THE RESIDUAL LEVELS OF NITRITE IN CURED MEAT PRODUCTS

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The purpose of this survey of residual levels of nitrite in cured meat products is to present current data, and for comparative purposes older data, on the nitrite content of various cured meat products. Considerable confusion exists on the amount of nitrite commonly found, or expected, in cured meats. Therefore, the effects of various factors upon residual nitrite levels will also be briefly reviewed.

Current Meat Inspection Regulations (1970) permit the addition of 3 1/2 oz. sodium or potassium nitrate to 100 lb. of meat in dry cure or 2 3/4 oz. to 100 lb. chopped meat. Sodium or potassium nitrite may be added at 1 oz. to 100 lb. meat in dry cure and 1/4 oz. to 100 lb. chopped meat and/or meat by-product. The use of nitrites, nitrates, or their combination may not result in more than 200 ppm nitrite in the finished product. When used alone, the 1/4 oz. of nitrite permitted in 100 lb. chopped meat is equivalent to 156 ppm at time of formulation. The nitrite content of the various cured meat products is often quoted as the amount permitted at the time of formulation. However, the amount of nitrite at time of formulation is vastly reduced by the time the cured meat product is consumed. Furthermore, the amount added is often less than permitted levels (Meat Science Review, 1971).

The use of sodium nitrite in curing meat was authorized in 1925 by the Bureau of Animal Industry. The first experiments on the use of nitrite in cured products were authorized in January, 1923. In 1926 (Kerr *et al.*), studies reported by the Bureau of Animal Industry of the USDA in cooperation with the meat industry demonstrated the advantages of using nitrite versus the older nitrate cure. Typically, the nitrite contents of products cured by the older methods were higher and more variable.

The Disappearance of Nitrite

Loss after addition to raw meat. A loss of nitrite upon addition to ground beef before thermal processing was illustrated in the data of Lewis (1936). Of 1000 ppm of nitrite of soda added to beef, a range of 66-78% of the nitrite was recovered. Greenwood (1940) varied this study by adding 2000 ppm nitrate and 500 ppm nitrite to ground beef; he recovered 250 ppm, a 50% loss rate. These data are essentially in agreement with the recent data of Greenberg (1972). His data indicated 53-75% recovery of nitrite after formulation when added to ground raw pork (see following Table).

Item	Nitrite level as formulated, ppm							
	0	50	100	150	200	300	400	500
Recovery, ppm	0	29	70	110	144	158	280	378

Similar recoveries were found in meat industry data obtained in the spring of 1972. Raw beef formulated with 200 ppm had an average of about 155 ppm after mixing. This was further reduced to about 130 ppm after 28 days frozen storage at -30°C. An increase in storage temperature to either 1.7 or 7.2°C increased losses to a residual level of about 20 ppm after 25-28 days of storage. In a parallel study, a mixture of beef and pork stored at 2.2-4.4°C sustained an average loss of about 6.4 ppm nitrite per day after the first day of storage. A loss of 35-50 ppm occurred within the first day from the calculated amount added (156 ppm). A loss rate of 20-25% nitrite was estimated immediately upon addition to raw meat.

Loss during thermal processing. In 1936, Lewis observed a loss of nitrite in hams between curing and soaking (17%) and between soaking and smoking (30%). This observation lead to studies to determine the effect of various temperatures between 48 and 150°C on the disappearance of nitrite in ground beef containing 1000 ppm nitrite at the time of formulation. After 1 hour of heating, losses ranged from 9% to 82%, with losses increasing with increasing temperature. And, after 2 hours of heating, losses ranged from 13% to 98%.

Greenwood (1940) continued the studies on the loss of nitrite by heating used ham pickles containing 289 or 311 ppm nitrite for 20 minutes at temperatures ranging from 60 to 100°C. Nitrite losses increased from 6 to 12% due to the increase in heating temperature. By increasing the length of heating to 60 minutes at 100°C, the loss of nitrite increased to 47%. Greenwood also heated ground beef formulated with 2000 ppm nitrate and 500 ppm nitrite; residual nitrite was 250 ppm prior to heating. Heating for 1 hr. at 38°C to 127°C increased nitrite losses from 28% to 96% and for 2 hr. from 36% to 99%, respectively.

