AG-FS-0974-A
Revised 1992

MINNESOTA EXTENSION SERVICE

UNIVERSITY OF MINNESOTA
AGRICULTURE

Nitrite in Meat

Richard J. Epley, Paul B. Addis, and Joseph J. Warthesen
Animal Science

BACKGROUND

For centuries, meat has been preserved with salt. At certain levels, salt prevents growth of some types of bacteria that are responsible for meat spoilage. Salt prevents bacterial growth either because of its direct inhibitory effect or because of the drying effect it has on meat (most bacteria require substantial amounts of moisture to live and grow).

As use of salt as a meat preservative spread, a preference developed for certain salts that produced a pink color and special flavor in meat. This is the effect we see in cured meats today. Near the turn of the century it was determined that nitrate, present in some salt, was responsible for this special color and flavor. Still later it was determined that nitrate actually is changed to nitrite by bacterial action during processing and storage and that nitrate itself has no effect on meat color. Today the nitrite used in meat curing is produced commercially as sodium nitrite.

WHAT NITRITE DOES IN MEAT

Nitrite in meat greatly delays development of botulinal toxin (botulism), develops cured meat flavor and color, retards development of rancidity and off-odors and off-flavors during storage, inhibits development of warmed-over flavor, and preserves flavors of spices, smoke, etc.

Adding nitrite to meat is only part of the curing process. Ordinary table salt (sodium chloride) is added because of its effect on flavor. Sugar is added to reduce the harshness of salt. Spices and other flavorings often are added to achieve a characteristic "brand" flavor. Most, but not all, cured meat products are smoked after the curing process to impart a smoked meat flavor.

Sodium nitrite, rather than sodium nitrate, is most commonly used for curing (although in some products, such as country ham, sodium nitrate is used because of the long aging period). In a series of normal reactions, nitrite is converted to nitric oxide. Nitric oxide combines with myoglobin, the pigment responsible for the natural red color of uncured meat. They form nitric oxide myoglobin, which is a deep red color (as in uncooked dry sausage) that changes to the characteristic bright pink normally associated with cured and smoked meat (such as wieners and ham) when heated during the smoking process.

HOW MUCH NITRITE CAN BE USED?

For the curing process, sodium nitrite legally can be used at up to the following levels, set by the Meat Inspection Regulations, Title 9, Chapter 111, Subchapter A, Code of Federal Regulations, 1974:

- 2 pounds per 100 gallons pickle brine at the 10 percent pump level in the product
- 1 ounce per 100 pounds meat (dry cured)
- 1/4 ounce per 100 pounds chopped meat and/or meat by-product.

As established by the U.S. Department of Agriculture (USDA) in the Meat Inspection Regulations cited above, the use of nitrites, nitrates, or combinations of them cannot result in more than 200 parts per million (ppm), calculated as sodium nitrite, in the finished product. Parts per million can be calculated as follows:

$$\text{ppm} = \frac{\text{grams sodium nitrite x 1 million}}{\text{grams of cured meat sample}}$$

For example:

$$\frac{0.01 \text{ gram sodium nitrite x } 1{,}000{,}000}{50 \text{ grams cured meat}} = 200 \text{ ppm sodium nitrite}$$

Another way of expressing 200 ppm is to say it is 1 pound of sodium nitrite in 5,000 pounds of meat.

Effective June 15,1978, the USDA changed the curing procedures of "pumped" bacon as follows: the use of sodium nitrate and potassium nitrate is prohibited; the level of ingoing sodium nitrite shall be 120 ppm (or 148 ppm potassium nitrite); the level of ingoing sodium ascorbate (vitamin C) or sodium erythorbate (isoascorbate) shall be 550 ppm. According to USDA surveys, these changes have resulted in bacon that does not form nitrosamines when cooked at 340° F for 3 minutes on each side. These three changes apply only to pumped bacon and do not apply to dry cured bacon.

TOXICITY

The following information on nitrite toxicity is from "GRAS (Generally Recognized as Safe) Food Ingredients: Nitrates and Nitrites (Including Nitrosamines)," 1972. This report was prepared for the U.S. Food and Drug Administration (FDA) by Battele-Columbus Laboratories and Department of Commerce, Springfield, VA 22151.

According to this source, the fatal dose of potassium nitrate for adult humans is in the range of 30 to 35 grams consumed as a single dose; the fatal dose of sodium nitrite is in the range of 22 to 23 milligrams per kilogram of body weight. Lower doses of sodium or potassium nitrate or sodium nitrite have caused acute methemoglobinemia (when hemoglobin loses its ability to carry oxygen), particularly in infants, resulting from conversion of nitrate to nitrite after consumption. There is no confirmable evidence in the literature on the carcinogenicity (cancer-causing capacity) of nitrate as such.

