K/8

RECENT STUDIES ON THE ROLE OF SODIUM NITRITE AND SODIUM NITRATE IN CURED MEAT PRODUCTS

BY

HAROLD K. HERRING

ARMOUR AND COMPANY

801 W. 22nd STREET

OAK BROOK, ILLINOIS 60521

U.S.A.

FOR PRESENTATION

AT THE

19TH EUROPEAN MEETING OF MEAT RESEARCH WORKERS

PARIS, FRANCE

September 2 - 7, 1973

NEUE UNTERSUCHUNGEN UEBER DIE ROLLE, DIE SODIUMNITRIT UND SODIUMNITRAT IN HALTBAR GEMACHTEN FLEISCHPRODUKTEN SPIELEN

Harold K. Herring

Diese Abhandlung ist ein Ueberblick ueber Arbeiten, die sich mit der Verwendung von Sodiumnitrit (Nitrit) und Sodiumnitrat (Nitrat) in gehackten Schinkenprodukten und in Wiener Wuerstchen und der Verwendung von Nitrit in Speck beschaeftigen. Diese Untersuchungen wurden gemeinsam vom American Meat Institute, der Drug Administration und dem U.S. Department of Agriculture durchgefuehrt, um die Rolle festzustellen, die Nitrit und Nitrat bei der Produktion von botulinalem Toxin, bei der Bildung von Nitrosamin und den Erfordernissen bei der Herstellung von haltbar gemachten Fleischprodukten spielen.

Bei gehacktem Schinken beeinflusst die Menge Nitrit, die Fleisch beiggeben wird, die Toxin Produktion durch Clostridium botulinum. Bei 90 C.botulinum Sporen pro gramm Fleisch trat botulinales Toxin in den Proben auf und formulierte mit 150 μgr aber nicht mit 200 μgr Nitrit pro gramm Fleisch. Bei einer Sporenanzahl von 5000/gr. trat Toxin in den Proben mit 400, aber nichtin denen mit 500 μgr Nitrit pro gramm des Produktes, das bei 27 Grad C. im Inkubator war, auf.

In Wiener Wuerstchen wurde Toxin nach 14 Tagen Inkubation unter 27 Grad C. entdeckt, falls kein Nitrit beigefuegt worden war. Botulinales Toxin trat nach 56 Tagen Inkubation bei der geringsten beigefuegten Menge Nitrit (50 μgr/gr.) auf. Groessere Mengen von Nitrit verhinderten die Toxinproduktion waehrend der Inkubationszeit voellig. Das Aroma der Wiener Wuerstchen mit Nitrit war groesser als das der ohne Nitrit.

Bei einer Sensitivitaet von 10ng/gr. wurden weder im gehackten Schinken, noch in den Wiener Wuerstchen Nitrosamine entdeckt. Die Verwendung von Nitrat zeigte nur geringen Einfluss auf die Toxinproduktion in gehacktem Schinken oder Wiener Wuerstchen.

In vakuumverpackten Speck wurden mindestens 30 μgr/gr Nitrit fuer die Aufnahme durch den Speck und die Bildung der richtigen Faerbung und fuer die Verminderung der Erzeugung von Nebengeschmack benoetigt. Konzentrationen von bis zu 24 gr/gr N-nitrosopyrrolidin (NP) wurden durch Braten des Specks mit 170 μgr/gr von beigefuegtem Nitrit gebildet. Die Verwendung von Mikrowellen fuer das Kochen verringerte NP auf 5 ngr/gr. oder weniger. Auch die Verwendung von Ascorbaten verringerte die NP Konzentrationen in gebratenem Speck.

Im Speck resultierten erhoehte Nitrit Mengen in einer verringerten Wahrscheinlichkeit der C. botulinum Toxinformation in Speck, der entweder durch die Eurke oder in in Scheiben geschnittenen Speck nach der Verarbeitung okuliert wurde. Botulinales Toxin entwickelte sich in Speck, der mit 200 Sporen pro Gramm okuliert wurde und 120 gr/gr Nitrit oder weniger enthielt, wogegen bei 170 µgr/gr Nitrit oder mehr kein Toxin entdeckt wurde.

