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M. Haugum, T.B. Tjaberg and A. Skulberg

Research Committe for Preservation of Agricultural Food Products, Oslo, Norway

Evaluation of Nitrite Content in Meat Products After Combined Curing With Nitrate and Nitrite

Introduction

Addition of nitrite and nitrate to food is a matter of considerable discussion. Nitrite is the most important of the two, but to some extent it is regarded as being harmful if it is not used under the proper conditions. High concentrations of nitrite have a poisonous effect. Nitrite may go into complex with free amines, and the result is nitrosamines, which are regarded as being a cancerogenic substance.

From a technological point of view addition of nitrite to certain meat products is of great importance. Originally the formation of nitrosomyoglobin thus giving meat products a desirable red colour was regarded as the most important effect. The antimicrobial effect of nitrite is, however, probably even more important from a modern technological point of view. Nitrite is interfering with the outgrowth of bacterial spores (Gould 1963), and certain products like canned luncheon meat and canned ham could hardly be produced if addition of nitrite was not allowed. An eventual prohibition of addition of nitrite to meat products would in any case probably substantially enhance the risk

for outbreaks of botulism.

Although nitrite is more important than nitrate technologically, practical experience indicates that simultaneous addition of the two components to meat products may in some cases be advantageous in order to achieve a better stability of nitrosomyochromogene. In some countries simultaneous use of nitrite and nitrate is prohibited. The reason for this restriction is probably that the final nitrite content may be too high.

The object of this investigation was to try to assay the content of nitrite in prepared meat products after addition of nitrite and nitrate singly and in combination.

Material and methods

In Norway addition of nitrite to meat products is only permitted in the form of a salt/nitrite mixture. The nitrite concentration in the mixture is limited to 0.5 - 0.6 per cent. The use of nitrate is limited to 0.5 grams per 100 gram of meat, which is more than 10 times the amount commonly used in the industry.

In the experiments the following curing mixtures were used:

I: The official nitrite mix (99,5 % NaCl + 0,5 % $NaNO_2$)

II: The mixture was mixed half and half with a common salt/nitrate mixture (98,75 % NaCl + 1 % KNO_3 + 0,25 % $NaNO_2$)

III: A common used salt/nitrate mixture (98 % NaCl + 2 % KNO_3).

To each curing mixture 6 % sucrose was added.

The following meat products were used for the experiments: Frankfurter - and Bologna sausages and cooked ham. The two types of sausages were made from the same emulsion in order to see whether the diameter of the sausage was important to the residual quantity of nitrite.

The composition of the emulsions were the following:

Table 1:

Nitrite content of two different types of sausages and ham after addition of different quantities of sodium nitrite and potasium nitrate and stored under different conditions for different length of time.

Product	Addition PPM of $NaNO_2$	Addition PPM of KNO_3	Curing temp. C°	Nitrite content PPM After preparation Unheated	After heating	Storage at 4 °C, days 7	14	21	Storage at 20 °C, days 7
Frankfurt.	80	-	-	55	51	34	34	37	5
Frankfurt.	40	170	-	26	20	17	25	24	10
Bologna	80	-	-	47	50	40	33	53	10
Bologna	40	170	-	32	27	20	24	17	14
Ham	80	-	4	-	39	43	49	44	17
Ham	80	-	18	-	33	53	53	61	13
Ham	-	330	4	-	3	11	6	70	34
Ham	-	330	18	-	22	28	32	160	53
Ham	40	165	4	-	40	33	25	80	62
Ham	40	165	18	-	32	42	43	67	54

3,5 kg lean beef
3,5 kg pork (fat and lean)
3,0 kg skinn milk
440 grams potato starch
160 grams curing (salt) mixture
20 grams spice-mix

Only the curing mixtures 1 and 11 were used for the sausages, because the nitrate cure is not commonly used in the sausage production.

The sausages were smoked before cooking.