British workers (Brooks et al. 1940) at the same time reported: 31-47% destruction of nitrite in bacon heated for 10 minutes at 100°C; 61-67% destruction in 30 minutes; and, 73-77% in 1 hr. Earlier, Lewis (1936) reported 98% loss in baking ham (2 ppm left), 45% in frying bacon (16 ppm remaining) and 99% in corned beef on boiling (1 ppm remaining) when compared to the amounts present after curing. Tanner and Evans as early as 1934 stated "it has been shown that boiling and frying frequently destroys all of the nitrites not even a trace showing on analyses even with products which have received a commercial nitrite or nitrate cure". A range of nitrite loss during cooking was presented by Ashton (1970) in citing the Food Standards Committee Report on Preservatives, 1959. The range of nitrite loss from frying bacon was 40-90% compared to 20-75% for grilling; the range for boiling ham was 20-80%.

A marked reduction (about 90%) of nitrite due to thermal processing of meat at 110°C for 90 minutes was reported by Johnston et al. (1969). Products made with 75, 150 and 200 ppm nitrite contained 6, 15 and 21 ppm, respectively, after thermal processing. Earlier, Silliker et al. (1958) had stated that finished product made with 78 ppm nitrite "will show between 10 and 20 ppm residue after retorting". The data of Pivnick et al. (1967) indicated a lesser destruction of nitrite during thermal processing. Hams heated to an internal temperature of 70°C and to which 50, 100, 200 and 300 ppm nitrite had been added contained 37, 67, 114 and 160 ppm nitrite, respectively. The percent loss of nitrite increased with increasing input of nitrite (26, 33, 43 and 47%, respectively). Later, Pivnick et al. (1969) reported much less recovery of nitrite after thermal processing and an increased loss with increased severity of the thermal process. Canned ground pork made with 146 ppm nitrite and thermally processed to Fo = 0, 0.15, 0.29, 0.61, 1.27, 2.36 and 3.7 had 101, 64, 51, 49, 27, 17 and 15 ppm nitrite after processing, respectively (31 to 90% loss).

One of the most comprehensive studies on nitrite depletion in ham was reported by Nordin in 1969. He concluded that : the rate of depletion is proportional to concentration and exponentially related to temperature and pH; and, it doubles for each increase of 12.2°C in temperature or a decrease in 0.86 pH units. The depletion of nitrite was described by the equations:

Log $NaNO_2$ concentration = a + bt, where a is the log of the initial concentration, b is the constant depending on pH and temperature and t is time;

Log_{10} (1/2 life) = 0.65 - 0.025 (Temperature, °C) + 0.35 (pH)

In a recent report, Greenberg (1972) presented data on the nitrite content of canned ground ham after processing to an internal temperature of 68°C. Recoveries of nitrite for the 8 levels of nitrite (0, 37, 65, 96, 139, 155, 268, 352 ppm) after heat processing were very similar to values found after formulation and before heat processing (0, 29, 70, 110, 144, 158, 280, 378 ppm, respectively). The difference in results of this study with most others may have been due to less time required to heat process the product because of the size of can used (208 x 107, 85 gm. cans). On the other hand, canned hams having 130 ppm nitrite before thermal processing had 50 ppm after thermal processing, a loss of about 61% (industry data, 1972). Lesser losses were found in frankfurters during thermal processing in a recent industry study (1972). Nitrite losses averaged 34% to yield an average of 38 ppm in the finished product.

In another industry study (1972), liver sausage was formulated with 156 ppm sodium nitrite and heat processed to an internal temperature of 62.8°C or 68.3°C. The sausage processed to the lower temperature contained an average of 73 ppm (53% loss) compared to 21 ppm nitrite (86% loss) in the product processed to the higher temperature, approximately a fourfold difference due to temperature of processing.

The results of an interesting study on the residual levels of nitrite in Rapid Processed (40 min.) or Conventional Processed (16 hr. from stuffing to stripping) wieners were recently obtained (1972, industry data). In the Rapid Process, the wieners averaged 37 ppm nitrite (range, 32-44) compared to 20 ppm (range, 14-24) for the Conventional Process. Ten runs were completed and the wieners were formulated with 115 ppm nitrite.