Da Nitrit bei einer Lagerung bei 27 Grad C. sehr schnell verschwand, wurden zur Bildung der hemmenden Substanz(en) in den Produkten, die antibotulinale Effekte boten, anfaenglich hohe Konzentrationen Nitrit benoetigt.

ETUDES RÉCENTES SUR LE RÔLE DU NITRITE DE SODIUM ET NITRATE DE SODIUM DANS LES PRODUITS FUMÉS DERIVÉS DE LA VIANDE

Par Harold K. Herring

Ce document est une revue des travaux sur l'emploi du nitrite (nitrite) de sodium et nitrate (nitrate) de sodium dans un produit hâché dérivé du jambon et dans les saucisses types viennois, et l'emploi du nitrite dans le lard. Les études furent réalisées en coopération entre l'Institut Américain de la Viande (American Meat Institute) et l'Administration des Denrées Alimentaires et Produits Pharmaceutiques (Food and Drug Administration) et le Ministère de l'Agriculture des Etats- Unis (United States Department of Agriculture) pour déterminer le rôle du nitrite et du nitrate sur la production de la toxine botulinale, la formation nitrosamine, et les besoins de fabrication parmi les produits fumés dérivés de la viande.

Dans le jambon hâché, le niveau de nitrite ajouté à la viande influença la production de toxine par Clostridium botulinum. Avec 90 spores de botulinum C. par gramme de viande, la toxine botulinale se développa en échantillons formulés avec 150 ug mais pas avec 200 ug de nitrite par gramme de viande. Avec un niveau de spore de 5.000/gr. la toxine fut décelée dans les échantillons avec 400 mais pas 500 ug de nitrite par gramme de produit incubé à 27° C.

Dans les saucisses type viennois, la toxine botulinale fut décelée après 14 jours d'incubation à 27° C sans addition de nitrite. La toxine botulinale se développa après 56 jours d'incubation au niveau le plus bas de nitrite ajouté (50 ug/gr.) . Des niveaux plus élevés de nitrite retenirent complètement la production de toxine durant la période d'incubation. La saveur des saucisses type viennois faites avec le nitrite fut meilleure que celle des saucisses faites sans nitrite.

A une sensitivité de 10 ng/gr. on ne décela point de nitrosamines dans le jambon hâché ou dans les saucisses type viennois. L'emploi de nitrite démontra peu d'effet sur la production de toxine dans le jambon hâché et les saucisses type viennois.

Dans le lard empaqueté à vide, il fallut au moins 30 ug/gr. de nitrite pour l'acceptation du lard et la formation de la couleur fumée et pour réduire le taux de formation de rupture de saveur; et dans le lard empaqueté par système autre que celui à vide, il fallut 60 ug/gr. de nitrite. Des concentrations de N- nitrosopyrrolidine (NP) de jusqu'à 24 ng/gr. furent formées dans la friture de lard avec 170 ug/gr. de nitrite ajouté. Les concentrations de NP furent plus basses avec des niveaux de nitrite plus bas. L'emploi de cuisson par micro-onde abaissa le NP à 5 ng/gr. ou moins.

Egalement, l'emploi d'ascorbates réduisit les concentrations de NP dans le lard frit.

Dans le lard, les niveaux de nitrite augmentés amenèrent une possibilité réduite de formation de toxine botulinum C. inoculée soit par la saumure ou dans le lard en tranches après traitement. La toxine botulinale se développa dans le lard inoculé avec 200 spores par gr. et contenant 120 ug/gr. de nitrite au moins, alors qu'à 170 ug/gr. de nitrite ou moins, on ne décela pas de toxine.

Du fait que le nitrite disparassait rapidement durant l'emmagasinage à 27° C., il était besoin de hautes concentrations de nitrite pour la formation de la substance inhibiteuse dans les produits offrant l'effet anti-botulinal.

