

Dry Cured Hams — European Style

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Europe has very many widely differing cultures, whose development has been affected by a great number of different factors. One important factor, of course, is the climate, which varies considerably both in Europe and on the continent proper. Climatic conditions have also been responsible for shaping meat processing techniques in different parts of Europe; the dry curing of meat, for example, has been particularly widespread in the warm countries of southern Europe. The final product has been basically the same: the aim has been to produce a microbiologically safe and stable product that consumers can keep for long periods without cold storage. Because of the cultural and climatic differences mentioned above, the experience gained over centuries has led to the achievement of this aim using slightly different combinations of curing, temperature, time and smoking.

Principles used to achieve these various shelf-stable products are shown in Table 1. Such principles as (1) low initial temperature of meat; (2) using a dry mixture of nitrite/nitrate, salt and/or seasoning; (3) repeated application of this mixture over a period of time and; (4) drying or drying and smoking, are used.

Table 1. General principles for dry curing shelf-stable products (not refrigerated).

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- *Low initial temperature (32-40°F) of hams.
 - *Dry mixture of salt; salt and cure (NO₃); or salt, cure and seasoning.
 - *Multiple application of dry mixture.
 - *Air drying and/or smoking.
 - *Total process time varies from 2 mo. to 2 yrs.
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The large quantity of meat consumed today in the industrialized countries is due principally to the extremely rapid development of refrigeration techniques and distribution systems, which together ensure a plentiful supply of fresh meat and meat products throughout the year. The traditional methods used for the dry curing of meat, which often could only be used at certain times of the year, have been left behind

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Reciprocal Meat Conference Proceedings, Volume 35, 1982.

in the wake of this development, while very little has been done to develop local methods of preparing meat products. Nevertheless, there are still some consumers and indeed researchers who value this old tradition as a refreshing breeze from the roots of history. Although involving a great deal of work and expense, these old traditional products have a flavor and a general aura of enjoyment that is not to be found among today's hastily prepared mass-produced meat products.

My first example is presented in Table 2. Parma ham, which originated in Italy, required 1½ to 2 yrs. for the complete process. Rapid post-slaughter chilling to an internal temperature of 32°F is accomplished in two stages: (1) 12 hours at 32°F and, (2) 36 hours at 25°F. Sometimes rapid chilling during the second stage is accomplished at temperatures

Table 2. Method for producing Parma ham (origin, Italy).

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- *Post-slaughter chilling: 12 Hr. @ 32°F; 36 Hr. @ 25°F.
 - *Apply salt only, to meat at 32-38°F; hold for 16 Da; second application of salt for 13 Da @ 36-41°F.
 - *After 30 Da., air dry for 7 to 24 mo. in a dark room with low humidity and temperature of about 70°F.
 - *Parma ham is not smoked and is not cured with NO₂ or NO₃.
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Leistner, 1981.

lower than 25°F. Only salt, not nitrite or nitrate, is applied to the meat initially and again after 16 days of curing. After about 30 days, hams are removed and air dried in dark rooms with low humidity for 7 to 24 months. Since so much time is allowed for the initial curing of meat at low temperatures, there are no problems from PSE or DFD pork.

The quality of meat has also changed over the years, particularly the thickness of pork fat, which has decreased. In Spain, for example, pigs are reared separately for the preparation of dry cured ham. The animals are fed on chestnuts up to the age of two years, by which stage they have developed a thick layer of fat and the meat has its typical aroma. The hams are prepared by dry curing over a period of several months. Instead of smoking the hams, a covering of mold is allowed to develop on the surface.

In Table 3, Michalski et al (1974) describes an industrial process for production of the traditional German cold smoked ham (Katenschinken) as follows: Hams best suited for Katenschinken are selected to have initial pH values of less than 6.0. A firm outer layer of fat that is pinkish-white is desired. Residual blood in hams is further removed by bending or press-

Table 3. Methods for producing Katenschinken (origin, Germany).

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- *Select hams based on pH of < 6.0; firm fat layer.
 - *Remove free water and/or residual blood by pressing — bending.
 - *Apply dry mixture of salt, nitrate, sugar and seasoning by hand rubbing. Place hams in vats for 4 to 9 wks. @ 40°F.
 - *May use dry mixture of salt and nitrite curing salt (1:1 ratio). May also make multiple application of dry mixture during 4 to 9 wk. period.
 - *Remove from vats, brush off excess dry mixture. Place on shelves in 47°F room (low humidity) for 3 to 4 wks.
 - *Turn hams over on shelves, daily.
 - *Remove hams from shelves and wash in vat with slow continuous inlet of cold water for 36 to 48 hrs.
 - *Dry in air for 12 hr; rub with seasoning and smoke 3 to 5 hr/day for 4 to 6 wks.
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Michalski et al., 1974.