Losses in storage. The dependence of the rate of disappearance of nitrite upon "the temperature of storage and probably the numbers and activity of the bacteria present" was noted by Tanner and Evans in a 1934 report. In 1967, Pivnick and co-workers, reported the amounts of nitrite (ppm) in cooked, sliced ham after storage in air-impermeable plastic pouches for 1 week at 3 temperatures as follows:

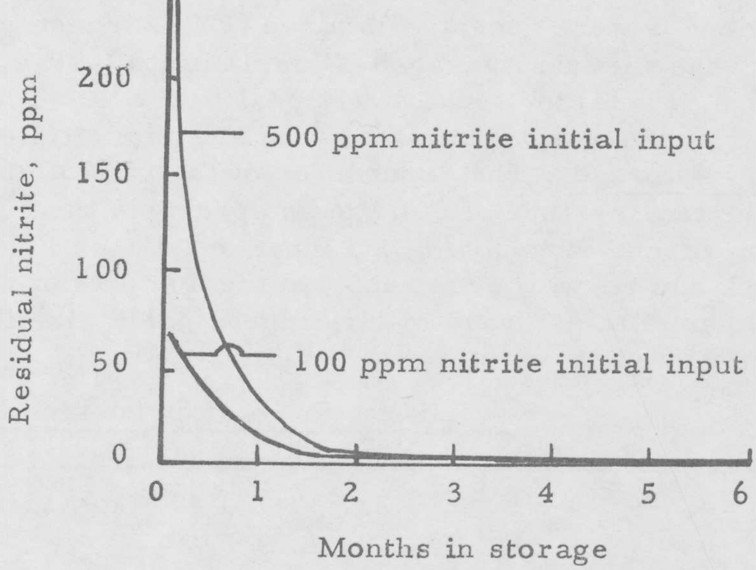
Temperature of storage, °C	Nitrite found after cooking, ppm				
	0	37	67	114	160
20	0	23	48	111	130
25	0	9	14	35	42
30	0	9	9	9	15

The same group of workers (Pivnick et al. 1969) presented data on the amount of nitrite remaining in canned ground pork after heat processing (146 ppm at time of formulation) and 18 months of storage at 30°C. Product processed to Fo = .15 to 3.70 had a range of 64 to 15 ppm nitrite after thermal processing and 1.3 to 4.2 ppm nitrite after 18 months of storage.

In a current industry study, canned ground hams made only with nitrite and having 50 ppm nitrite after heat processing, had the following amounts of nitrite after refrigerated storage by weeks: (1) 51; (2) 39; (3) 38; (4) 33; (5) 30; (6) 28; (7) 24; (8 weeks) 21 ppm.

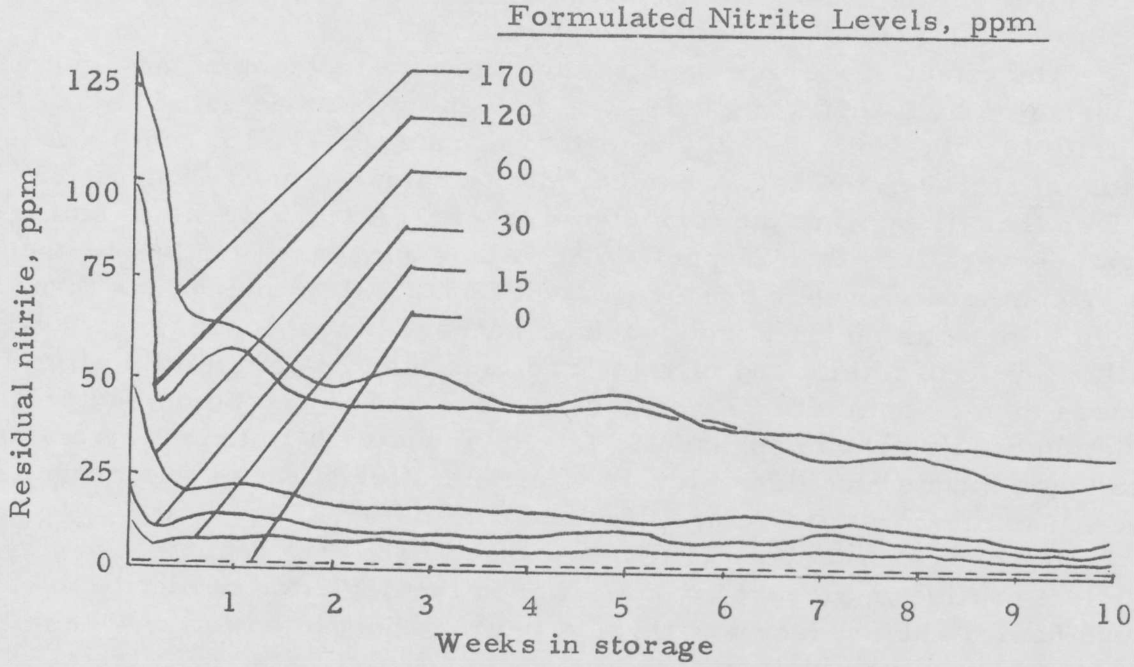
The effect of storage upon residual nitrite in vacuum packaged bologna is illustrated by industry data (1972). Bologna was made with varying levels of nitrite (0, 50, 100, 150, 200 ppm) and nitrate (0, 75, 150 ppm). After 1 week of storage at 7.2°C, residual nitrite values ranged from 16-25% (all less than 41 ppm) of the formulated levels. After 5 weeks of storage all values were less than 21 ppm. The values decreased further to about 7 to 17 ppm after 7 weeks of storage, with most values being less than 10 ppm. In a companion study, vacuum packaged meat loaves, made with similar levels of nitrite and nitrate, had less than 29 ppm nitrite after 1 week and less than 14 ppm after 7 weeks of storage at 7.2°C. Some bacterial reduction of nitrate was apparent. Loaves made with 150 ppm nitrate and up to 150 ppm nitrite had higher levels of nitrite after 5 weeks of storage than 1-week samples; nitrite values declined thereafter.