НОВЫЕ ИССЛЕДОВАНИЯ О РОЛИ АЗОТИСТО-КИСЛОГО И АЗОТНО-КИСЛОГО НАТРИЯ В КОНСЕРВИРОВАННЫХ МЯСНЫХ ПРОДУКТАХ

Гарольд Н. Херринг

Эта статья является обзором употребления нитрита и нитрата в крошеных продуктах ветчины и в "венских" (франкфуртер), также эта статья обслужает употребление нитрита в konченой свиной грудинка (секонс). Эти исследования были осуществлены кооперативно (совместно)-- Американским мясным институтом. Уравлением контроля пищевых продуктов и медикаментов, и также американским Министерсвом земледелия. Все это с целю установить роль и влияние нитрита и нитрата на образование (на распространение) ботульно яда, на образование нитросамина, и также постараться определить производственые нужди в консервировании мясных продуктов.

В крошеной ветчине уровень нитрита, включенный в мясо, повлиял на образование токсина посредством колострида-ботулина.

При 90 градусов цельсия, в спорах (зародышах) ботулина в грамме мяса, ботулиновый токсин развился в образцах, формулированных со 150 микрограммами, но не с 200 микрограммами нитрита в одном грамме мяса.

При уровне 5,000 спор в 1 грамме, токсин был обнаружен в образцах с 400, но не с 500 микрограммами нитрита на 1 грамм продукта, введенного при 27 градусов Цельсия.

В "венских" (франкфуртер) ботулиновый токсин был обнаружен после 14 дней инкубации при 27 градусов Цельзия, когда нитрит не был включен. Ботулиновый токсин развился после 56 дней инкубационного периода при самом ниском уровне включенного нитрита (50 микрограммов на 1 грамм).

Более высокие уровни полностью задержали образовывание токсина во время инкубационного периода.

Вкус "венских" приготовленных со включением нитрита, оказался лучше, чем те "венские", которые были приготовлены без нитрита.

Никаких нмтросаминов не было обнаружено ни в крошеной ветчине, ни в "венских" при уровне чувствителности в 10 нг/г.

Употребление нитрата оказало незначителное влиянкие на образование токсина в крошеной ветчине и в "венских."

В беконе, герметически запакованном, нужны были, по меншей мере, 30 мг/г нитрита для того, чтобы этот нитрит был воспринят, и чтобы цвет бекона был сохранен без изменений, также чтобы процесс образовывани безкусовзой дозы (зоны) уменшен; в не герметически запакованном беконе, для тех же целей нужни были 60 мг/г.

Концентрации "Н"--нитро-сопыромида (НП) вплоть до 24 нг/г образовались в процессе жарения бекона со 170 мг/г добавленного нитрита. Концентрации НП были ниже при боле низких уровнях нитрита.

Употребление системы микроволнистой варка снизило НП до 5 нг/г и ниже.

Также употребление аскорбатов в жареном беконе уменьшило концентрации НП.

В беконе--увеличенные уровни нитрата имели результатом уменьшенную вероятностб образования стоградусного ботуминого токсина, введенного после обработки или путем рассола или в нарезанные ломтики грудинки. Ботулиновый токсин образовался в беконе после введения 200 спор на грамм, и содержащих 120 мг/г нитрата или даже меньше, между тем, как при 170 мг/г нитрита или больше, никакого токсина не было обнаружено.

В виду того, что нитрит быстро испарялся во время его хранения в складе, при температуре 27 градусов Цельзя, то нужни были высокие первоначальные концентрации нитрита для образовывания задерживающих веществ в продуктах, и таковые вещества обладали свойствами противо-ботулиного еффекта.

RECENT STUDIES ON THE ROLE OF SODIUM NITRITE AND SODIUM NITRATE IN CURED MEAT PRODUCTS

SUMMARY

This paper is a review of research on the use of sodium nitrite (nitrite) and sodium nitrate (nitrate) in a chopped ham product and in wieners and of the use of nitrite in bacon. The studies were carried out under the auspicies of the American Meat Institute[1], and with the active participation of the Food and Drug Administration and the United States Department of Agriculture to determine the role of nitrite and nitrate on botulinal toxin production, nitrosamine formation, and manufacturing needs in cured meat products.

