Bacon Curing – a historical review

Bacon Curing – a historical review.
By Eben van Tonder
31 May 2016

The question came up, what is dry cured bacon? A historical review of the curing process yields interesting perspectives.

The Curing Process

Curing is a fascinating process. A modern understanding of the benefits of curing is that it fixes a pinkish-reddish cured meat colour. It endows the meat with unique longevity, even if left outside a refrigerator, many times longer than that of fresh meat. It is powerful enough to prevent the deadly toxin formation by clostridium botulinum. It prevents rancidity of fat. It lastly gives meat a unique cured taste.

Discovering the curing process and the mechanics behind it was a slow process that took hundreds of years. The object was the preservation of meat for future consumption. Bacon and other cured products, properly prepared, have, however, always been a delicacy as it remains to this day. Today, taste and a visual appeal probably dominates, but ask any outdoor's person and they will tell you that preservation for future consumption is still a huge factor in the immense popularity of cured meats.

Salt Only

Before the 1600's meat preservation was done with salt only. Vegetable dyes were used to bolster colour. The practice of salting meat existed in many cultures including the Far East, the Romans, the Celts and the Gauls. (economist.com)

According to the iconic 1975 review article of Binkerd and Kolari about the history and use of nitrates and nitrites in the curing of meat, “it appears that meat preservation was first practiced in the saline deserts of Hither Asia and in coastal areas. Desert salts contained nitrates and borax as impurities. However, the reddening effect of nitrates was not mentioned until late Roman times.” (Binkerd, E. F. and Kolari O. E.; 1975: 655)

The renowned South African meat scientist, Dr. Francois Mellett speculates that “curing started even earlier by sea farers. When a protein is placed in sea water, the surface amino acids are de-aminated to form nitrite for a period of 4 to 6 weeks. Nitrite is then converted to nitrate over the next 4 weeks. Finally, ammonia and ammoniac are formed from nitrate. It is possible that they preserved meat in sea water barrels or *stone troughs* and that the whole process of curing was discovered accidentally.” In private correspondance on the matter he empahsised that it is speculation and he explained that his hunch developed after extensive work on sea water tanks.

The first recorded specific account of pork curing is probably from the works of Cato the Elder who wrote in 160 BCE. In his Latin work, De Agricultura (On Farming), this Roman statesman and farmer, gives an ancient recipe for curing pork with salt.

“After buying legs of pork, cut off the `feet. One-half peck ground Roman salt per ham. Spread the salt in the base of a vat or jar, then place a ham with the skin facing downwards. Cover completely with salt. After standing in salt for five days, take all hams out with the salt. Put those that were above below, and so rearrange and replace. After a total of 12 days take out the hams, clean off the salt and hang in the fresh air for two days. On the third day take down, rub all over with oil, hang in smoke for two days…take down, rub all over with a mixture of oil and vinegar

and hang in the meat store. Neither moths nor worms will attack it."(economist.com)

Cato may have imitated a process whereby ham's are smoked over juniper and beech wood. The process was probably imported by the Roman gourmets from from Germania. (economist.com)

Salt with a little bit of saltpeter

People discovered that certain salt, for example, sea salt or bay salt, had the ability to turn meat reddish/ pinkish and prevented it from turning brown.

Salt naturally contains nitrate and in very rear occasions, even a tiny amount of nitrites. Sea salt has all the minerals and chemical elements of the earth washed into it by rain. Some cultures discovered that particular salts, mined from specific locations in dry regions, had far more of this "special power", endowed with a peculiar bitter taste and a greater ability to bring about this reddish/ pinkish colour.

This salt came to be known as saltpeter. The "*change from vegetable dyes to saltpeter for the coloring or color preservation, respectively, of meat, occurred between 1600 and 1750, probably near 1700.*" (Lauer K. 1991.)

This same saltpeter had great use in the production of explosives such as gunpowder and had very productive applications as a fertiliser. It became a widely traded commodity and companies were created around the world who specialised in not just mining and shipping it, but later in manufacturing it. (Hui, Y. H., 2012: 540)

The earliest form of dry curing was done with a mixture of salt and saltpeter, liberally rubbed over the meat. As it migrates into the meat, water and blood are extracted and drained off. The meat is

usually laid skin down and all exposed meat are plastered with a mixture of salt and saltpeter. Pork bellies would cure in approximately 14 days. (3) (Hui, Y. H., 2012: 540)

Salt, saltpeter and sugar

The addition of sugar which favours the reduction of nitrate to the active agent nitrite became common practice during the 19th century." (Lauer K. 1991.) At first, it was added to reduce the saltiness of the meat and make it generally more palatable. Curers soon discovered that when sugar is added, the meat cures faster and the colour development is better.