Recently, Greenberg (1972) presented data (see Figure following) on the effect of time in storage at 26.7°C upon the depletion of nitrite in canned, ground ham. The product was thermally processed to an internal temperature of 68°C and was formulated with varying levels of nitrite and nitrate.



In discussing his results, Greenberg stated "even at 500 ppm initial input, residual nitrite was below 100 ppm within 2 weeks".

The results of an AMI study (1972, in cooperation with Armour and Company) on the depletion of nitrite in vacuum packaged bacon during storage at 7.2°C are in the following Figure. The "0" values for nitrite are analyses after pumping.



Recent industry data (1972) illustrate the effect of storage upon nitrite depletion in wieners. Wieners were formulated with 112 ppm nitrite and made with either a 40-minute Rapid Process or a 16-hour Conventional Process. After stripping, wieners made by the Rapid Process had an average of 37 ppm nitrite (32-44 ppm) compared to 20 ppm (range, 14-24 ppm) in the Conventional Process. After 3 weeks of storage at 7.2°C, the nitrite content of the wieners was essentially similar (11 ppm (range, 8-12 ppm) and 15 ppm nitrite (range, 9-23 ppm), respectively).

On the other hand, the reduction in nitrite content in storage has not always been large. Liver sausage stored at 6.8°C for 3 weeks (industry data) had only an imperceptible decrease in nitrite content from "0" day when heat processed to 62.8°C (72.9 to 69.2 ppm) or 68.3°C (20.6 to 18.1 ppm).

The depletion of nitrite in bacon after its addition, and after processing and storage, is illustrated in the following partial data taken from a current AMI study (1972, in cooperation with Swift & Company):

	Analytical nitrite values, ppm					
Formulated level, ppm[a]	Before smoking	After smoking	7 days storage 7.2°C	7 days storage 26.7°C	28 days storage 7.2°C	28 days storage 26.7°C
0	0	0	0	0	0	0
30	26	10	8	3	6	1
60	54	19	12	1	7	1
120	96	46	20	6	10	1
170	220	95	48	14	26	0
340	380	160	104	56	51	3

[a]Calculated on the basis of 10% of pump retained (no nitrate in pickle).

The recovery of nitrite from formulated values ranged from 30-56% after smoking and from 17-31% after 1 week of storage at 7.2°C.

Losses of nitrite have been reported in canned ground hams heat processed to 70°C internal temperature and held in frozen storage (Hougham and Watts, 1958). Hams produced with 100, 200 and 400 ppm nitrite had 71, 143 and 271 ppm, respectively, after 2-3 days storage at 25°C. After (1) 33-35 days storage at 25°C and (2) storage from this point to 188 days in the frozen state, the hams had (1) 15, 26.5, 68.5 and (2) 12, 28, 3.3 ppm nitrite, respectively.