In chopped ham, the level of nitrite added to the meat influenced toxin production by Clostridium botulinum. With 90 C. botulinum spores/g of meat, botulinal toxin developed in samples, formulated with 150 ug but not with 200 ug of nitrite per g of meat. At a spore level of 5,000/g toxin was detected

---

[1]All Research in the meat industry was carried out in the laboratories and plants of:

1. Armour and Company
2. Hormel & Company
3. Oscar Mayer & Company
4. Swift & Company

in samples with 4000 but not 500 ug of nitrite per g of product incubated at 27°C.

In wieners, botulinal toxin was detected after 14 days of incubation at 27°C when nitrite was not added. Botulinal toxin developed after 56 days of incubation at the lowest level of added nitrite (50 µg/g). Higher levels of nitrite completely inhibited toxin production during the incubation period. The flavor rating of wieners made with nitrite was higher than that of wieners made without nitrite.

No nitrosamines were detected at a sensitivity of 10 ng/g in the chopped ham nor in wieners. The use of nitrate showed little effect on toxin production in chopped ham and wieners.

In vacuum packaged bacon at least 30 µg/g of nitrite was needed for bacon acceptance and cured color formation and for decreasing the rate of formation of off-flavor; and in non-vacuum packaged bacon, 60 µg/g nitrite was needed. Concentrations of N-nitrosopyrrolidine (NP), up to 24 ng/g were formed in frying of bacon with 170 µg/g of added nitrite. Concentrations of NP were lower with lower nitrite levels. Use of microwave cooking lowered NP to 5 ng/g or less. Also, use of ascorbates reduced or eliminated NP in fried bacon.

In bacon, increased nitrite levels resulted in a decreased probability of C. botulinum toxin formation in bacon inoculated either via the pickle or into sliced bacon after processing. Botulinal toxin developed in bacon inoculated with 200 spores per g and containing 120 ug/g nitrite or less, while at 170 µg/g nitrite or more, no toxin was detected under abuse conditions at 27°C.

Since nitrite disappeared rapidly during storage at 27°C, high initial concentrations of nitrite were needed for the formation of the inhibitory substance(s) in the products that offered the anti-botulinal effect.

RECENT STUDIES ON THE ROLE OF SODIUM NITRITE AND SODIUM NITRATE IN CURED MEAT PRODUCTS

Harold K. Herring
Armour and Company
801 W. 22nd Street
Oak Brook, Illinois 60521
U.S.A.

The use of salts of nitrite and nitrate in cured meat products has received considerable attention in recent years. There is interest in the role of these curing salts on the possible formation of nitrosamines in meat products and the stomach and in the necessity for reducing the potential for growth of Clostridium botulinum. Cured meat products such as ham, wieners, bacon, dry sausage, etc., differ from each other in many respects. The formulation, processing conditions, marketing, and packaging techniques for each product differ from the others.

With these, as well as other considerations in mind, the meat industry through the American Meat Institute, in cooperation with the United States Department of Agriculture and the Food and Drug Administration, initiated a series of studies on its different types of meat products to determine the role of nitrite and nitrate on botulinal toxin production, nitrosamine formation, and manufacturing needs.

This paper is a brief review of the work that has been conducted on the use of sodium nitrite and sodium nitrate in a chopped ham product and in wieners and of sodium nitrite in bacon.

Perishable Canned Comminuted Ham

The first collaborative study was conducted on a perishable, canned, comminuted ham (Greenberg, 1972). The detailed study appeared in the March Issue of Applied Microbiology (Christiansen, et al., 1973). Canned ham does not receive sufficient thermal processing to prevent the possibility of botulinal toxin production and is labeled "Keep under refrigeration." However, it is often temperature abused at the retail and consumer levels.