The curing was added to the hams by arterial injection in an amount corresponding to a salt content of 16 grams pr kg.

The hams were stored 4 days before cooking, the one half at + 4°C and the other at + 18°C. The cooking procedure involved heating to 68°C in the centre of the hams.

The nitrite content of the products was determined immediately after preparation both before and after heat treatment and after storage at 4°C for 7, 14, and 21 days. In addition the nitrite content was determined after storage at 20°C for 7 days.

The determinations of nitrite was carried out according to the standard methods for determination of nitrites in meat products given in Official Methods of Analysis of the Association of Official Agricultural Chemists (10th ed.). The methods were slightly modified as a standard solution of $NaNO_2$ was used instead of $AgNO_2$.

Results

The results of the nitrite analyses in sausages and ham appear from table 1. These results are average values obtained in two different experiments.

Table 1: please see next page (no. 4).

For the sake of convenience these results are visulized in figs 1, 2, 3, and 4. The values obtained for the two sausage types are fairly similar, and in fig. 1 therefore the average nitrite values in Frankfurter and Bologna sausages are plotted against time. In fig. 2, 3, and 4 the values obtained in the experiments with ham are given.

Discussion

The Norwegian meat industry is interested in the application of a curing mixture containing both nitrite and nitrate as practical experience indicates that this mixture enhances the colour stability. The primary aspect of this experiment was to elucidate what happens to nitrite and nitrate in meat products after cooking and during storage. This question is interesting both from the point of view of food technology and food hygiene. Codex Alimentarius Standards for meat products are also concerned with this question.

Another intention was to use these results as background material for an eventual application to the health authorities in Norway for an approval of such a curing mixture.

In the experiments mixtures of sodium nitrite and potassium nitrate were used. Scientificly it might have been preferable to use only sodium salts, but the reason for choosing potassium nitrate was that this is almost entirely used under practical conditions in Norway.

The quantities of nitrite and nitrate being used were determined on the basis of practical experience and with due consideration to the existing regulations.

In the experiments a storage temperature of 20°C and a curing temperature for hams of 18°C were applied. From a practical point of view these temperatures are unrealistic, and they were only used in order to try to elucidate the effect of these high temperatures on the reduction of nitrate and the residual content of nitrite in the product.

The results indicate that about one half of the quantity of nitrite added might be demonstrated in the products after cooking. When nitrite was added alone the residual quantities were not substantially changed after storage from three weeks at 4°C. At 20°C a reduction of nitrite occured after storage for one week.

When nitrate was added alone to hams, very small amounts of nitrite could be traced after curing at 4°C for four days. At a curing temperature of 18°C amounts of about 20 ppm could be demonstrated. Hams cured at 4°C and stored at the same temperature after cooking showed a moderate increase in the nitrite content after three weeks. In hams cured at 18°C the nitrite content increased substantially under the same conditions. The reason for this difference may be growth of nitrate reducing organisms during curing and that a small number may have survived the cooking process.

The organisms seem to grow at 4°C although the results indicate that the log face is rather long.

In hams cured with both nitrite and nitrate the residual content of nitrite was inbetween the values obtained from the products cured with the two ingredients separately. This was especially relevant at a curing temperature of 18°C, but if the experiments with the hams cured at 4°C had been continued a similar result would most likely have been obtained.

In the sausages the samples which had been added a mixture of nitrite and nitrate and stored at 4°C showed a lower residual nitrite content than those which were added nitrite alone. At a storage temperature of 20°C for one week a more rapid fall in the nitrite content occurred.

These results must be regarded as preliminary as the number of replicates is inadequate. Furthermore it would have been desirable to include additional products in the experiments and to use higher amounts of nitrate. It should

also be emphasized that these experiments are not at all dealing with the question of formation of nitrosoamines.