Mechanism of Nitrite Losses

The chemical reactions of nitrite in meat resulting in the disappearance of nitrite are not known. Lewis (1936) of the Institute of American Meat Packers (now, American Meat Institute) treated glycine with 10% excess nitrite. The reaction was characterized as vigorous at 100°C and of the gases evolved 93-95% was nitrogen and the remainder carbon dioxide. He then reacted peptone (to represent a partially hydrolyzed protein) with nitrite (1000 ppm) at boiling temperature. Of the gases collected, 6.22% was CO_2 and NO_2, 42.06% was NO and 51.72% was N_2 by volume. He also presented data on the rate of evolution of gas when nitrite-treated beef was heated at 100°C.

Later the same group of workers (Greenwood, 1940) demonstrated that the heating of increasing levels of peptone (0-5%) in water (100°C for 30 min.) with 500 ppm nitrite, resulted in increasing losses of nitrite (0-68%). Likewise, the heating of the water-peptone-nitrite solution with increasing concentrations of NaCl (0-20%) gave similar results (68-98%). The exact mechanism by which salt influenced the results was not known. And, reducing the pH of the solution from 5.75 to 5.30 increased the loss of nitrite from 68 to 90%.

Rose and Peterson (1953) concluded that the reducing systems in meat caused a progressive destruction of nitrite that was independent of bacterial activity. They also noted increased losses with decreased pH and increased temperature up to the temperature of protein denaturation.

The chemistry of pigment fading in cured meat was examined by Draudt and Deatherage (1955). They found a portion of the nitric oxide of heat denatured globin nitric oxide myohemochrome further oxidized to yield nitrite and nitrate ions in the presence of light and air or air alone. They suggested that the nitric oxide could be lost as a gas, possibly nitric oxide or nitrogen dioxide. Also noted was the production of a gas, possibly CO_2, in the oxidation of the hemochrome in air and in high intensity visible light. Earlier, Greenberg et al. (1943) indicated nitrite reacted with oxygenated heme pigments to yield nitrate and methemoglobin.

Walters and Taylor (1963) incubated samples of pork plus nitrite and confirmed the evolution of nitric oxide, nitrogen, carbon dioxide and nitrogen dioxide in one out of four trials. Recently, Walters (1971) indicated the gaseous products of the incubation of muscle minces with $Na^{14}N_2O$ and $Na^{15}NO_2$ under a reduced pressure of argon as NO, N_2O, CO_2, N_2 and O_2.

The effect of pH upon the rate of depletion of nitrite was thoroughly investigated by Nordin (1969) in which nitrite depletion was described as doubling for each decrease in 0.86 pH units. GDL (glucono delta lactone) decreases the pH of finished sausages by about .2 to .3 pH units when used at permitted levels (8 oz. per 100 lb. meat). Sair (1963) showed a reduction in residual nitrite in bologna formulated with 156 ppm from 78 ppm for the control to 48 ppm with 4 oz. GDL to 31 ppm with 8 oz.

Ando and associates of Japan (1963a) studied the effects of polyphosphates on the color of cooked sausages. The addition of 0.5% disodium pyrophosphate ($Na_2H_2P_2O_7$) resulted in a decreased pH (about .1 pH unit from control), increased reducing power of the meat, less residual nitrite in the finished product and superior color formation and stability when compared to the control or sausages made with the addition of other more basic polyphosphates. Earlier, the same group (Ando et al. 1961) reported somewhat similar results with the use of an acidic orthophosphate (NaH_2PO_4 and KH_2PO_4) when compared to the control or more basic orthophosphates.

The effect of sulphydryl groups on nitrite loss was studied by Mirna and Hoffmann (1959). Model experiments with beef and pork showed a decrease in nitrite content concomitant with a decrease in SH groups. Their work with low-molecular SH-compounds suggested that the products formed were nitrosothioles (RS-NO).

Reducing agents, such as sodium ascorbate, are widely used to accelerate the development of color and increase the stability of color of cured meat products. The paper of Fox (1966) provides an excellent review of the role of ascorbic acid in cured meat pigments.

