

# Nitrates and Nitrites in Country Cured Products

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The practice of curing meat goes back to antiquity. Ancient people discovered that meat, if properly salted and dried, would keep a long time. This allowed stockpiling for warm weather, for a reserve food supply and for transportation. Several excellent reviews have dealt with this history. They include a review by Binkerd and Kolari (1975), CAST Report 74 chaired by Richard Leckowich (1978) and an AMSA Nitrate-Free Processed Meat Committee chaired by Dennis Buege and presented at the RMC (1980).

The salt used for curing by the early people was not pure in most cases. Contaminants probably included nitrate and nitrite which, in addition to having curative properties, also helped impart a red color to the meat. The cause of this color was studied in Europe in the late 1800's (Polenske, 1891) and was further documented by Haldane in 1901. In his classic work he reported that (1) the red color of meat is due to the presence of NO-hemochromagen, (2) the NO-hemochromagen is produced by the decomposition by heat of the NO-hemoglobin to which the red color of unsalted meat is due, (3) the NO-hemoglobin is formed by the action of nitrite on hemoglobin in the absence of oxygen and in the presence of reducing agents and (4) the nitrite is formed by reduction within the raw meat of the nitrate used in salting. Hoagland expanded the work further and reported in 1908 that the action of nitrate and nitrite occurred when nitrate was converted to nitrite by microbial action, that the direct application of nitrite, therefore, would be feasible and would be more controllable. He postulated that the direct use of nitrate could be eliminated if nitrite were used.

The Meat Inspection Law regulating meat in interstate and foreign commerce was enacted in 1906. In 1908, the regulations were amended to allow the use of nitrate. Regulation 22, Section 1, as amended, in part, says, "There may be added to meat or meat food products common salt, wood smoke, vinegar, pure spices and saltpeter." No mention was made of the amount. The use of nitrate was thus approved and its use remained as part of a standard procedure until 1926 at which time the regulations were amended to involve the use of both nitrate and nitrite and specified the maximum levels to be used. This revision was based mainly on the research of Kerr et al (1926) who described the procedure and suggested that ¼ to 1 ounce of nitrite is sufficient to fix the color in 100 pounds of meat, the exact quantity depending on the meat to be cured

and the process to be employed. The regulations state that the maximum allowable amount of sodium or potassium nitrate is 7 pounds in 100 gallons of pickle or 3½ ounces per 100 pounds of meat in dry cure. The limits for sodium or potassium nitrite are 2 pounds per 100 gallons of pickle at a 10% pump level or 1 ounce for each 100 pounds meat in dry cure. When used alone or in combination, the finished product is limited to 200 ppm calculated as sodium nitrite in the finished product. These regulations were in effect until 1978 (Angelotti, 1978) when the use of nitrate for curing pumped bacon was discontinued. The amount of sodium or potassium nitrate for dry cured products remained at 3½ ounces per 100 pounds of meat while the amount for sodium nitrate remained at 1 ounce per 100 pounds.

The use of nitrate and nitrite came under fire a few years ago when it was discovered that some cured meat products, especially those fried at high temperatures, produced nitrosamines which are carcinogenic. The evidence for these claims is well documented in the review articles of the AMI, 1977; CAST, 1978; and the RMC, 1980. These review articles give the pros and cons of using nitrite and nitrate and stress their antibolium properties. Additional impetus to ban the use of nitrites was brought about by the Newberne report (1979) which gave statistical evidence that the direct consumption of nitrite by rats was carcinogenic. This report has been partially discredited but the claim is still there.

Because of the possibility of a ban on nitrite, an expert panel sponsored by the AMI and the meat industry did an extensive review of available data to determine the levels of nitrosamines in cured meat, especially commercially processed bacon. Partially as a result of this study and the industry sponsored research that accompanied it, new regulations were formulated for injected bacon that reduced the level of ingoing nitrite and required the use of ascorbate. This has satisfied the regulators, at least for the time being, and nitrite is still approved.

