the perfect temperatures for each phase of production. The Jinhua hams are still traditionally produced with masterful precision.

The green hams are the pig's hind legs that have unbroken bones with good muscle, a thin layer of fat, and a thin layer of skin. The shank bone is left in the leg. The fat, tendon, and muscle membranes are removed and then the blood is squeezed out. Removing the blood controls the risk of spoilage. The optimal weight is between 5.5 to 7.5 kg after trimming. The hams are cooled out on bamboo mats or hung for 18 hours before processing.

The optimal conditions for salting are 5-10 °C with a relative humidity of 75-85%, so the process is carried out in winter when the weather is favorable. The specifics of Jinhua salting are kept secret, but it is understood that the applied salt is 7.5-8.5% of the total ham weight. The hams are salted five times: the first round is 15% of the salt, the second round is 40-50% of the salt, the third round is 25%, and the fourth and fifth rounds are 5-7%. Due to the secrecy of the processes, the times of applications are not clarified. The days for salting vary depending on ham size. Small hams (<5 kg) are cured for 25 days and large hams are cured for 35 days, but on average, hams are cured for 30 days. Nitrates are used on hams only when irregular weather creates potential problems. Hams are either hung or piled, but when piled, hams are flipped regularly for even salting.

Next the hams are soaked to remove excess salt or dirt from the surface. The soak time is determined by the water temperature and the ham's appearance but normally varies from four to six hours. Next, the hams are brushed off with a bamboo brush and soaked in fresh water for 16 to 18 more hours.

The hams are then hung in a room with sufficient air flow and sun exposure to be sun-dried for 15 days. The hams are cut to look like a bamboo leaf. Next, the hams are moved to a ripening room where the hams are layered three to four hams high on centipede gallows that separate each ham 5 cm apart. The room increases from 15- 37 °C with a relative humidity of 55-75%, and the hams stay here for six to eight months. The color of the mold is an indicator of the doneness; the gray and green molds with some yellow indicate perfect conditions. White molds indicate future spoilage either from high moisture or low salt. The hams are trimmed and reshaped in April and finished by August.

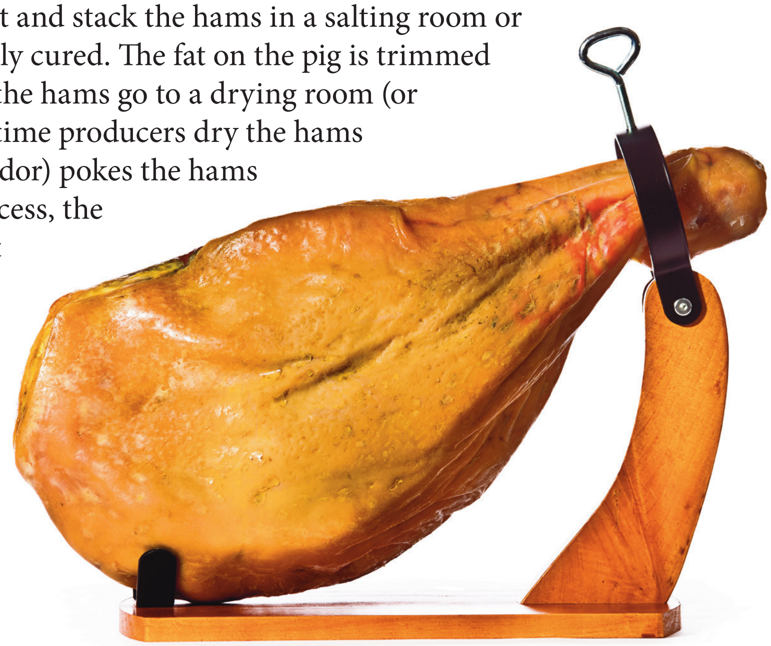
Postripening is optional and is designed to make the hams less dry. The hams are rubbed with vegetable oil and stacked skin-side up in a ripening room until acceptable.

Throughout the whole process, the hams lose 56-58% of total green ham weight and develop an intense flavor. The hams are graded by the government (normally other Jinhua masters) and prepared for sale. Stored under natural conditions, these hams last an optimal time of two to three years, or up to eight years at the longest (12).

