

# Curing (food preservation)

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**Curing** is any of various food preservation and flavoring processes of foods such as meat, fish and vegetables, by the addition of combinations of salt, nitrates, nitrites,<sup>[1]</sup> or sugar, with the aim of drawing moisture out of the food by the process of osmosis. Many curing processes also involve smoking, spicing, or cooking.

Dehydration was the earliest form of food curing.<sup>[1]</sup> Because curing increases the solute concentration in the food and hence decreases its water potential, the food becomes inhospitable for the microbe growth that causes food spoilage. Curing can be traced back to antiquity, and was the primary way of preserving meat and fish until the late 19th century.

Nitrates and nitrites, in conjunction with salt, are one of the most common agents in curing meat because they further inhibit the growth of *Clostridium botulinum*. They also contribute to the characteristic pink color of cured meats like ham.

**Meat preservation** in general (of meat from livestock, game, and poultry) is the set of all treatment processes for preserving the nutritious properties, taste, texture, and color of raw, partially cooked, or cooked meats while keeping them edible and safe to consume. Curing has been the dominant method of meat preservation for thousands of years, although modern developments like refrigeration and synthetic preservatives are now beginning to complement and supplant it.

While meat preservation processes like curing were mainly developed in order to prevent disease and increase food security, the advent of modern preservation methods mean that in most developed countries today, curing is instead mainly practised for its cultural value and desirable impact on the texture and taste of food. For lesser-developed countries, curing remains a key process in ensuring the viability of meat production, transport and access.



Sea salt being added to raw ham to make prosciutto



Curing salt, also known as "Prague powder" or "pink salt", is typically a combination of sodium chloride and sodium nitrite that is dyed pink to distinguish it from table salt.

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Slices of beef in a can.

## Necessity of curing

Untreated meat decomposes rapidly if it is not preserved, at a speed that depends on several factors, including ambient humidity, temperature, and the presence of pathogens. Most meats cannot be kept at room temperature in excess of a few days without spoiling, even in winter.

If kept in excess of this time, meat begins to change colour and exude a foul odour, indicating the decomposition of the food. Ingestion of such spoiled meat can cause serious food poisonings, like botulism.

While the short shelf life of fresh meat does not pose a significant problem when access to it is easy and supply is abundant, in times of scarcity and famine, or when the meat must be carried over long voyages, it spoils very quickly. In such circumstances the usefulness of preserving foods containing nutritional value for transport and storage is obvious.

Curing is able to significantly extend the life of meat before it spoils, by making it inhospitable to the growth of spoilage microbes.

## History

A survival technique since prehistory, the conservation of meat has become, over the centuries, a topic of political, economic, and social importance worldwide.

### Traditional methods

Food curing dates back to ancient times, both in the form of smoked meat and salt-cured meat.<sup>[2]</sup>

Several sources describe the salting of meat in the ancient Mediterranean world. Diodore of Sicily in his *Bibliotheca historica* wrote that the Cosséens<sup>[3]</sup> in the mountains of Persia salted the flesh of carnivorous animals.<sup>[4]</sup> Strabo indicates that people at Borsippa were catching bats and salting them to eat.<sup>[5]</sup> The ancient Greeks prepared *tarichos* (τάριχος), which was meat and fish conserved by salt or other means.<sup>[a]</sup> The Romans called this dish *salsamentum* – which term later included salted fat, the sauces and spices used for its preparation.<sup>[6]</sup> Also evidence of ancient sausage production exists. The Roman gourmet Apicius speaks

of a sausage-making technique involving *œnogaros* (a mixture of the fermented fish sauce *garum* with oil or wine).<sup>[7]</sup> Preserved meats were furthermore a part of religious traditions: resulting meat for offerings to the gods was salted before being given to priests, after which it could be picked up again by the offerer, or even sold in the butcher's.<sup>[6]</sup>

A trade in salt meat occurred across ancient Europe. In Polybius's time,<sup>[8]</sup> the Gauls exported salt pork each year to Rome in large quantities, where it was sold in different cuts: rear cuts, middle cuts, hams, and sausages. This meat, after having been salted with the greatest care, was sometime smoked. These goods had to have been considerably important, since they fed part of the Roman people and the armies. The Belgians were celebrated above all for the care which they gave to the fattening of their pigs. Their herds of sheep and pigs were so many, they could provide skins and salt meat not only for Rome, but also for most of Italy. The Ceretani of Spain drew a large export income from their hams, which were so succulent, they were in no way inferior to those of Cantabria. These *tarichos* of pig would become especially sought, to the point that the ancients considered this meat the most nourishing of all and the easiest to digest.<sup>[6]</sup>



Young man preparing a pig's head after a sacrifice. Vase v. 360-340 BC, National Archaeological Museum of Spain

In Ethiopia, according to Pliny,<sup>[9]</sup> and in Libya according to Saint Jerome, the Acridophages (literally, the locust-eaters) salted and smoked the crickets which arrived at their settlements in the spring in great swarms and which constituted, it was said, their sole food.