Up to now I have talked mainly about the general use of nitrates and nitrites when used with injected cures. Dry-cured products have not been ignored, however, and my assignment is to talk about the use of nitrates and nitrites in such products. Although most of the furor over nitrosamines has been connected to injected bacon and that probably was proper as most bacon is produced that way, dry-cured hams and bacon also have been and are being closely observed. Pensabene et al (1979) and the Nitrite Safety Council (1980) reported detectable levels of nitrosamines in several dry-cured products with bacon being the worst offender. A dry-cured bacon task force headed by Bill Dennis of the USDA and including several AMSA members, including some of us here, is doing an extensive survey of dry-cured bacon procedures

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all across the country. We are trying to relate processing methods to nitrosamine formation. Results of this study will be forthcoming and, hopefully, will provide background data upon which to base curing recommendations if the need arises. Up to April 12, fifty-six samples from across the country had been collected and analyzed. Nitrosopyrrolidine levels ranged from none to 60 ppb. A level of 17 ppb was considered to be the upper acceptable limit so a few samples would not be acceptable. The study is continuing and more samples are being analyzed.

As stated earlier, the curing of meat goes back to antiquity. The art was practiced in Europe so it naturally came to America with the settlers. Some meat was cured for export in the New England area in the early to mid-1600's (National Provisioner, 1981). A lot of pork was cured on farms for use in the summer. Many of the well-to-do farmers during the 18th and 19th centuries had an ice house and a smoke house as part of the homestead. They didn't know much about meat chemistry or meat microbiology but they knew that a properly cured and aged ham made for excellent eating and was the mark of a well-set table. Some of the curers used salt only, some used salt and sugar, some used nitrate, mostly saltpeter or potassium nitrate, and others included molasses, pepper, and other spices. The so-called secret recipes were sometimes guarded but many were shared. These varied methods of curing prevailed until relatively recent times when the production of country hams moved from a backyard business to a large scale commercial business.

Since most country hams produced prior to the enactment of the Wholesome Meat Act of 1968 were not subject to federal inspection, no public record was kept of the types of cures used. Curing recipes often were in terms of spoonfuls or cupfuls per ham rather than on a weight basis. With the enactment of the Wholesome Meat Act, it became mandatory that the curing procedures be approved either to comply with federal regulations or with state regulations that were equal to federal. Therefore, it became necessary to establish some guidelines to recommend to processors. A few research stations including Kentucky, North Carolina, Missouri and Virginia conducted research comparing the use of curing mixtures with and without nitrates, nitrite or combinations when used in different amounts.

Kelly (1974) reported on the production of nitrite free processed meat products. Most, other than dry-cured products, had a relatively short shelf life unless stored in the frozen state. The RMC-Buege paper (1980) reported similar data. It pointed out that in Kentucky alone there were 13 federally inspected dry-cured ham processors who produced ham without nitrate and or nitrite. This process is approved but the hams must have a  $A_w$  of not more than .92 (Mulhern, 1975) which indicates they will be saltier than when nitrate or nitrite is used. In addition to these commercial producers, there are many non-inspected on-the-farm curers who use no nitrate or nitrite.

Several studies dealing with this problem have been reported. In 1974, Kemp et al gave results of a study where hams were cured with salt and sugar only; salt, sugar and potassium nitrate; or salt, sugar and sodium nitrite. In general, those hams cured with a mixture containing either nitrate or nitrite were superior in color, general appearance and flavor to those containing salt-sugar only. However, many of those cured without nitrate or nitrite were highly acceptable. This

suggested to us that nitrate or nitrite, although desirable, was not absolutely essential, especially in hams aged under ambient temperatures or up to 3 months under controlled temperature. Additional work by Kemp et al (1975) with 5 curing mixtures; salt, sugar only; salt, sugar, nitrate; salt, sugar, nitrite; salt, sugar, nitrate, nitrite; and salt, sugar, praque powder; was reported. Hams were held in cure for 35 days at 3°C, held for 14 days at 16°C for salt equalization and aged without smoking for 30 days at 26°C. This would be equivalent to the procedures used by many commercial ham processors. Hams were sliced and vacuum packaged. Part of the slices were held under refrigeration and evaluated within a week of slicing. The remainder were held for 30 days either at 1°C or 24°C. Color scores were more desirable for any treated group than for controls when evaluated within one week. After 30 days at 1°C all treated groups retained their color while color of the control group had deteriorated. After 30 days at 24°C, all groups except those treated with nitrite had poor color.