It has been reported that people normally consume more nitrates from their vegetable intake than from the cured meat products they eat. Spinach, beets, radishes, celery, and cabbages are among the vegetables that generally contain very high concentrations of nitrates (*J. Food Sci.,* 52:1632). The nitrate content of vegetables is affected by maturity, soil conditions, fertilizer, variety, etc. It has been estimated that 10 percent of the human exposure to nitrite in the digestive tract comes from cured meats and 90 percent comes from vegetables and other sources. Nitrates can be reduced to nitrites by certain microorganisms present in foods and in the gastrointestinal tract. This has resulted in nitrite toxicity in infants fed vegetables with a high nitrate level. No evidence currently exists implicating nitrite itself as a carcinogen.

To obtain 22 milligrams of sodium nitrite per kilogram of body weight (a lethal dose), a 154-pound adult would have to consume, at once, 18.57 pounds of cured meat product containing 200 ppm sodium nitrite (because nitrite is rapidly converted to nitric oxide during the curing process, the 18.57 pound figure should be tripled at least). Even if a person could eat that amount of cured meat, salt, not nitrite, probably would be the toxic factor.

NITROSAMINES

In the 1970s, newspaper articles discussed the safety of meat products cured with nitrite. Under certain conditions not yet fully understood, the natural breakdown products of proteins known as amines can combine with nitrites to form compounds known as nitrosamines. There are many different types of nitrosamines, most of which are known carcinogens in test animals.

Not all cured meat products contain nitrosamines; when present, they usually are in very minute amounts. According to S.R. Tannenbaum and T.Y. Fan in "Uncertainties about Nitrosamine Formation in and from Foods," proceedings from the Meat Industry Research Conference, University of Chicago, 1973, many variables influence nitrosamine levels: amount of nitrite added during processing, concentrations of amines in meat, type and amounts of other ingredients used in processing, actual processing conditions, length of storage, storage temperatures, method of cooking, and degree of doneness. For example, the USDA now requires adding ascorbic acid (vitamin C) or erythorbic acid to bacon cure, a practice that greatly reduces the formation of nitrosamines.

The effects of heating meat products cured with nitrite have been investigated. The previously cited study, "Effect of Frying and Other Cooking Conditions on Nitrosopyrrolidine Formation in Bacon," by J.W. Pensabene, et al., indicated that when bacon was fried at 210° F for 10 minutes (raw), 210° F for 105 minutes (medium well), 275°F for 10 minutes (very light), or 275° F for 30 minutes (medium well), no conclusive evidence of nitrosopyrrolidine could be found. But when bacon was fried at 350° F for 6 minutes (medium well), 400° F for 4 minutes (medium well), or 400° F for 10 minutes (burned), nitrosopyrrolidine formation was conclusively found at 10,17, and 19 parts per billion. Thus, well done or burned bacon probably is potentially more hazardous than less well done bacon. Bacon cooked by microwave has less nitrosamine than fried bacon. Consumers should cook bacon properly.

The same study and one by W. Fiddler, et al. (*J. Food Sci.* 39:1070,1974) have shown that fat cook-out or drippings usually contain more nitrosopyrrolidine than the bacon contains.

It is unknown at what levels, if any, nitrosamines are formed in humans after they eat cured meat products, or what constitutes a dangerous level in meat or in humans. Nitrosamines are found very infrequently in all cured products except overcooked bacon, as discussed above.

Feeding studies documented in the "GRAS" report using meats containing high levels of nitrite showed no evidence of carcinogenesis. However, nitrosamines still are considered a definite potential hazard to human health.

Bacon manufacturers are under a USDA surveillance program whereby bacon is sampled, cooked, and tested for nitrosamines. Levels above a certain maximum amount are not permitted.

Although nitrite is a controversial food additive, recent studies indicate that nitrite can inhibit the production of malonaldehyde, which may be toxic to living cells. In small quantities (yet at 1,000 times the levels of nitrosamines), malonaldehyde frequently is found in food products that turn rancid. Wieners, ham, bacon, and corned beef resist the accumulation of malonaldehyde due to their nitrite content.

WHO CONTROLS USAGE?

The Food and Drug Administration (FDA) is the federal agency responsible for testing or validating scientific data related to human safety of food additives. On November 16, 1973, the FDA established guidelines for packaging nitrite and nitrate to eliminate the possibility of nitrosamine formation in stored curing spice premixes to be used for curing meat products (see *Federal Register,* Vol. 38, No. 221, Friday, November 16, 1973, page 31,679). Questions concerning the safety of nitrite in meat should be directed to the FDA.

The USDA is the federal agency responsible for monitoring proper use of nitrite by meat processors, including the testing of finished meat products, to insure that nitrite is not present in amounts exceeding 200 ppm. Questions concerning use of nitrite in meat should be directed to the USDA.

A National Academy of Sciences Committee recently reviewed several aspects of nitrite usage in cured meats. The committee recommended that the search for alternatives and alternative approaches to the use of nitrite be continued. They cautioned, however, that no new agent or combination of agents should be substituted for nitrite until adequate testing has ensured that it does not present a hazard to human health .

SUMMARY

Based on available evidence to date, nitrite as used in meat and meat products is considered safe because known benefits outweigh potential risks.

Printed on recycled paper.

Produced by the Educational Development System, Minnesota Extension Service.