The smoking of meat was a traditional practice in North America, where Plains Indians hung their meat at the top of their tipis to increase the amount of smoke coming into contact with the food.<sup>[2]</sup>

## Middle Ages

In Europe, medieval cuisine made great use of meat and vegetables, and the guild of butchers was amongst the most powerful. During the 12th century,<sup>[10]</sup> salt beef was consumed by all social classes. Smoked meat was called *carbouclée* in Romance tongues<sup>[11]</sup> and *bacon* if it was pork.<sup>[12]</sup>

The Middle Ages made *pâté* a masterpiece: that which is, in the 21st century, merely spiced minced meat (or fish), baked in a terrine and eaten cold, was at that time composed of a dough envelope stuffed with varied meats and superbly decorated for ceremonial feasts. The first French recipe, written in verse by Gace de La Bigne, mentions in the same *pâté* three great partridges, six fat quail, and a dozen larks. *Le Ménagier de Paris* mentions *pâtés* of fish, game, young rabbit, fresh venison, beef, pigeons, mutton, veal, and pork, and even *pâtés* of lark, turtledove, cow, baby bird, goose, and hen. Bartolomeo Sacchi, called Platine, prefect of the Vatican Library, gives the recipe for a *pâté* of wild beasts: the flesh, after being boiled with salt and vinegar, was larded and placed inside an envelope of spiced fat, with a *mélange* of pepper, cinnamon and pounded lard; one studded the fat with cloves until it was entirely covered, then placed it inside a *pâte*.

In the 16th century, the most fashionable pâtés were of woodcock, au bec doré, chapon, beef tongue, cow feet, sheep feet, chicken, veal, and venison.<sup>[13]</sup> In the same era, Pierre Belon notes that the inhabitants of Crete and Chios lightly salted then oven-dried entire hares, sheep, and roe deer cut into pieces, and that in Turkey, cattle and sheep, cut and minced rouelles, salted then dried, were eaten on voyages with onions and no other preparation.<sup>[14]</sup>

## Early modern era

During the Age of Discovery, salt meat was one of the main foods for sailors on long voyages, for instance in the merchant marine or the navy. In the 18th century, salted Irish beef, transported in barrels, was considered finest.<sup>[15]</sup>

Scientific research on meat by chemists and pharmacists led to the creation of a new, extremely practical product: meat extract, which could appear in different forms. The need to properly feed soldiers during long campaigns outside the country, such as the Napoleonic Wars, and to nourish a constantly growing population often living in appalling conditions drove scientific research, but a confectioner, Nicolas Appert, in 1795 developed through experimentation a method which would become universal and in one language bears his name: airtight storage, called *appertisation* in French.



Barrels of salt beef in a reconstruction of an American Civil War stockpile, at Fort Macon State Park, North Carolina

With the spread of *appertisation*, the 19th-century world entered the era of the "food industry", which developed new products such as canned salt meat (for example corned beef), but also led to lowered standards of food quality and hygiene – such as those Upton Sinclair described in *The Jungle*. These bad practices led to the creation of the Pure Food and Drug Act in 1906, followed by the national agencies for health security and the establishment of food traceability over the course of the 20th century. It also led to continuing technological innovation.

In France, the summer of 1857 was so hot that most butchers refused to slaughter animals and charcutiers lost considerable amounts of meat, due to inadequate conservation methods. A member of the Academy of Medicine and his son issued a 34-page summary of works printed between 1663 and 1857, which proposed some solutions: not less than 91 texts exist, of which 64 edited for only the years between 1851 and 1857.