Science later revealed that the sugars contributes to "maintaining acid and reducing conditions favorable" for the formation of nitric oxide." (Kraybill, H. R.. 2009) "Under certain conditions reducing sugars are more effective than nonreducing sugars, but this difference is not due to the reducing sugar itself. The exact mechanism of the action of the sugars is not known. It may be dependent upon their utilization by microorganisms or the enzymatic systems of the meat tissues." (Kraybill, H. R.. 2009)

Ralph Hoagland, Senior Biochemist, Biochemie Division, Bureau of Animal Industry, United States Department of Agriculture, discovered that saltpeter functional value upon the colour of meat is its reduction to nitrites and the nitrites to nitric oxid, with the consequent production of NO-hemoglobin. He showed that the reactant is nitrous acid (HNO_2) or one of its metabolites such as nitric oxide (NO).

He wrote an important article in 1921, Substitutes for Sucrose in Cured Meats. Writing at this time, this formidable meat scientist is ideally placed to comment on the use of sugar in meat curing in the 1800's since the basis of its use would have been rooted in history.

He writes about the use of sugar in meat curing in the USA and says that it is used “extensively.” He reveals that according to government records, 15,924,009 pounds of sugar and 1,712,008 pounds of syrup, totaling 17,636,017 was used in curing meats in pickle in establishments that were inspected by the US Government, in 1917. If one would add the estimated use of sugar in dry cures in the same year, he placed the usage at an estimated total of 20,000,000 pounds. This estimate excludes the use of sugar in meat curing on farms. (Hoagland, R. 1921.)

Hoagland says that the functional value of sugar in meat curing at this time (and probably reaching back into the 1800’s) was entirely related to product quality and not preservation. “Sugar-cured” hams and bacon were viewed as being of superior quality. He states that a very large portion of bacon and hams produced in the USA are cured with sugar or syrup added to the cure. The quantity of sugar used in the curing mix is so small that it does not contribute to meat preservation at all. “Meat can be cured in entire safety without the use of sugar, and large quantities are so cured.” (Hoagland, R. 1921.)

The contribution to quality that he speaks about is probably related to both colour and flavour development. The colour development would have been related to the formation of the cured colour of the meat (The Naming of Prague Salt) as well as the browning during frying.

Dry-salt-curing in combination with injection

Ham press from the 1910's

It seems that the basic definition distinguishing between dry and wet curing is not based on whether injection is applied or not, but the state of the salts that the meat is left in, even after it has been injected with a brine (mixture of salt and water). So, if it is packed in a dry mix, it is dry curing and if it is soaked in a brine, it is wet-curing.

It was a certain Mr. Morgan, in England, who invented the technique of injecting a liquid brine into the meat in the first place. The motivation was to increase the rate of curing in order to reduce the time required for processing. In temperatures above 20 deg C, pork spoils in three days.

It was important for farmers to cure the meat before a warm snap could allow spoilage organisms to work before the cure was properly diffused through the meat. Later, in industrial plants, the drive for

a faster curing time would be cost factors. Increased output with limited and expensive equipment and people.

By injecting a liquid brine into the meat at evenly spaced intervals, the brine would diffuse quicker through the meat. It is also important to state that his interest was the preserving of meat generally for example for long sea voyages and not the curing of meat by farmers. The application of his method of injection, however, found its way into many homes and factories around the world.

Edward Smith writes in his book, Foods, in 1873 and account the events of "Mr Morgan [who] devised an ingenious process by which the preserving material, composed of water, saltpetre, and salt, with or without flavouring matter, was distributed throughout the animal, and the tissue permeated and charged. His method was exemplified by him at a meeting of the Society of Arts, on April 13, 1854, when I [Edward] presided." (Smith, E, 1873: 35)

He describes how an animal is killed in the usual way, the chest opened and a metal pipe connected to the arterial system. Brine was pumped through gravity feed throughout the animal. Approximately 6 gallons were flushed through the system. Pressure was created to ensure that it was flushed into the small capillaries. Smith reported overall good results from the process with a few exceptions. He himself seemed unconvinced.

