RESIDUAL NITRITE, NITRATE AND ASCORBATES IN CURED MEAT

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KEYWORDS: nitrite, ascorbates, food safety, meat curing

BACKGROUND: Because of potential health effects--both positive and negative--thought to be associated with the meat curing process, a vigilance is maintained by the industry. Nitrite is known to impart an important preservation effect to cured meats as well as giving distinctive color, flavor and textural properties. Nitric oxide is the active nitrosating agent formed from nitrite, and it is known that nitrosation results in N-nitroso compounds, some of which are carcinogens. The formulation of many cured meats has been altered in the last decade to meet consumer demands regarding fat content. To further complicate the situation, typical cured meats are usually in a complex distribution system for up to 6 weeks after leaving the manufacturing plant and before appearing in the retail case.

It was reported recently that, "Children who eat more than 12 hot dogs per month have nine times the normal risk of developing childhood leukemia" (Maugh, 1994). This conclusion was based on epidemiological studies (see Peters et al., 1994, for example) that linked residual nitrite in hot dogs to cancer risk. On the other hand, it is now known that nitric oxide is formed in the human body (nitric oxide synthase catalyzes the stepwise oxidation of the amino acid l-arginine to nitric oxide and l-citrulline) and that nitric oxide is a biological messenger important to the physiological functions of neurotransmission, blood clotting, blood pressure control and immune system function (Culotta and Koshland, 1992; Feldman et al., 1993).

Ascorbates (ascorbic acid, sodium ascorbate, erythorbic acid, sodium erythorbate) are used routinely in the production of cured meats. Mirvish et al. (1995) recently studied intragastric formation of nitrosamines in humans. Although higher doses of nitrate produced more N-nitroso compounds, it was also demonstrated that ascorbic acid inhibited their formation.

In 1981 (NAS), it was concluded that of dietary nitrite intake, 39% was from cured meat, 34% was from baked goods and cereals and 16% was from vegetables. It is important to realize that intake of nitrite does not equate to endogenous exposure since 50% of ingested nitrate (mainly from vegetables) is converted to nitrite *in vivo*. Nitrate is important in the total picture since it is found in substantial quantities in other foods such as green leafy and root vegetables and sometimes in drinking water. In 1975, White reported an average residual nitrite in cured meats of 52.5 ppm. The data he quoted for wieners had a range of 0 to 195 ppm of residual nitrite. More recently, Cassens (1995; 1996) reported means of 5 ppm and 10 ppm residual nitrite in cured meats manufactured in the United States.

OBJECTIVE: The objective was to establish the levels of residual nitrite, residual nitrate and residual ascorbates in typical retail meat products manufactured in the United States.

METHODS: During December 1995, a firm was contracted to retrieve cured meats from supermarket cases in the metropolitan areas of Los Angeles, Denver, St. Louis and Tampa. The only provision was that the packages be within code date. The products were selected from a list of major manufacturers that account for about one-third of the products manufactured in the United States. A total of 55 packages were retrieved consisting of 6 bacon, 7 ham, 23 bologna and 19 wiener samples. Samples were shipped refrigerated to Madison, WI where they were logged in and then delivered refrigerated to a commercial laboratory for analysis.

Nitrite was determined by AOAC (1990) methods 976.14 (c) and 973.31, and nitrate was determined by method 935.48. What is referred to as ascorbates includes any ascorbic acid and erythorbic acid present (AOAC 967.21B, and J. Biol. Chem. 147, 399, 1943). Statistical analysis was conducted using SAS (1990).

RESULTS AND DISCUSSION: The mean residual nitrite for all products was 10 ppm with a standard deviation of 12 ppm, and the range was 0 to 45 ppm. All analytical values for residual nitrate were less than 10 ppm. Because the stated detection level was 10 ppm, all nitrate values are therefore reported as 0 ppm. The overall mean for residual ascorbates was 209 ppm with a standard deviation of 66 ppm.

The results for product categories are reported in Table 1. Bologna had a higher ($p<.05$) residual nitrite than bacon and ham but was not different from wieners. Wieners had a lower ($p<.05$) ascorbates than bacon and ham but were not different from bologna.

The residual nitrite (over all products) for cities was 3 ppm for Los Angeles (13 samples), 7 ppm for St Louis (21 samples), 16 ppm for Tampa (16 samples) and 17 ppm for Denver (5 samples). Even though there were statistical differences, no interpretation was placed on the results. There was no difference for residual ascorbates.

Forty-five of the samples contained phosphates and 10 did not. For samples containing phosphates residual nitrite was 10 ppm and residual ascorbates was 210 ppm. For those samples without phosphates, residual nitrite was 8 ppm and residual ascorbates was 205 ppm. There were no statistical differences.

When bacon and ham were excluded, 19 samples did not contain poultry meat and 23 samples were made from poultry or contained poultry as a component. There was no

difference in residual ascorbate with the values being 177 ppm and 207 ppm respectively. Product without poultry had a residual nitrite of 3 ppm compared to 16 ppm for product containing poultry. The difference was significant ($p<.05$).

These results substantiate previous trials (Cassens 1995; 1996) which demonstrated that residual nitrite is low in modern cured meats. The mean of 10 ppm, compared to the results reported (White, 1975) 20 years ago, represents an approximate five-fold reduction of residual nitrite in cured meat. In addition, nitrate was not detectable in any of the products.

The presence of phosphates did not influence residual nitrite. However, if poultry meat was present, residual nitrite was higher.

Of importance was the finding that modern cured meats contain substantial levels of ascorbates with the overall mean being 209 ppm. This is interpreted to mean that considerable inhibitory power against nitrosation reactions is present in cured meats and would be consumed simultaneously with the residual nitrite.

CONCLUSION: Residual nitrite is substantially lower in cured meats than it was 20 years ago: nitrate is not found in cured meats but substantial levels of ascorbates are present.

ACKNOWLEDGEMENTS: This work was supported by the College of Agricultural and Life Sciences, University of Wisconsin and by project funding from the American Meat Institute Foundation.

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TABLE 1

	Nitrite	Ascorbates	Nitrate
Bacon	3^{b} (4)	240^{a} (128)	0
Ham	4^{b} (4)	257^{a} (44)	0
Bologna	15^{a} (14)	215^{ab} (43)	0
Wieners	8^{ab} (12)	175^{b} (55)	0

Results given as a mean, with standard deviation in brackets, and expressed as ppm. Means with the same superscript, in a single column, are not different ($p>.05$).