In an early study (Hollenbeck and Monahan, 1953), it was noted that the addition of ascorbic acid to an acidified sodium nitrite-water solution yielded a "marked increase in nitric oxide production". The production of increased quantities of nitric oxide, they postulated, largely accounted for the more rapid formation of nitroso pigments in meat curing systems. Later, in somewhat similar studies, Ando et al. (1963b) added sodium ascorbate (100 ppm) to a buffered nitrite (100 ppm) solution (pH, 5.5) at 0°C and found drastically reduced recoveries of nitrite (by AOAC method) immediately after adding the ascorbate (26-35 ppm). The effects of time, temperature, pH and salt concentration upon nitrite and ascorbate recoveries in curing pickles have been reported (Hollenbeck and Monahan, 1955). Pickles with high concentrations of salt, stored under refrigeration and in the pH range of 6.5 to 7.0 had slow reaction rates between nitrite and ascorbate.

Data on the effect of ascorbate on residual nitrite in cured meat products are limited. However, results obtained from industry (1972) on liver sausage are interesting. Liver sausage heat processed to 62.8°C without ascorbate had 71 ppm nitrite compared to 33 ppm nitrite in the sausage made with ascorbate. However, when both types of sausages were heat processed to 68.3°C, both contained 16 ppm nitrite. The disappearance of nitrite was almost imperceptible during refrigerated storage for up to 3 weeks for the four treatments. Frankfurters also were made with and without ascorbate. After heat processing to 68.3°C, the differences between the control franks and those made with ascorbate were small (27 to 32 vs. 22 to 28 ppm residual nitrite, respectively).

Finally, a very interesting aspect of the effect of ascorbate upon nitrite was recently reported by Mirvish and co-workers (1972). They reacted nitrite with several nitrosatable compounds in the presence or absence of ascorbate. Ascorbate, under their laboratory conditions, served as an effective blocking agent in the formation of N-nitroso compounds with most of the six nitrosatable compounds tested.

Survey of Nitrite in Cured Meat Products

In 1936, the amounts of nitrite (ppm) in various cured products made with a combination of nitrite and nitrate were reported by the Institute of American Meat Packers (Mighton) in a survey of products at the retail market as follows:

Item	No. of samples	$\overline{X}$	Range
Smoked hams	6	52	7 - 145
Picnics	6	54	9 - 136
Boiled hams	10	59	11 - 87
Canned spiced hams	6	17	5 - 55
Canned corned beef	6	3	3 - 5
Pork butts	6	86	31 - 232
Frankfurters	6	84	55 - 146
Bologna	6	61	44 - 86
Raw bacon	6	13	4 - 22
Fried bacon	6	19	4 - 58

Lewis (1937) continued the survey of cured products made with both nitrite and nitrate and reported the following analytical results for nitrite (ppm) for several brands of commercial products obtained at retail:

Item	No. of brands	$\overline{X}$	Range
Hams	5	80	34 - 184
Bacon	5	16	11 - 29
Hams, boiled	5	49	31 - 63
Corned beef	5	75	1 - 216
Bologna	10	71	0 - 185
Frankfurters	15	54	20 - 94
Bologna	5	72	60 - 114
Frankfurters	12	69	42 - 116
Frankfurters	8	72	13 - 195

Partial results of the amounts of nitrite (ppm) recovered in various meat products sent to the American Meat Institute Laboratory for analysis were reported in 1971 (Meat Science Review) as follows:

Ham	13.6, 6.4, 6.4, 14, 8, 6, 6.2, 6.2, 12, 31.2, 29, 20, 480, 138, 50

(Table continued on next page)

Bacon	78, 125, 272, 218, 142, 1.3, 92, 76, 43.1, 3.4, 17, 35.5, 34, 29, 1.45, 18.25, 25, 10, 20, 37.5, 47.5
Picnics	22, 2.5, 12, 2.8
Bologna	36, 92, 62, 43, 45
Franks	0, 120, 113

The history of the above products prior to analysis for nitrite was not known. Generally, however, products are sent in a refrigerated condition to the laboratory for analysis shortly after production.

A limited amount of data was obtained on the nitrite content of various meat products analyzed during 1970 from the Chicago MIP laboratory. Results in ppm nitrite for a number of products reported were (Meat Science Review, 1971):

Beef brisket	0, 0, 5, 10, 0, 0, 0, 0, 0, 10, 0, 10
Smoked hams	75, 35, 75, 120, 60, 0, 50, 5
Smoked picnics	75, 10, 30, 100, 0, 5, 100, 50
Pork belly	100, 75, 50
Bacon	5, 50, 125, 5, 50, 20
Pork jowls	50, 75, 75
Beef tongue	10, 10, 0, 10, 0, 5, 20
Loaves	15, 0, 0, 10, 10, 25, 50, 15, 5, 5, 0, 25, 10, 65, 50, 15
Franks, wieners	40, 20, 60, 0, 19, 90, 50, 5, 0, 5, 0, 10, 40, 10, 5, 25, 5, 50, 0, 10, 0
Bologna	5, 0, 10, 5, 20, 50, 40, 50, 0, 25, 5
Knockwurst	60, 50, 50, 50, 5, 50, 0
Polish sausage	0, 35, 5, 0, 60, 0, 0