ing these cuts, manually. Mixtures of salt, nitrate alone or combinations of nitrate and nitrite, sugar and seasoning are applied by hand rubbing. After rubbing hams with curing mixtures, they are placed in vats at 40°F for 4 to 9 weeks. Repeated applications of this mixture are made during this 4 to 9 week period. Hams are removed from vats, excess dry curing mixture is removed by brushing and they are placed on shelves in a room with low humidity for 3 to 4 weeks. Hams are turned over daily while on shelves and during this “ripening” period the meat becomes firm and develops the desired flavor and aroma. Katenschinken is then washed for 36 to 48 hrs. using a slow continuous inlet of water. They are then hung to dry for 12 hrs. in a drying chamber and outer surfaces are rubbed with seasoning. Hams are then smoked for 3 to 5 hrs. per day for a total period of 4 to 6 weeks. These hams may contain 4 to 7% salt and benzopyrene contents are usually 0.1 ppb or less. The bacterial count is usually 10^4 to 10^6 cells/gram. Many dry cured hams today, in Germany, are produced by combinations of pickle injection and dry curing.

Wirth et al (1976) has reported data regarding the microbial safety precautions to use in preparation of dry cured ham. These are shown in Table 4. During smoking, product temperature should not exceed 64°F and the relative humidity should be about 80%. After smoking, product must be stored at

Table 4. Microbial considerations for dry curing smoking of hams.

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- *Product temperature < 64°F during smoking; relative humidity @ 80%.
 - *Storage after smoking: 46 to 54°F; R.H. 65 to 75%.
 - *Where allowed (not in Germany) can use potassium sorbate: 15% solution for dipping.
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Wirth et al., 1976.

temperatures of 46 to 54°F and at a relative humidity of about 65 to 75%. Too low relative humidity may cause a “drying ring” while too high relative humidity prevents sufficient drying and encourages undesirable growth of molds. Where allowed, hams can be dipped in a 15% solution of potassium sorbate to further inhibit mold growth. However, this practice is not allowed in Germany or in Finland.

Because some outbreaks of *Clostridium botulinum*, in Germany, have been associated with “Home Cured Ham,” Leistner (1981) recommended practices as shown in Table 5. Toxin can be formed in 11 days at 46°F. Rapid post-mortem chilling of hams to 39°F or below is suggested. Initial pH should be 5.8 or less and a maximum level of 600 mg/kg of

Table 5. Clostridium botulinum — dry cured hams.

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- *Toxin can be formed at 46°F in 11 Da.
 - *Use rapid post-mortem chilling to 39°F.
 - *pH of the meat for dry curing should be < 5.8.
 - *Maximum use of KNO_3 ; 660 mg/kg raw meat.
 - *Temperature during dry curing must be below 41°F until A_w of < 0.96 is reached.
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Leistner, 1981.

KNO_3 is recommended. During the curing process, temperatures must be kept below 46°F until the salt content is high enough for the water activity to reach values below 0.96. Removal of skin and fat, prior to applying cure mixtures, speeds up the rate of penetration and thus reduces the possibility of toxin formation. Additional instructions, via Leistner, stress the importance of good hygiene and rapid chilling at slaughter houses. When these practices are followed, hams can be stored at room temperatures without danger of botulin toxin formation. When these procedures are followed, the use of nitrate or nitrite is of no practical significance regarding toxin formation.

At this point, I would like to add some comments regarding improved hygiene and the use of nitrite in place of nitrate for dry cured products. These are shown in Table 6. Extreme hygienic conditions have contributed to a loss of traditional flavor and aroma in these products. This is probably so because the natural microflora is reduced via extreme hygiene and the use of nitrite, initially, appears to further decrease growth of desirable microflora associated with traditional flavor and aroma. The use of nitrite is difficult because it may

Table 6. Effects of new technologies on dry cured products.

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- *Extreme hygienic conditions — loss of traditional flavor and aroma.
 - *Initial application of nitrite further decreases growth of organisms associated with traditional flavor.
 - *Reduce levels of nitrite and/or use starter cultures.
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result in nitrite burn on the surface and nitrite does not diffuse easily into the inner parts of the ham. Nitrate, on the other hand, is reduced slowly to nitrite, at low temperatures (Puolanne, et al 1978) required for curing and surface "burn" is not apparent when nitrate is used. Work at our Institute (Petäjä and Niinivaara, 1973) suggest that starter cultures can be used to produce a desired flavor and aroma in such products when extreme hygienic conditions are used. We recommend the simultaneous use of 80 ppm nitrite/150 ppm nitrate with starter cultures for making dry cured hams. An industrial culture containing *Staphylococcus* sp. is available for this purpose.