<sup>[16]</sup>

## Chemical actions

### Salt

Table salt (sodium chloride) is the primary ingredient used in meat curing.<sup>[2]</sup> Removal of water and addition of salt to meat creates a solute-rich environment where osmotic pressure draws water out of microorganisms, slowing down their growth.<sup>[2][17]</sup> Doing this requires a concentration of salt of nearly 20%.<sup>[17]</sup> In addition, salt causes the soluble meat proteins to come to the surface of the meat particles within sausages. These proteins coagulate when the sausage is heated, helping to hold the sausage together.<sup>[18]</sup>



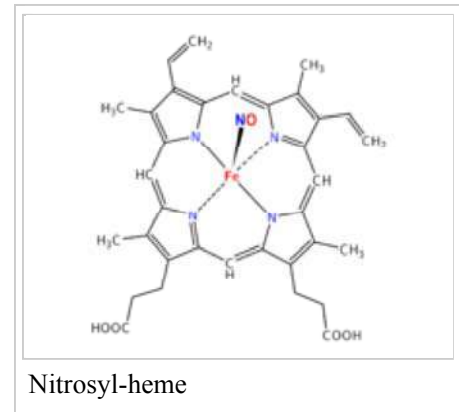
## Sugar

The sugar added to meat for the purpose of curing it comes in many forms, including honey, corn syrup solids, and maple syrup.<sup>[19]</sup> However, with the exception of bacon, it does not contribute much to the flavor,<sup>[20]</sup> but it does alleviate the harsh flavor of the salt.<sup>[2]</sup> Sugar also contributes to the growth of beneficial bacteria such as *Lactobacillus* by feeding them.<sup>[21]</sup>

## Nitrates and nitrites

Nitrates and nitrites not only help kill bacteria, but also produce a characteristic flavor and give meat a pink or red color.<sup>[22]</sup> Nitrite ( $\text{NO}_2^-$ ) is generally supplied by sodium nitrite or (indirectly) by potassium nitrate. Nitrite salts are most often used in curing. Nitrate is specifically used only in a few curing conditions and products where nitrite (which may be generated from nitrate) must be generated in the product over long periods of time.

Nitrite further breaks down in the meat into nitric oxide (NO), which then binds to the iron atom in the center of myoglobin's heme group, reducing oxidation and causing a reddish-brown color (nitrosomyoglobin) when raw, and the characteristic cooked-ham pink color (nitrosohemochrome or nitrosyl-heme) when cooked. The addition of ascorbate to cured meat reduces formation of nitrosamines (see below), but increases the nitrosylation of iron.



The use of nitrite and nitrate salts for meat curing goes back to the Middle Ages, and in the US has been formally used since 1925. Because of the relatively high toxicity of nitrite (the lethal dose in humans is about 22 mg/kg of body weight), the maximum allowed nitrite concentration in meat products is 200 ppm. Plasma nitrite is reduced in persons with endothelial dysfunction.<sup>[23]</sup>

The use of nitrites in food preservation is controversial due to the potential for the formation of nitrosamines when nitrites are present in high concentrations and the product is cooked at high temperatures.<sup>[22]</sup> The effect is seen for red or processed meat, but not for white meat or fish.<sup>[24][25]</sup> The production of carcinogenic nitrosamines can be potently inhibited by the use of the antioxidants Vitamin C and the alpha-tocopherol form of Vitamin E during curing.<sup>[26]</sup> Under simulated gastric conditions, nitrosothiols rather than nitrosamines are the main nitroso species being formed.<sup>[24]</sup> The use of either compound is therefore regulated; for example, in the United States, the concentration of nitrates and nitrites is generally limited to 200 ppm or lower.<sup>[22]</sup> They are considered irreplaceable in the prevention of botulism from consumption of cured dry sausages by preventing spore germination.<sup>[27]</sup>

## Smoke

Meat can also be preserved by "smoking", which means exposing it to smoke from burning or smoldering plant materials, usually wood. If the smoke is hot enough to slow-cook the meat, it will also keep it tender.<sup>[28]</sup> One method of smoking calls for a smokehouse with damp wood chips or sawdust.<sup>[29]</sup> In North America, hardwoods such as hickory, mesquite, and maple are commonly used for smoking, as are the wood from fruit trees such as apple, cherry, and plum, and even corncobs.

Smoking helps seal the outer layer of the food being cured, making it more difficult for bacteria to enter. It can be done in combination with other curing methods such as salting. Common smoking styles include hot smoking, smoke roasting (pit barbecuing) and cold smoking. Smoke roasting and hot smoking cook the meat while cold smoking does not. If the meat is cold smoked, it should be dried quickly to limit bacterial growth during the critical period where the meat is not yet dry. This can be achieved, as with jerky, by slicing the meat thinly.

## Effect of meat preservation

### On health

The preservation of meat has allowed safe and plentiful access to this nutrient-rich food for thousands of years. It has therefore prevented countless cases of malnutrition and of food poisoning.