Conclusion

The results of these experiments seem to indicate that a simultaneous use of nitrite and nitrate in moderate amounts does not increase substantially the residual quantities of nitrite in meat products. It seems therefore that no public health hazard eventually would be involved. The quantities of nitrite and nitrate added simultanously must be reduced in relation to the quantities used when they are added individually.

References

Gould, G.W.: 1964 Effect of Food Preservatives on the Growth of Bacteria from Spores, 19 - 24. Microbial Inhibitors in Food (Almwvist & Wiksell, Stockholm.)

Tjaberg, T.B.: 1968 Nitritt som tilsetningsstoff til lett-konserverte kjøttvarer. Tidsskrift for Hermetikkindustri, 54, 119 - 126.

Fig.1. Nitrite content in Frankfurter and Bologna Sausages

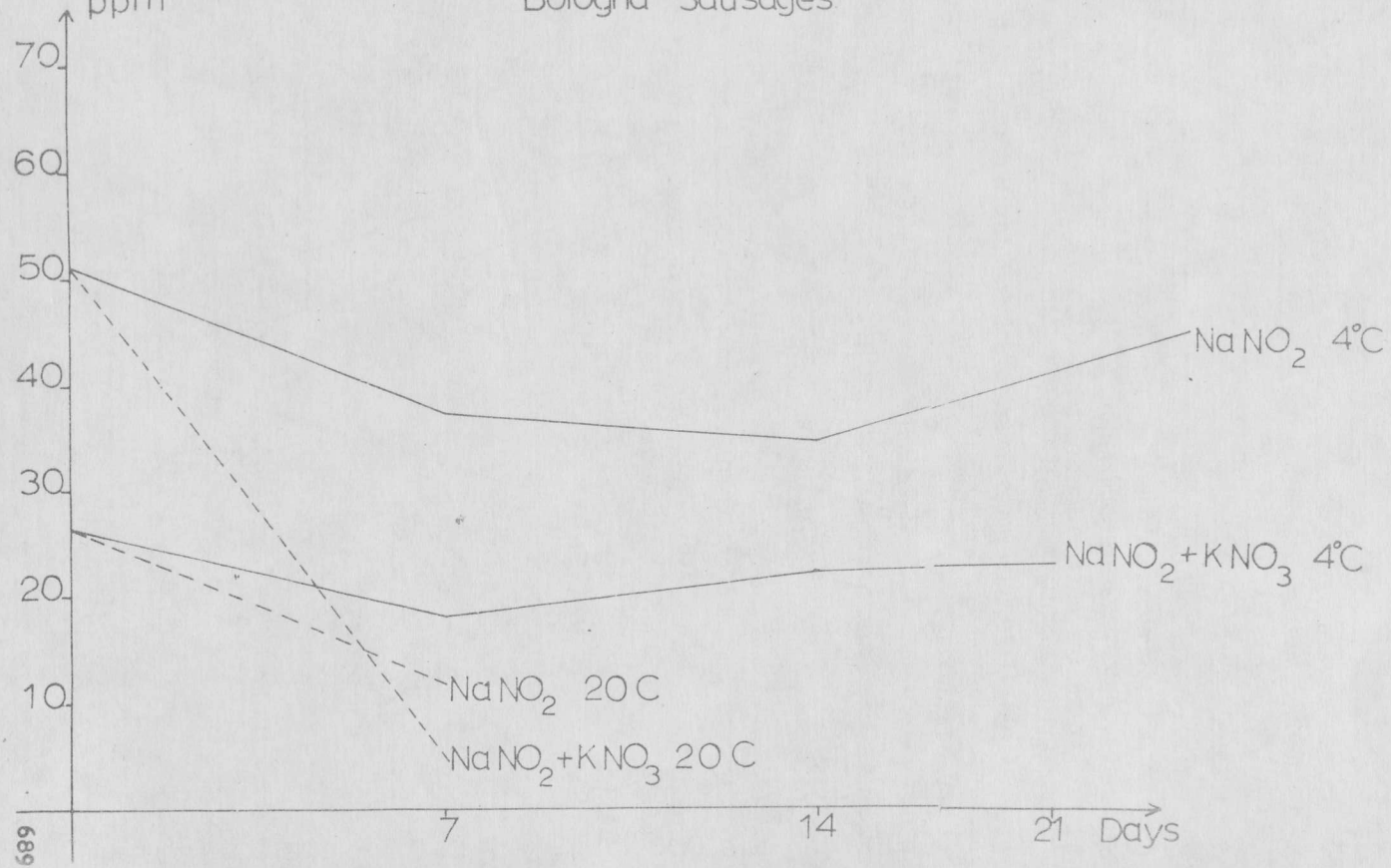


Fig.2. Nitrite content in ham cured at 4°C and 18°C, and stored at 20°C for 7days.