An article appeared in the Sydney Morning Herald that mentions Dr. Morgan and his arterial injection method. An important observations from the article is the date of 1870. By this date he is referred to as "Dr. Morgan", cluing us in about the time-line of Morgan's life.

A second observation is a drawback of the system. The article states that "salting is the most common and best known process of

preservation (*of meat*), the principal modern novelty being Dr. Morgan's plan of injecting the saline solution into the arterial system – the principal objection to which has been that the meat so treated has been over-salted." (Sydney Morning Herald, 1 March 1870, p4)

The brine mix that Mr Morgan suggested was 1 gallon of brine, ¼ to ½ lb. of sugar, ½ oz. of monophosphoric acid, a little spice and sauce to each cwt of meat. (Smith, E, 1873: 36)

Seventeen years later after Smith met Mr Morgan at the Society of Arts meeting, in 1871, Yeats reports on a certain "Professor Morgan in Dublin, who has proposed a method of preservation by injecting into the animal as soon as it is killed, a fluid preparation, consisting, to every hundredweight of meat, of one gallon of brine, half a pound of saltpetre, two pounds of sugar, half an ounce of monophosphoric acid, and a small quantity of spice." (Yeats, J, 1871: 225)

The plan was widely tested at several factories in South America and by the Admiralty, who had reported that they had good results from the technique. (Yeats, J, 1871: 225, 226)

It was in all likelihood the same Morgan that Smith reports on who, by 1871, became a professor in Dublin. One interpretation of the Yeats report is that Morgan, by this time, abandoned his arterial injection method for a more general injection into the muscle. It is also possible that Yeats simply is not concerned with a detailed process description.

Notice, as a matter of interest that he used the same basic brine mix of salt, water, saltpeter, sugar, monophosphoric acid and spices. This, together with the similarity in surname makes it quite certain that Mr. Morgan and Prof. Morgan is the same person. In itself, this is an example of perseverance! In 1854 his arterial

injection was met with skepticism where Yeats reports in 1871 that the Admiralty viewed his improved method with great interest.

It is reported today by some bacon curers that they use the dry-curing in conjunction with injection. In this case, the meat is injected with approximately 10% saturated brine solution and the injected meat is then treated the usual way in the application of dry-salt-cure. There is a record showing that the famous Harris from Calne in the United Kingdom used injection with their dry cured bacon from 1843.

After it has been dry-cured, the meat is smoked at a temperature of not higher than 38 deg C (100 deg F) in order to prevent nitrate burn which presents itself as green spots that appear on the meat. Care should also be taken if these products are stored to prevent damage from insects such as cheese skippers, mites, red-legged ham beetles, and larder beetles. (Hui, Y. H., 2012: 540)

Brine-soaking

Brine-soaking followed dry-salt-curing. Again, note that dry or wet curing is defined by what the meat if left in to cure and not what is injected into the meat. The process is also relatively slow and meat pieces are placed in a mixture of salt, saltpeter and water. It is important to take temperature into account since spoilage may occur before the brine had a chance to penetrate the meat. (Hui, Y. H., 2012: 540)

An 1830 description of a “wet-cure” survived where a farmer describes the dry cure method as “tedious.” He credits Europe as the birthplace of the wet-cure method. One of the benefits of this simple system is that it can be used for mutton and beef also. The down-side is that it is more expensive than dry-cure, but the wet cure could be re-used and taking everything into account, would

work out cheaper in the long run than dry-cure. (The Complete Grazier, 1830: 304)

This re-using of the brine would turn out to become the cornerstone of the industrial revolution for bacon curing and the country credited for this development is Denmark. Before we get to that, we have to first look at barrel pork.

Barrel pork

Barrel pork was an easy way to cure pork that involved liquid brine. It had the benefit that it could be put in barrels, loaded onto a wagon or a ship for transport and cure in transit. It also had the benefit of being stored in the cure and being safe from flies and other insects.

In the 1800's, this was the main way that the packing plants in the USA exported pork to England as bacon. There are many accounts in newspapers of the time where advice is given to the bacon producers on how to make sure that the meat arrives in England unspoiled. One of the main points was the importance of using good, new wood for the barrels.