Since the 20th century, with respect to the relationship between diet and human disease (e.g. cardiovascular, etc.), scientists have conducted studies on the effects of lipolysis on vacuum-packed or frozen meat. In particular, by analyzing entrecôtes of frozen beef during 270 days at  $-20\text{ °C}$  ( $-4\text{ °F}$ ), scientists found an important phospholipase that accompanies the loss of some unsaturated fat n-3 and n-6, which are already low in the flesh of ruminants.<sup>[30]</sup>

In 2015, the International Agency for Research on Cancer of the World Health Organization classified processed meat, that is, meat that has undergone salting, curing, fermenting, and smoking, as "carcinogenic to humans".<sup>[31][32][33]</sup>

### On trade

The improvement of methods of meat preservation, and of the means of transport of preserved products, has notably permitted the separation of areas of production and areas of consumption, which can now be distant without it posing a problem, permitting the exportation of meats.

For example, the appearance in the 1980s of preservation techniques under controlled atmosphere sparked a small revolution in the world's market for sheep meat: the lamb of New Zealand, one of the world's largest exporters of lamb, could henceforth be sold as fresh meat, since it could be preserved from 12 to 16 weeks, which would be a sufficient duration for it to reach Europe by boat. Before, meat from New Zealand was frozen, thus had a much lower value on European shelves. With the arrival of the new "chilled" meats, New Zealand could compete even more strongly with local producers of fresh meat.<sup>[34]</sup> The use of controlled atmosphere to avoid the depreciation which affects frozen meat is equally useful in other meat markets, such as that for pork, which now also enjoys an international trade.<sup>[35]</sup>

## See also

- Charcuterie
- Cured fish
- Curing salt
- List of dried foods
- List of smoked foods
- Sausage making
- Biltong

## Notes

- a. In time the original term came to mean salted fish only, whereas salted meat was called *kreas tarichrou* (κρέας ταριχηρὸν), according to Athenaeus of Naucratis in his *Deipnosophistae*, IV, 14.137f (en ligne (<http://remacle.org/bloodwolf/erudits/athenee/livre4.htm#137f>))

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4. Diodore de Sicile, *Bibliothèque historique*, XIX, 19 cité par Koehler, 1832, p. 432, note 724 (p. 486).
5. Strabon, *Géographie*, XVI, 1.7.
6. (French) M. Koehler, *Tarichos ou recherches sur l'histoire et les antiquités des pêcheries de la Russie méridionale*, in *Mémoires de l'Académie impériale des sciences de Saint-Petersbourg*, 6th series, book I, Imp. of the Académie impériale des sciences, Saint Petersburg, 1832, p. 347 à 490 (en ligne (<https://books.google.com/books?id=zH0-AAAAcAAJ&pg=PA347#v=onepage&q=&f=false>))
7. (Latin) Apicii Coelii, *De opsoniis et condimentis, sive arte coquinaria, libri decem. Cum annotationibus Martini Lister*, Londres, 1705, livre II, ch. 2, p. 59.
8. Cf. Joaquim Marquardt, *La Vie privée des romains*, 2, dans *Manuel des antiquités romaines*, 15, sous la dir. de Theodor Mommsen, Paris, 1893 [1874-1875], p. 52-56 et part. p. 54 (en ligne (<https://archive.org/stream/manueldesantiqui15momr>))
9. Pliny, *Histoire naturelle*, VI, 35.17
10. En Normandie par exemple : Léopold Delisle, *Études historiques et archéologiques en province depuis 1848* cité dans la *Revue des deux mondes*, XI (XXI<sup>e</sup> année), Paris, 1851, p. 1048.
11. Jean-Baptiste-Bonaventure de Roquefort, *Supplément au glossaire de la langue romane*, Chasseriau et Hécart, Paris, 1820, 308 pages
12. Jean Baptiste Bonaventure de Roquefort, *Glossaire de la langue romane*, T. I, B. Warée, Paris, 1808, 772 pages
13. Paul Lacroix et Ferdinand Séré, *Le Moyen Âge et la Renaissance, histoire et description des mœurs et usages, du commerce et de l'industrie, des sciences, des arts, des littératures et des beaux-arts en Europe*, T. I, ch. *Nourriture et cuisine*, Paris, 1848, not paginated.
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## External links

- National Center for Home Food Preservation - Curing Foods ([http://nchfp.uga.edu/publications/nchfp/lit\\_rev/cure\\_smoke\\_cure.html](http://nchfp.uga.edu/publications/nchfp/lit_rev/cure_smoke_cure.html))
- National Center for Home Food Preservation - How Do I? Curing and Smoking ([http://www.uga.edu/nchfp/how/cure\\_smoke.html](http://www.uga.edu/nchfp/how/cure_smoke.html))



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