The products were analyzed for nitrite up to 2 weeks after sampling and, presumably, samples were taken shortly after production. Thus, the data most likely reflect nitrite levels found up to about 2 weeks after production.

Data in the following Table were obtained this summer from industry on the amounts of nitrite found in several shelf-stable and pasteurized products. The products were analyzed for nitrite within 1-2 days after production.

Product	Theoretical input of $NaNO_2$, ppm	No. of samples	$\overline{X}$, ppm	Range, ppm
Shelf-stable				
Lunch meat	144	20	48	13-61
Lunch meat	144	30	47	32-65
Vienna sausage (packed in meat broth)	124	33	8	6-16
Canned ham	172	34	11	3-37

(Table continued on next page)

Product	Theoretical input of $NaNO_2$, ppm	No. of samples	$\overline{X}$, ppm	Range, ppm
Pasteurized				
Bulk lunch meat	144	30	45	13-172
Bulk lunch meat	144	33	28	13-180
Bulk lunch meat	144	30	45	32-102
Bulk lunch meat	144	31	43	14-128
Canned ham	172	34	62	17-130
Canned ham	172	32	54	26-128
Canned ham	111	34	34	18- 55

Additional analytical data were obtained from another industry firm in which data were pooled from five of their plants between December 1971, and June, 1972. The amount of sodium nitrite used in production was according to amounts permitted by Federal Regulations. The products were analyzed within 1-2 days after production. Results in ppm nitrite are in the following Table:

Product	No. of samples	$\overline{X}$	Range	Standard deviation
Franks	34	38.2	15-80	13.1
Cold cuts, Bolo sausage	23	35.6	0-76	18.1
Bacon	128	95.7	24-170	29.3
Smoked ham	56	47.6	16-100	19.2
Other smoked meats[a]	18	79.4	19-115	23.3
Canned hams	93	55.8	0-160	32.4
Miscellaneous[b]	83	48.5	0-178	34.0

[a]Includes Canadian bacon, picnics, center-cut loin, tongue.
[b]Mostly cooked ham but also includes corned beef and 12 oz. luncheon meat.

Variability in Analytical Results for Nitrate-Nitrite

A yearly Check Sample Program has been conducted by the AMI in cooperation with a number of laboratories. Nitrate and nitrite analyses were included in the program. A brief summary of the pooled results for nitrate and nitrite analyses from 1965 through 1972 is in the following Table:

Product category	No. of results NO$_3$	NO$_2$	Nitrate[a] $\overline{X}$, ppm	SD, ppm	CV, %	Nitrite[a] $\overline{X}$, ppm	SD, ppm	CV, %
Uncooked meat	37	261	518	326	52	110	51	63
Processed meat	140	507	187	137	81	69	52	76
Dry cure mix	130	198	1.1	0.6	56	4.9	0.5	21

[a]Average values represent an average value of yearly average values.

One of the major problems in evaluating the nitrate and nitrite contents in cured meat products is the variability in results. Variability is expected in raw meat and processed meat Check Samples as shown in the preceding Table because of time and temperature differences prior to analysis. However, variability was also apparent with the Dry Cure Mix. These data suggest the need for examination and improvement of current nitrate-nitrite analytical methods.

Summary

The amount of nitrite present in a given cured meat product is dependent upon factors such as, time, temperature, reducing activity, initial input and pH. The disappearance of nitrite when added to raw meat ranges from about 20 to 50%, with most values tending to cluster around 25%. Nitrite losses during heating or thermal processing are variable, most likely being related to time and temperature. Nitrite losses during heating reported herin range from practically none to an almost total disappearance. The recovery of nitrite in various commerically produced cured meat products shortly after production (within 1-2 days) is also variable but average values ranged from 8 to 96 ppm. Further losses of nitrite occur in storage and the amount recovered is related to time and temperature. Finally, further losses of residual nitrite occur during cooking before consumption.

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