In the study eight levels of nitrite (0, 50, 150, 200, 300, 400, and 500 µg/g) and four levels of nitrate (0, 500, 1000, and 2000 µg/g) were tested. C. botulinum spore inoculum (five type A and five type B strains) levels were 0, 100, and 10,000 spores/g of meat. The product was formulated with 2.5% sodium chloride, 0.5% dextrose, and 0.02% sodium isoascorbate. The product was canned and cooked in 77°C water to an internal temperature of 68.5°C. Product was chilled, stored at 7° and 27°C, and then observed and analyzed at weekly intervals for botulinal toxin.

The authors (Christiansen, et al., 1973) noted that although nitrite decreased on contact with meat, cooking had little effect on nitrite concentrations. Storage at 27°C caused a rapid depletion of sodium nitrite while the reduction of nitrite at 7°C was less rapid. There was little change in nitrate concentrations during cooking and storage.

The level of nitrite added to the meat influenced growth and toxin production by C. botulinum. Also, the concentration of nitrite needed to effect complete inhibition was dependent on the inoculum level. The rate of toxin production was decreased, and the number of toxic cans was reduced by increased nitrite. At a spore level of 90/g they confirmed toxin production up to 150 µg/g of nitrite, but none at 200 µg/g and higher. At a spore level of 5,000 per g, toxin was confirmed up to 400 µg/g of nitrite. However, only 8 of 280 samples with nitrite levels of 200 µg/g or greater were botulinogenic with the high spore inoculum. Nitrate was shown to have a statistically significant inhibitory effect; however, the effect may have been through increased production of nitrite. Nevertheless, the authors concluded the effect of nitrate was not sufficient to be of practical value.

No toxin was produced in canned ham samples stored at 7°C. However, they found that the omission of nitrite led to what was termed nontoxic spoilage. The cans were swollen and the product was sour and had a green discoloration. This spoilage occurred within one month, but was inhibited by use of nitrite.

Samples of ham analyzed with various levels of nitrite and nitrate were negative for 14 volatile nitrosamines with a confirmable sensitivity of 10 ng/g.

Wieners

The next study was conducted on wieners, a product selected to represent those products which are finely comminuted (Bard, 1973). This study appears in detail in the July issue of Applied Microbiology (Hustad, et al., 1973).

Commercial conditions were approximated as closely as possible for formulation and processing of the wieners. Six levels of nitrite (0, 50, 100, 150, 200, and 300 µg/g), four levels of nitrate (0, 50, 150, and 450 µg/g) and two inoculum levels (0 and 620 C. botulinum spores/g) were used. Incubation periods up to 56 days were used and portions of each batch were stored at either 7°C, 27°C, or 21 days at 7°C followed by 27°C for 56 days. The product was formulated with 42.5% pork (50% lean) 31.41% beef (95% lean), 17.13% ice, 3.2% water, 2.51% salt, 1.80% dried corn syrup, 1.02% dextrose, 0.39% spice, and 0.04% sodium ascorbate (ascorbate). Spores were added during the second minute of chopping followed by nitrite and nitrates. After processing and vacuum packaging, samples of each lot were alloted to different storage conditions. Samples were analyzed for botulinal toxin, and nitrite and nitrate periodically during the incubation periods.

During processing the authors noted an average 67% reduction in added nitrite. There was a further depletion of nitrite during storage, but the rate was dependent on temperature, as was observed in the ham study at 27°C, the reduction occurred within the first few days, while at 7°C, concentrations decreased only after 3 weeks of storage. Nitrate also decreased during storage, particularly at 27°C. Small quantities of nitrite and nitrate were present in samples where none was added.

The authors (Hustad, et al., 1973) found that added nitrite suppressed botulinal toxin formation. Toxin was present in 79 of 220 nitrite-free samples. Two samples containing 50 µg/g of nitrite were toxic after 56 days storage at 27°C while no samples became toxic at higher nitrite levels. They indicated that wieners were not a good medium for toxin production by C. botulinum. Nitrate had little effect on toxin production as a large number of toxic samples were detected where nitrate, but not nitrite, had been added.