Iberian ham (Spain)

Much like prosciutto, Iberian ham started after dry curing ham techniques were brought over from China. Iberian ham comes from Spain's Iberian Peninsula and is a smaller subsection of Serrano ham; Iberian ham compares to Serrano ham as Parma ham is to prosciutto. Iberian ham makes up 7% of Serrano hams and is produced in four mountainous regions of the country: Guijelo, Jabugo, Los Pedroches, and Extremadura. The pigs pasture graze on fields with dropped acorns. The acorns are like sweet candies to the pigs, and Spaniards attribute part of the flavor to the acorns.

After slaughter, producers cure the meat with sea salt and stack the hams in a salting room or saldadero. The hams are rotated frequently and evenly cured. The fat on the pig is trimmed to a perfect level to control the rate of curing. Next, the hams go to a drying room (or secadero) to hang for at least two years. Most of the time producers dry the hams for three to four years or until a trained nose (el calador) pokes the hams and smell for a specific scent. During the curing process, the storing rooms (bodegas) are kept slightly cool and at 55-65% relative humidity. These conditions are maintained by sprinkling water on the floor and having open windows for air flow (11).



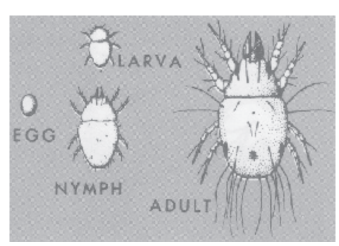
Overall, Iberian ham is treated using traditional methods without smoking or brining the meat—just natural sea salt. The exact specifics are not mentioned, but the end product is considered to be a valuable gem to Spain.

Pests

Pests often pose a problem during the aging period, when insects and rodents tend to get into storehouses and infest the hams. There are five main types of pests: ham mites, skippers (cheese skippers), larder beetles, red-legged ham beetles, and rodents (8).

Ham mites

Ham mites are hard to see and the most common kind of infestation. The mites cause a powder to develop on the surface of the ham. This powder is made up of the bug's waste, shedding, and dead bodies (1, 4). In the case of a bad infection, the ham will smell minty (8). The infected part of the ham can be trimmed off while the rest of ham continues to age.

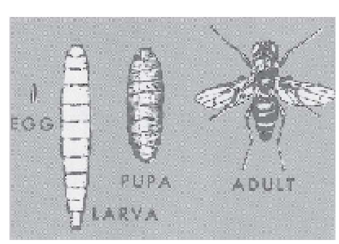


The ham mite's life cycle from egg to adult.

Photo: L. H. Townsend, University of Kentucky

Skippers or cheese skippers

Skippers are black with a bronze tint and red eyes, and they are smaller than house flies. They burrow in the ham and lay eggs. The larvae feed on the meat, and removing them is possible but difficult. A film will form on the meat and the whole ham must be thrown out. (3, 8).

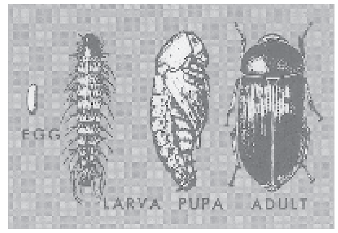


The skipper's life cycle from egg to adult.

Photo: L. H. Townsend, University of Kentucky

Larder beetles

These beetles have a dark brown/black exterior with tan or light-colored spots and dark spots on the wings. They feed just below the surface with only cosmetic damage; the damaged parts can be trimmed off and thrown away (3, 8).

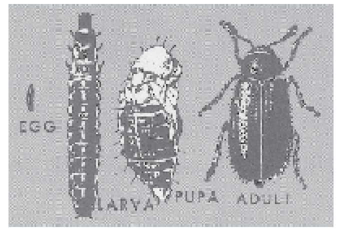


The life cycle of the larder beetles.

Photo: L. H. Townsend, University of Kentucky

Red-legged ham beetles

The larvae are purple with red legs and the adults are greenish-blue with red legs. These beetles are the rarest of pests, and they cause only cosmetic damage that can be trimmed off and thrown away (3, 8).



The picture shows the life cycle of the red-legged ham beetles.

Photo: L. H. Townsend, University of Kentucky

Rodents

Rodents eat ham just like any other food product. The best control is to lay traps and discourage living spaces around the storehouse (8).