A 1776 description is given on how barrel pork was produced.

"After the meat has cooled <*probably, after the hair was removed*> , it is cut into 5 lb. pieces which are then rubbed well with fine salt. The pieces are then placed between boards a weight brought to bear upon the upper board so as to squeeze out the blood. Afterward, the pieces are shaken to remove the surplus salt, [and] packed rather tightly in a barrel, which when full is closed. A hole is then drilled into the upper end and brine allowed to fill the barrel at the top, the brine being made of 4 lb. of salt (1.8kg or 10%), 2 lb. of brown sugar (0.9kg or 5%), and 4 gallons of water (15L or 84%) with a touch of salt-petre. When no more brine can enter, the hole is closed. The

method of preserving meat not only assures that it keeps longer but also gives it a rather good taste." (Holland, LZ, 2003: 9, 10)

Again, notice the brine make-up of salt, saltpeter, sugar mixed in water. The role of the sugar was to break the hard salt taste.

Barrel pork would remain an important curing method throughout the 1700's and would make a spectacular return almost a 100 years later when pressure pumps were introduced to inject the brine into the meat through needles. A plank would be run across the barrel opening. The meat is placed on the plank for injection with between one and three needles. The three needles are fed brine through a hand pump that would pump brine directly from the barrel. The barrel is half filled with brine. After the meat has been injected, it is pushed off the plank, to fall into the brine which act as a cover brine. It would remain in the cover brine the prescribed time before it is removed and smoked.

Boiling of the brine

The original founders of the St. Edmunds Bacon Factory are shown in this old print of the laying of the factory's foundation stone in 1911.

We can now return to the 1830 account of wet-curing where we identify important developments in brining technique. The farmer who wrote down the brining technique suggests that the brine mix must be boiled over a gentle fire for the impurities to rise to the top before these were skimmed off and the brine allowed to cool down. (The Complete Grazier, 1830: 304)

When it is cooled down, the brine is poured over the meat so that the meat is completely submerged. Meat from small pigs are kept in the brine for three to four days and longer. An older pig may require one, two, or three days longer. (The Complete Grazier, 1830: 304)

If the meat is intended for hams, it must be left in the brine for two days. At the end of the curing time, rub with pollard (a by-product from the milling of wheat, like bran) and cover with a paper bag to keep flies away. (The Complete Grazier, 1830: 304)

In warm weather, make sure that the blood is all drained from the meat and the meat is rubbed with fine salt before the brine is poured over. (The Complete Grazier, 1830: 304)

Remember that wet-cure is more expensive than dry cure unless the brine is re-used. Our farmer states that brine is re-used “with advantage”. Before it is re-used, the old brine must be boiled first and water and the other ingredients must be added proportionately. (The Complete Grazier, 1830: 304)

It is this old brine or re-used brine that became the cornerstone of the industrial bacon curing plants in Denmark and which they call the “mother brine”. Needle injection of meat along with the faster curing action of the mother brine would become the key feature of curing plants in Denmark and would later be adopted by factories around the world. It was the fastest way of producing bacon and was remarkably effective.