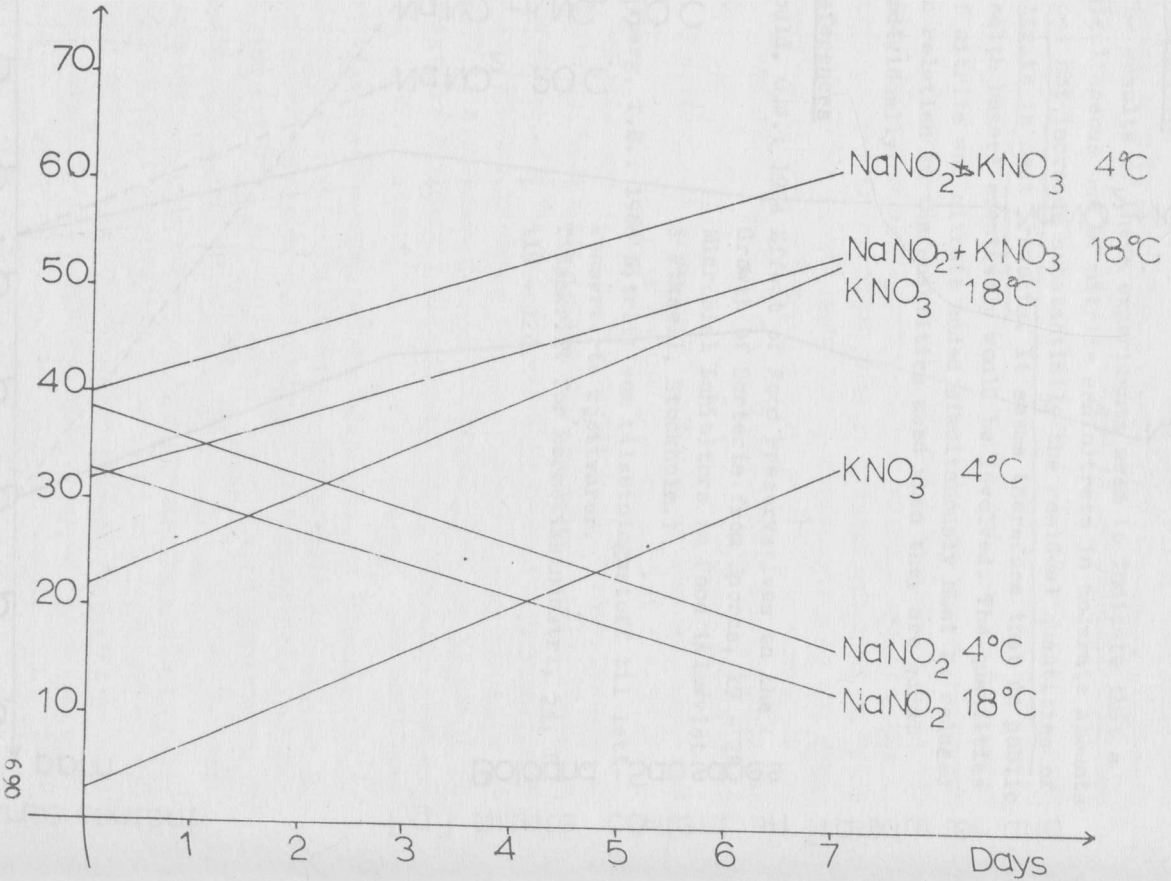
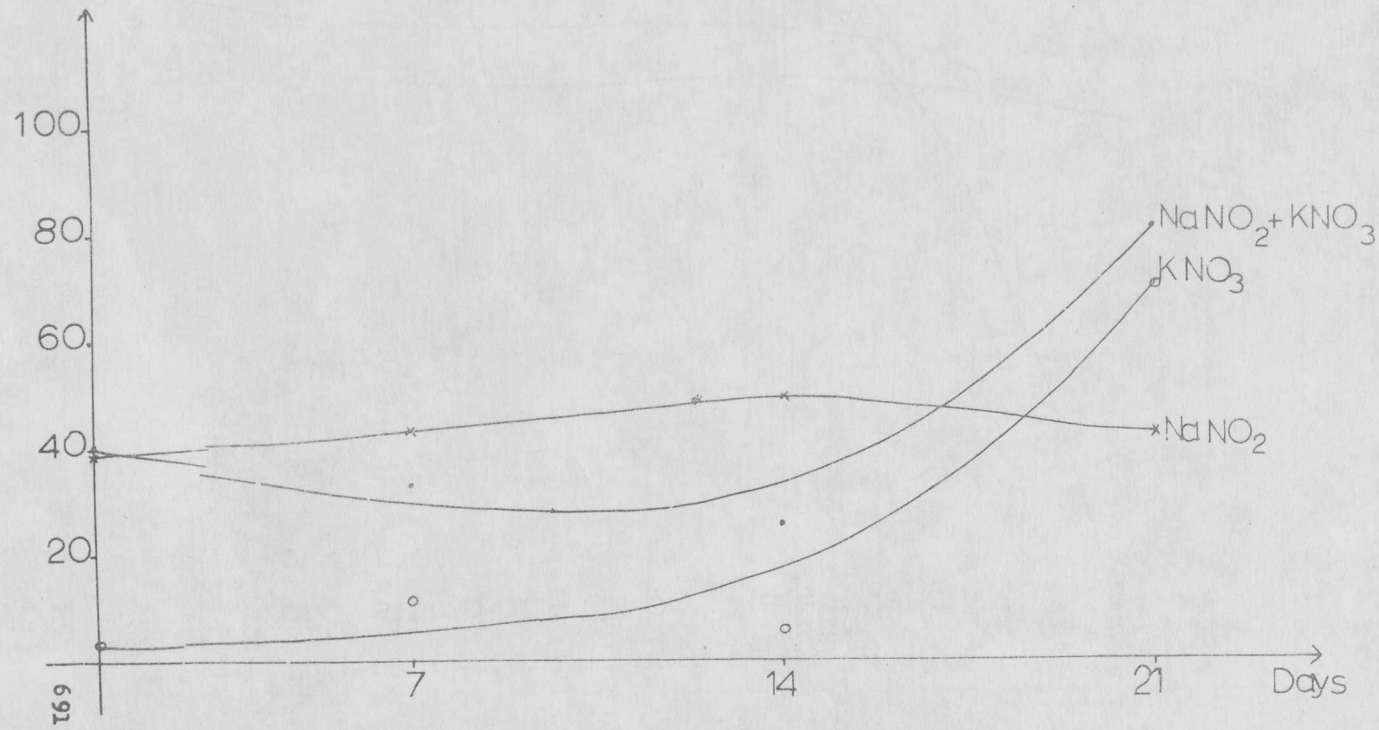


Fig. 3. Nitrite content in ham cured at 4°C and stored at 4°C for different length of time