The authors reported nitrite affected flavor and that wieners containing nitrite had a significantly higher flavor score than did those not containing nitrite.

Also, samples containing varying levels of nitrite and nitrate were analyzed for nitrosamines. None were detected at a confirmable sensitivity of 10 ng/g in uncooked, water cooked, or pan-fried wieners.

Bacon

Preliminary reports were given recently on studies conducted on bacon (Herring, 1973; Greenberg, 1973). In the United States, bacon is that product prepared from pork bellies. It is processed at low temperatures (56 - 60°C) and must be further cooked prior to consumption. The study was designed to determine the effect of nitrite from three distinct aspects; product manufacture and physico-chemical characteristics, nitrosamine formation during cooking, and inhibition of growth of C. botulinum.

Bacon was produced with six levels of nitrite (0, 15, 30, 60, 120, and 170 µg/g) and two packaging types, non-vacuum and vacuum. Nitrate was not incorporated into the study because few processors use it in their curing pickles and use a very short curing time. Bacon was injecto-pumped to retain 10%, a curing pickle containing 13.4% sodium chloride, 2.9% sucrose, 2.5% sodium tripolyphosphate, 0.23% sodium isoascorbate, and varying levels of nitrite. The bellies were processed within five hr. at 54 - 60°C for about 11 hr and to an internal temperature of 53 - 54°C. After chilling to -4°C, the bacon was molded, sliced, and packaged.

There was a 23% decrease in nitrite after pumping and a 60% reduction after processing. However, there was considerable nitrate generated where none was added. Up to 50 µg/g sodium nitrate was present within a few days of processing. Residual nitrite concentrations were a function of added nitrite, being higher with higher added nitrite; and nitrate concentrations were also higher with higher added nitrite.

Added nitrite level had an effect on bacterial growth.

Concentrations of 15 to 60 μg/g had little effect on the lag phase of growth in vacuum packaged bacon. 120 to 170 μg/g of nitrite delayed bacterial growth for four to five weeks.

Flavor stability and acceptance of bacon were also affected by added nitrite level. Bacon produced without nitrite had lower flavor acceptance scores than bacon produced with nitrite. Off-flavor scores were higher initially and increased at a faster rate in bacon with 0 and 15 μg/g nitrite. In non-vacuum packaged bacon containing 0 to 30 μg/g nitrite, sensory tests were terminated early due to mold growth, while bacon with 60 μg/g nitrite or higher were sampled throughout the storage period of 7 weeks and had a lower rate of decline of acceptance score. Thirty μg/g nitrite was needed to produce the pink coloration in vacuum packaged bacon while in non-vacuum packaged bacon 60 μg/g was required.

Added nitrite level and cooking method affected the formation of nitrosamines. Since uncooked samples contained no nitrosopyrrolidine (NP), it had formed during cooking. NP increased with increasing nitrite levels. Pan fried samples had the highest (0 - 24 ng/g) oven baked samples intermediate (0 - 14 ng/g), and microwave cooked samples the least (0 - 5 ng/g) NP.

Tests were then conducted to evaluate the effectiveness of ascorbates on preventing or blocking the formation of NP.

(Mirvish, 1972). Three types of processing conditions were used: Company A used an intermediate 11 hr process (as described above), Company B used a short 4 hr process, and Company C used a 22 hr process two days after pumping of bellies.

No nitrosamines were detected in the short-processed, fried bacon, even though no ascorbate was added. In the intermediate processed bacon of Company B, 5 - 10 ng/g NP was found with use of 170 µg/g of nitrite and 0 ascorbate. Increased concentrations of ascorbate to 500 µg/g appeared to block NP formation in bacon. In the long processed bacon, 5 - 13 ng/g NP were present when 0 ascorbate was used, 5 ng/g was present when 500 µg/g ascorbate was used, and 0 NP was detected with 2000 µg/g ascorbate.

In another test, storage of bellies for 13 days at 4.5°C before processing (long process of Company C) increased NP to 18 from 7 ng/g after 1 day at 4.5°C. At the same time, formation of NP was blocked when 1000 µg/g of ascorbate was used.