At our institute, Petäjä and Niinivaara, (1973) and Petäjä et al (1975) have studied a modification of the traditional German method using starter cultures in dry curing hams. A summary of his studies is shown in Table 7. Hams are boned and chunked into 2 to 4 lb. pieces. These pieces are pumped with a 98° salometer pickle (8% of green wt.) containing 0.1% nitrite, 0.2% nitrate, 5.0% glucose and starter culture (to achieve 10 7/g in meat). The lactic acid bacteria that are important in the ripening of dry sausage are not quite so suitable for whole

Table 7. Modification of traditional dry curing method by pickle injection.*

*Bone ham, inject pieces of meat (2 to 4 lb.) with 98° salometer pickle containing 0.1% NaNO₂; 0.2% KNO₃; 5.0% glucose (dextrose) and starter culture.

*Culture organisms: *vibrio costicolus* and *staphylococcus* sp. (Not pathogenic): use 10⁷/g.

*Pump to 8.0% of green weight.

*After injection, rub with coarse salt: hold in vat for 1 to 2 Da. (α 36-39°F.

*Remove from vat, wash in cold water, dry and smoke in drying chamber for 7 Da. (α 68°F; R.H. of 90-95%.

*Vacuum package.

Properties of modified dry cured product*

*Total weight loss = 25%.

*Salt content of ham = 3.0%

*Flavor and aroma is excellent.

*Rapid distribution of curing ingredients and starter culture improves safety of product.

*Commercially used with reindeer meat, also.

Other modifications of traditional dry curing methods.

*Bone ham: select pieces, stuff in casing.

*Rub with dry curing mixture (salt, nitrite, nitrate, sugar seasoning). Multiple application during 3-4 wk. period.

*Place in vats at 32 to 39°F for 3-4 wks.

*Remove and place in 18% salt solution (35 to 40°F) for several days.

*Air dry, 2 wks. (α 41 to 47°F; R.H. 80%; then smoke ham.

Petäjä and Niinivaara, 1973; Petäjä et al., 1975.

meat products. This culture contains non-pathogenic strains of *Vibro costicolus* and *Staphylococcus* sp. After pickle injection, hams are held for 1-2 days at 36-39°F, and the surfaces are rubbed with coarse grain salt. They are then washed and placed in the drying chamber at 68°F for about 7 days. The product is then vacuum packaged. Injection of the curing solution and culture increases the rate and uniformity of cure distribution. Properties of this modified dry cured product are also shown in Table 7. The total weight loss is about 25% and salt contents range from 3 to 4%. The flavor and aroma is excellent and rapid distribution of cure ensures microbial safety of product. Dr. Petäjä has also used this process to produce dry cured reindeer meat, a specialty of Nordic countries.

With some further modifications, the above described method is used at various meat processing plants. Boneless pieces of ham are stuffed into casings and rubbed with multiple applications of dry curing mixtures during a 3 to 4 week period at 32 to 39°F. They are then placed in an 18% salt solution at 41 to 47°F for several days, removed, air dried for 2 weeks and then smoked. The entire process takes from 9 to 11 weeks.

Another type of dry cured ham is the traditional Finnish "Sauna" Ham (Table 8). This ham is equivalent to the U.S. "Country cured ham" which originated on the farms. Hogs are slaughtered in the fall and hams are dry salted and placed in wooden barrels for 1 to 4 weeks for curing. Because of our winter climate in Finland, these farmers had developed dry heated bath houses called "saunas" for use by their families.

Table 8. Finnish Traditional "Sauna" Ham (country style).

*Slaughter in fall.

*Dry salt, place in wooden barrels for 1 to 4 mo.

*Smoke in sauna for several days: (a) hot smoke (α 120-160°F or (b) cold smoke (α 60-70°F.

*Yield is 70-80%

*Modern commercial method: inject pickle containing phosphate; vacuum massage/tumble; hot smoke and cook.

*Yield is 100-110%.

They began to use these saunas as a chamber for heating and smoking of their salted hams. The hams are hung from the ceiling and either hot smoked at 120-160°F or cold smoked at 60-70°F for several days, using a light application of wood smoke. The hams lose 20-30% of their original weight and have a good flavor and aroma. However, today the traditional "Sauna" ham is made commercially by using multi-needle injection of curing pickles containing phosphate in addition to salt and curing ingredients. These boneless hams are vacuum tumbled or massaged and then hot smoked. The commercial process greatly reduces the time required and the product yields are 100 to 110% which is higher when compared to the traditional "Sauna" ham process. The commercial product is not identical to the traditional product but it has an acceptable flavor and aroma. Vacuum packaging is also used to enhance shelf-life of this commercial "Sauna" ham.

In summary, there is no single method used to produce European dry cured hams, rather, each locality because of climatic and other conditions has developed methods suitable for shelf-stable preservation of meat. These products may be made with whole bone-in hams or made with smaller pieces of hams or other cuts of meat that are boneless. Regardless of locality or size of meat piece used, the general principles of salting and drying to achieve shelf stability are employed throughout Europe.

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