Infestation prevention and control

The cold weather provides the best prevention since most insects will be inactive. A properly sealed and sprayed down room will help to keep out pests. Preventative spray should be sprayed without meat present (3). Some chemical sprays such methyl bromide and sulfuryl floride (profume) are allowed to be used on the ham if desired (8).

After an infestation, the bad meat should be moved to a separate location designated for infected meat removal (except for skipper infections). To protect the exposed area, cover it in normal cooking oil and wrap it in butcher paper. The exposed part of the meat may cause the ham to cure earlier than usual (3).

Conclusion

Dry curing meat started long ago in order to have meat year-round, and dry cured meats are still made to this day. Country cured hams can be produced at home, but the proper processing steps must be taken to create a safe product. The product can't be sold unless the USDA inspects and approves the ham. The hams must be cured with a 1 to 10 (cure to ham) ratio and have 4% salt with an 18% loss of weight to qualify as a country cured ham. The 4% salt content kills and restricts any bacterial growth in the ham. Further processing can include smoking or aging and the product is shelf stable at the end of the process. If these conditions are met, anybody can produce safe country cured hams at home.

Acknowledgements:

Thanks to Gregg Rentfrow and L. H. Townsend of the University of Kentucky for the some of the images provided in this bulletin. Thanks also to Joe Link at the John Deere *The Furrow* and *Homestead* magazines for providing the cover image.

References:

1. Directorate-General for Communication. Prosciutto di Parma PDO. European Commission. Retrieved from https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/eu-quality-food-and-drink/prosciutto-di-parma_en
2. Toldrá, F., & Flores, M. (1998). The Role of Muscle Proteases and Lipases in Flavor Development During the Processing of Dry-Cured Ham. Critical Reviews in Food Science and Nutrition, 38(4), 331–352. doi: 10.1080/10408699891274237
3. Graham, P. P., Marriott, N. G., & Kelly, R. (2012). Dry curing Virginia-style ham.
4. Pearson, A. M, & Gillett, T. A. (1996). Processed Meat – 3rd Edition, International Thomson Publishing, 56-59.
5. Portocarrero, S. M., Newman, M., Mikel, B. (2002). Reduction of L *monocytogenes*, *Salmonella* spp., and *E. coli* O157:H7 During Processing of Country-cured Hams. Journal of Food Science: Food Microbiology and Safety. 67(5), 1892-1898.
6. Puolanne, E. (1982). Dry cured hams—European style. Paper presented at the Proceedings of the Reciprocal Meat Conference.
7. Rentfrow, G., Chaplin, R., & Suman, S. P. (2012). Technology of dry-cured ham production: Science enhancing art. Animal Frontiers, 2(4), 26-31. doi:10.2527/af.2012-0059
8. Rentfrow, G., & Suman, S. (2014). How to Make a Country Ham, University of Kentucky
9. Reynolds, A. E, Harrison, M. A, Rose-Morrow, R., & Lyon, C.E., (2001). Validation of Dry Cured Ham Process for Control of Pathogens. Journal of Food Science: Food Microbiology and Safety. 66(9), 1373-1379.
10. Serra, X, Ruiz-Ramirez, J., Armau, J., & Gou, P. (2005). Texture parameters of dry-cured ham m. biceps femoris samples dried at different levels as a function of water activity and water content. Elsevier: Meat Science. 69, 249-254. doi:10.1016/j.meatsci.2004.07.004
11. Tannenbaum, K. (2018). Spain's Prized Ham: Jamón Ibérico. Institute of Culinary Education. Retrieved from https://www.ice.edu/blog/manuel-recio-jamon-iberico
12. Zhou, G.-H, Zhaot, G.-M, (2012). History and heritage of Jinhua ham. Animal Frontiers. 2(4), 62-67. doi:10.2527/af.2012-0063
13. U.S. Centers for Disease Control. (2016). Nitrate/Nitrite Toxicity, Agency for Toxic Substance and Disease Registry.

Additional reading:

9 CFR 318.10, Dry Cured Meats, https://food.unl.edu/documents/Trichinae%20Control%209%20CFR%20318.10.pdf

extension.uga.edu

Bulletin 1526 **March 2020**

Published by the University of Georgia in cooperation with Fort Valley State University, the U.S. Department of Agriculture, and counties of the state. For more information, contact your local UGA Cooperative Extension office.