The third aspect of the studies on bacon dealt with the degree to which nitrite retards or prevents growth of *C. botulinum*. Nitrite levels were 0, 30, 60, 120, 170, and 340 µg/g; inoculum levels were 0, 100, and 10,000 spores/g. Also, it was decided to inoculate the bacon before processing via the pickle and after slicing. Product was vacuum packaged and incubated at 7° and 27°C for 12 weeks.

An inhibitory effect on C. botulinum toxin production was observed in both lightly and heavily inoculated bacon regardless of when the product was inoculated. At the low inoculum level and at 27°C storage, toxin was detected at 0 and 30 µg/g nitrite within one week, at 60 µg/g in two weeks and at 120 µg/g in four weeks. No toxin was detected at 170 and 340 µg/g throughout the three-month storage period.

In the heavily inoculated product, toxin was observed at all nitrite levels, but at a decreasing frequency with increased nitrite level.

In bacon inoculated after slicing, bacon with 120 µg/g added nitrite was considerably more resistant to botulinal toxin production than product with lower added nitrite. This indicated that a "Perigo factor" was observed in bacon and which acted to inhibit growth of C. botulinum. Also, residual nitrite levels decreased significantly (to less than 6 µg/g) within two weeks in bacon with up to 170 µg/g nitrite when incubated at 27°C. Therefore, it was the high initial added nitrite concentration rather than the residual nitrite that was responsible for the anti-botulinal effect.

Conclusions

In conclusion, these studies demonstrate that those concentrations of nitrite long used in commercial practice are essential in inhibiting growth of C. botulinum in those products studied to date. Clearly, the level of nitrite added at the time of manufacture rather than residual nitrite concentrations is necessary for the anti-botulinal effect when processed meat products are temperature abused. It would appear that the nitrite not only reacts with spores, but reacts with meat to form an inhibitor (Perigo factor) of spore germination and/or outgrowth.

No nitrosamines were detected in chopped ham or wieners even when they contained 500 and 300 µg/g added nitrite, respectively. In fried bacon, however, nitrosopyrrolidine concentrations up to 24 ng/g were detected at conventional (170 µg/g) levels of nitrite. The nitrosopyrrolidine concentrations were reduced by use of lower levels of nitrite, microwave cooking, or high levels (1000 - 2000 µg/g) of ascorbate.

REFERENCES

Bard, J. C. 1973. Effect of sodium nitrite and sodium nitrate on botulinal toxin production and nitrosamine formation in wieners. Proceedings, Meat Industry Research Conference, A.M.I.F. (In Press)

Christiansen, L. N., R. W. Johnston, D. A. Kautter, J. W. Howard and W. J. Aunan. 1973. Effect of nitrite and nitrate on toxin production by *Clostridium botulinum* and on nitrosamine formation in perishable canned comminuted cured meat. Applied Microbiology. 25, 357.

Greenberg, R. A. 1972. Nitrite in the control of *Clostridium botulinum*. Proceedings, Meat Industry Research Conference. A.M.I.F.

Greenberg, R. A. 1973. The effect of nitrite on botulinal toxin formation in bacon. Proceedings, Meat Industry Research Conference, A.M.I.F. (In Press)

Herring, H. K. 1973. Effect of nitrite and other factors on the physico-chemical characteristics and nitrosamine formation in bacon, Proceedings, Meat Industry Research Conference, A.M.I.F. (In Press)

Hustad, G. O., J. G. Arveny, H. Trenk, R. H. Deibel, D. A. D. A. Kautter, T. Fazio, and O. E. Kolari, 1973. Effect of sodium nitrite and sodium nitrate on botulinal toxin production and nitrosamine formation in wieners. Applied Microbiology 25 (In Press).

Mirvish, S. S., L. Wallcave, M. Eagen, and P. Shubik, 1972. Ascorbate-nitrite reaction: possible means of blocking the formation of carcinogenic N-nitroso compounds. Science 177, 65.