Wet-curing in combination with injection

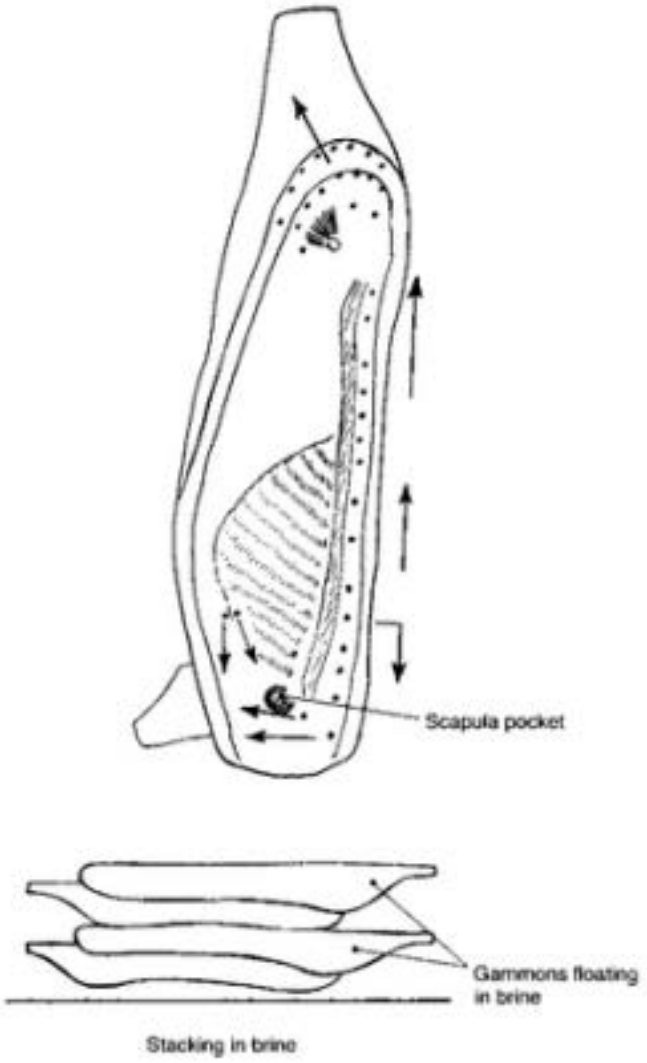
In Denmark, during the 1800's, a wet curing method was invented using a combination of stitch pumping and curing the meat in curing tanks with a cover brine. (Wilson, W, 2005: 219) Brine consisting of nitrate, salt and sugar was injected into the meat with a single needle attached to a hand pump (stitch pumping). Stitch pumping was either developed by Prof. Morgan, whom we looked at earlier or was a progression from his arterial injection method.

The meat was then placed in a mother brine mix consisting of old, used brine and new brine. The old brine contained the nitrate which was reduced through bacterial action into nitrite. It was the nitrite that was responsible for the quick curing of the meat.

Denmark was, as it is to this day, one of the largest exporters of pork and bacon to England. The wholesale involvement of the Danes in the English market made it inevitable that a bacon curer from Denmark must have found his way to Calne in Wiltshire and the Harris bacon factories. The tank-cured method, as it became known, was adopted by C & T Harris.

A major advantages of this method is the speed with which curing is done compared with the dry salt process previously practiced. Wet tank-curing is more suited for the industrialisation of bacon curing

with the added cost advantage of re-using some of the brine. It allows for the use of even less salt compared to older curing methods.



Clues to the date of the Danish invention come to us from newspaper reports about the only independent farmer-owned Pig Factory in Britain of that time, the St. Edmunds Bacon Factory Ltd. in Elmswell. The factory was set up in in 1911. According to an article from the East Anglia Life, April 1964, they learned and practiced what at first was known as the Danish method of curing bacon and later became known as tank-curing or Wiltshire cure.

A person was sent from the UK to Denmark in 1910 to learn the new Danish Method. (elmswell-history.org.uk) The Danish method involved the Danish cooperative method of pork production founded by Peter Bojsen on 14 July 1887 in Horsens. (Horsensleksikon.dk. Horsens Andelssvineslagteri)

The East Anglia Life report from April 1964, talked about a "new Danish" method. The "new" aspect in 1910 and 1911 was undoubtedly the tank curing method. Another account from England puts the Danish invention of tank curing early in the 1900's. C. & T. Harris from Wiltshire, UK, switched from dry curing to the Danish method during this time. In a private communication between myself and the curator of the Calne Heritage Centre, Susan Boddington, about John Bromham who started working in the Harris factory in 1920 and became assistant to the chief engineer, she writes: "John Bromham wrote his account around 1986, but as he started in the factory in 1920 his memory went back to a time not long after Harris had switched over to this wet cure." So, early in the 1900's, probably sometime between 1899 and 1910, the Danes invented and practiced tank-curing which was brought to England around 1911.

It only stands to reason that the power of "old brine" must have been known from early after wet curing and needle injection of brine into meat was invented around the 1850's by Morgan. Before the bacterial mechanism behind the reduction was understood, butchers must have noted that the meat juices coming out of the meat during dry curing had special "curing power". It was however the Danes who took this practical knowledge, undoubtedly combined it with the scientific knowledge of the time and created the commercial process of tank-curing which later became known as Wiltshire cure.

Multi-Needle Injection and Vacuum Tumbling

Multi needle injector, C & T Harris (Calne) Ltd. C 1960.