Organoleptic scores favored the treated groups for those sampled within a week and after a month at 1°C. After a month at 24°C all organoleptic scores had decreased, showing that it is essential to keep sliced products refrigerated even when nitrate or nitrite is used. After storage at 24°C for a month, those hams cured with nitrate had higher lactobacilli, indicating that nitrate actually enhanced microbial growth.

In further work with boneless hams, (Kemp and Fox, 1977; Kemp et al 1979) cures containing nitrite were as effective as those containing nitrate and nitrate in developing color, flavor or overall satisfaction scores.

Eakes and Blumer (1975) and Eakes et al (1975) reported similar results for color and organoleptic characteristics. They, too, found little difference in the use of nitrate, nitrite or a combination. Color in hams where no nitrate or nitrite was used improved with aging but was still less pronounced after aging and faded more during cooking.

Leckowich et al at VPI (1977) reported similar results when varying levels of nitrite, nitrate or a combination were used. They found that residual levels of nitrite varied with the amounts applied. Color and flavor favored the hams where nitrate or nitrite were used. Nitrosopyrrolidine formation was not a problem as less than 5 ppb was detected. Ham slices were inoculated after curing and aging with 5 strains of *Clostridium botulinum* spores. No toxins developed, indicating that the water activity, even in the hams where no nitrate or nitrite was used, was sufficiently low to prevent toxin formation. They also found that acceptable dry-cured bacon could be produced with very low potential for nitrosamine formation by using reduced levels of sodium nitrite coupled with sodium erythorbate.

So, in general, either nitrate or nitrite is equally effective in developing color and flavor in hams. Hams where these products are used are generally superior than if they are not used, especially on short aged hams. However, acceptable hams can be produced without either nitrate or nitrite.

Since some dry-cured hams, bacon and cured side meat contain nitrosamines (Pensabene et al 1979, and the Nitrite Safety Council, 1980, Bailey, 1982), there needs to be some method of eliminating or reducing the levels. Gray et al (1982) stated that there are two ways this can be done (1) eliminate or reduce the nitrite in the product or (2) add an inhibitor (blocking

agent) of the nitrosation reactions to the product during its processing. Several products have been tried. One of the most successful has been *a*-tocopherol which has been used in both dry-cured and brine-cured bacon. Bellies were dry-cured with salt, sugar, ascorbate and nitrite to which *a*-tocopherol was added to the curing mixture at 0, 250, 500 and 750 mg/kg mixture.

Almost complete inhibition of NPYR (96.4%) was achieved at the 500 mg level, followed by 83.3% inhibition at the 750 mg level and 65.3% at the 250 mg level. In addition, it was demonstrated that *a*-tocopherol does not interfere with the antibotulinal activity of nitrite in tests of *a*-tocopherol-treated bacon conducted shortly after processing.

Bailey (1982) reported that dextrose (0.25-0.50%), when used with 2% salt, 550 ppm sodium ascorbate and levels of sodium nitrite as high as 400 ppm, can be used to produce a dry-cured bacon with high acceptance, good storage stability and low N-nitrosopyrrolidine content. He also reported that this mixture, if used on extremely lean bellies (< 55% fat), produces a product that is essentially free of N-nitrosamines.

Therefore, it seems that there are possible methods for dry-curing which will allow continued nitrite or nitrate use without the formation of excess nitrosamines.

### Summary

1. The use of nitrate and/or nitrite in dry-cured hams generally improves the color and flavor.
2. The effect is more pronounced in hams that are short aged under high controlled temperatures than those aged longer at ambient temperature or at lower controlled temperatures.
3. Nitrate, nitrite or a combination of nitrate and nitrite work equally well in enhancing color and flavor.
4. Satisfactory country hams, especially those that are aged under ambient conditions or aged for longer periods under controlled conditions, can be produced without the use of nitrate or nitrite.
5. Vacuum packaged ham slices retain their color and flavor longer if nitrate or nitrite is used.
6. Nitrate enhances the growth of lactobacilli and certain anaerobes in vacuum packaged sliced ham.
7. Bacon needs nitrate or nitrite for proper color and flavor.
8. Nitrosamines are present in the drippings and cooked portion of some dry-cured ham and bacon.
9. Blocking or nitrosation agents such as *a*-tocopherol, ascorbate or dextrose, when used with nitrite, show promise in inhibiting the formation of nitrosamines without affecting the antibotulinum effect of nitrite.

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