

MECHANISMS EXPLAINING THE PRESERVATIVE ACTION OF NITRITE

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Nitrite is an excellent preservative for sealed and heated meat products. An objection, however, is the possible development, from residual nitrite, of carcinogenic N-nitroso compounds when these products are heated afterwards. Despite the small risk for this (Cassens, 1997), particularly when compared to other nitrite sources in food (Meah, 1994), several recent papers were published which suggest or even stress the need for an alternative (Pegg *et al.*, 2000; Stevanovi *et al.*, 2000; Tierno *et al.*, 2001).

Moreover, there is a tendency for the use of milder preserving methods. This means that more spore-forming microorganisms may survive these treatments. Apart from this, however, it is still necessary to better establish the mechanisms through which nitrite exerts its action.

Function of nitrite

Addition of nitrite leads to an attractive reddish colour in meat products, protects against fat oxidation and, in particular, inhibits outgrowth of *Clostridium* species. In a recent review it was postulated that these properties share their explanation, i.e., binding of iron to myoglobin in such a way that it is neither available as a catalyst nor as an iron source for clostridia which do not form siderophores and therefore are unable to utilize strongly chelated iron (Grever and Ruiter, 2001). The attractive colour of the product can be regarded as an additional feature. It is stated that NO-myoglobin binds iron stronger than does non-nitrosated myoglobin (Igene *et al.*, 1985). For each iron atom one molecule of nitric oxide is needed (Pegg and Shahidi, 1996, 1997). This means that, for an iron content of 20 mg/kg in the meat product, about 25 mg of sodium nitrite per kg is needed for a stoichiometric reaction which transfers myoglobin to its nitroso complex.

Working mechanism of nitrite

The mechanism by which nitrite contributes to these functions is only partly understood. For any further study it is imperative to know the iron content of the matrix, i.e., the meat product. As a matter of fact, more knowledge is also needed with respect to equilibrium constants of both myoglobin and NO-myoglobin with respect to the amounts of iron released from the heme group.

The next problem is that NO is needed for nitrosation, not nitrite. A reductant such as ascorbic acid is able to reduce nitrite (trivalent nitrogen), to a considerable extent, to nitric oxide (bivalent nitrogen). The reaction is not complete, however. (Payne *et al.*, 1990; Shahidi *et al.*, 1994) unless the nitric oxide is withdrawn from the redox system by binding to myoglobin.

Nitrite may react with many other components in meat products, in particular with functional groups of proteins such as, e.g., the sulphhydryl group. In an early publication, Cassens listed the fate of nitrite in meat products (1977) and found nitrite/protein reactions more abundant than the nitrite/heme reaction. The initial nitrite concentration, however, must have been in considerable excess to the iron content of the product. Thus it might be assumed that the amount of myoglobin present was saturated with NO, thus allowing other reactions with nitrite.

The role of nitrite is thus that of an NO donor (to Fe atoms) and our efforts should be directed to the question whether this donor is satisfactory enough.

It should be mentioned that iron nitrosyl sulphide (INS), also known as 'black Roussin salt' ($\text{Fe}_4\text{S}_3(\text{NO})_7$) has excellent properties in this respect. For this sake, INS may be able to block iron atoms in compounds that play key roles in cellular reaction mechanisms such as, for example, the phosphoroclastic system (Woods, Wood and Gibbs, 1989). This may explain why small amounts of INS may inhibit bacteria in nutrient media. For the protection of meat products against clostridia, however, INS was found to be unsuccessful, probably because the application of too small concentrations in relation to the amount of iron. After transferring its NO groups, INS leaves a residue of many small spickles (FeS ?) (Huhtanen *et al.*, 1977).

As a matter of fact, INS is unsuitable as a preservative because of its high toxicity which, to all probability, is based upon its excellent possibilities as an NO donor. An alternative worth to consider, however, is the application of NO gas which was recently considered (Thiemig *et al.*, 2000).

Finally, it has to be remarked that addition of nitrosomyoglobin to meat products for colour improvement can never be a means for reducing or omitting nitrite in meat products, and is nothing but setting the cart before the horse.

Conclusion

It is clear that much is unknown to find a good solution for the problem of reducing the nitrite content of meat products. If it is considered that to high a concentration of nitrite is a real problem, then further research is necessary. We like to state that a small group, preferably international, should be established to tackle and to definitively solve this problem.

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