The composition of the brine changed around the 1915 by the direct addition of sodium nitrite. Multi needle injectors and vacuum tumblers are commonly used in combination in modern meat curing plants around the world.

It is generally accepted that these developments took place in the mid to late 1900's, but an interesting US patent (number 23,141) was awarded to L. M. Schlarb from Allegheny, Pennsylvania on 3 June 1901 directly related to injection and vacuum machines for meat curing. (Journal of the Society of Chemical Industry; 1902: 269)

The process is described as "injecting brine and carbon dioxide under pressure into the meat by means of suitable needlenozzles connected to a tank containing the brine and carbon dioxide, the pressure in the tank being about 2 atmospheres." The nozzles it talks about may be the three needle injectors that were used till the

middle of the 1900's and the unique aspect of the patent was the use of brine in conjuction with carbon dioxide. (Journal of the Society of Chemical Industry; 1902: 269)

The next bit is fascinating as it is possibly the earliest recorded date of the use of a vacuum machine in meat processing. The patent is described in a journal article that "the meat is now placed in a vessel from which the air is exhausted, and brine is then allowed to flow in. The meat is allowed to remain in the brine for about 10 hours, and may then be subjected to the action of carbon dioxide under pressure." If one removes the presence of carbon dioxide, it is then reasonable to assume that a vacuum machine has been in use in one shape or another to facilitate the diffusion of brine into meat, as early as 1901 and probably earlier. (Journal of the Society of Chemical Industry; 1902: 269)

Over the next 60 years, the multi needle injector became bigger, with more needles until the present machines were being produced from the mid 1900's. Tumbling machines, as we know it today has been in use from the early 1970's.

Conclusion

Wet curing is not only if a brine (a salt and water mixture) is used, for example, as injection-brine and dry-curing is not when salt only is used. The history of curing techniques paints a rich picture of salt-only dry-curing, brine injected dry-curing, wet curing with no brine injection, wet curing with brine-injection, barrel pork curing, tank curing and finally multi-needle injectors and vacuum tumblers in use today. There are overlaps in the terminology and the practices used so that an exact definition is probably not possible.

References

Binkerd, E. F. and Kolari O. E.. 1975. The history and use of nitrate and nitrite in the curing of meat. Fd Cosmet. ToxicoL Vol. 13. pp. 655–661. Pergamon Press 1975. Printed in Great Britain

The Complete Grazier. 1830. Fifth edition. paternoster Row. Baldwin and Cradock

Hoagland, R. 1921. Substitutes for Sucrose in Curing Meats. United Stated Department of Agriculture. Bulletin Number 928. Professional Paper. Washington D.C. January 7, 1921.

Holland, LZ. 2003. Feasting and Fasting with Lewis & Clark: A Food and Social History of the early 1800's. Old Yellowstone Publishing, Inc.

Hui, Y. H.. 2012. Handbook of meat and meat processing. Second edition. CRC Press.

Journal of the Society of Chemical Industry. Feb 28, 1902. No. 4, Vol XXII.

Kraybill, H. R.. 2009. Sugar and Other Carbohydrates in Meat Processing. American Meat Institute Foundation, and Department of Biochemistry, The University of Chicago, Chicago, Ill. USE OF SUGARS AND OTHER CARBOHYDRATES IN THE FOOD INDUSTRY. Chapter 11, pp 83–88. Advances in Chemistry, Vol. 12. Publication Date (Print): July 22, 2009 . 1955

Lauer K. 1991. The history of nitrite in human nutrition: a contribution from German cookery books. Journal of clinical epidemiology. 1991;44(3):261-4.

Smith, Edwards. 1873. Foods. Henry S King and Co.

Sydney Morning Herald, 1 March 1870, p4

Yeats, J. 1871. The technical history of commerce; or, Skilled labour applied to production. Cassell, Petter, and Galpin

http://www.economist.com/node/8345876

http://www.elmswellhistory.org.uk/arch/firms/baconfactory/baconfactory.html

Images

Figure 1: Founders of bacon plant: http://www.elmswell-history.org.uk/arch/firms/baconfactory/article2.html

Figure 2: Stitch pumping, http://www.suffolkheritagedirect.org.uk/resources/tours/made-in-suffolk.html