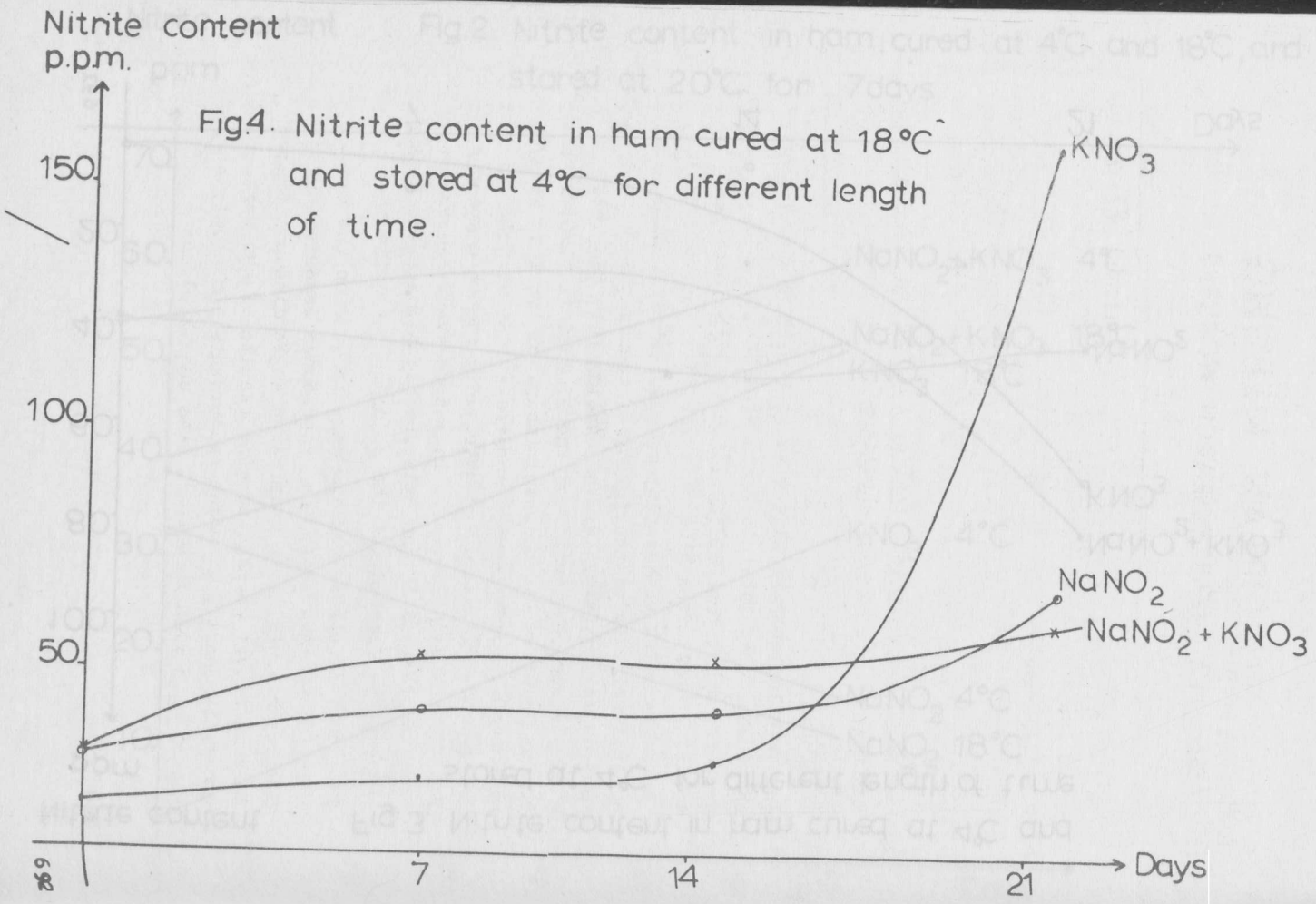


Fig.4. Nitrite content in ham cured at 18°C and stored at 4°C for different length of time.