The effect of nitrite and certain other food additives on the quality of Finnish cooked sausage

Esko Nurmi, Markku Raevuori, Pauli Hill

State Veterinary Medical Institute
and
College of Veterinary Medicine
Department of Food Hygiene
Hämeentie 57, 00550 Helsinki 55
Finland

ZUSAMMENFASSUNG

Die Wirkung des Natriumnitrits und gewisser anderen Zusatzstoffen auf die Eigenschaften und Restkonzentrationen des Nitrits in Finnisher Brühwurst wurde studiert. Natriumerythorbat mit Nitrit hatte einen schr günstigen Einfluss auf die Farbenentwicklung. Nitrit machte das Produkt geschmackvoller. Dasselbe Ergebnis wurde mit Erythorbat und Glucono-Delta-Lacton erreicht. Erythorbat und Zitronensäuse verstärkten die Bakterizide Wirkung des Nitrits. Wenn Natriumnitrit das einzige Zusatzmittel war, fand man im fertigen Produkt eine Restkonzentration von 60 % des ursprünglichen Menge. In den Fällen, wo es mit sowohl Erythorbat als Zitronensäure verwendet wurde, was die Restkonzentration des Nitrits ungefähr 50 % Wenn Glucone-Delta-Lacton der Masse zugesetzt wurde, um die Azidität des Produktes zu erhöhen, wurde der Verlust des Nitrits noch grösser.

The effect of nitrite and certain other food additives on the quality of Finnish cooked sausage

Esko Nurmi, Markku Raevuori, Pauli Hill

State Veterinary Medical Institute
and
College of Veterinary Medicine
Department of Food Hygiene
Hämeentie 57, 00550 Helsinki 55
Finland

ABSTRACT

The effects of sodium nitrite and certain other food additives on the characteristics and residual nitrite contents of Finnish cooked sausage were studied. Sodium erythorbate with nitrite had a very positive effect on colour development. Nitrite made the product taste better, as did erythorbate and glucono-delta-lactone as well. Erythorbate and citric acid enhanced the antibacterial effect of nitrite. When sodium nitrite was used alone, the residual content of the product was 60 % of the amount added. When used with both erythorbate and citric acid the residual sodium nitrite was about 50 %. When GDL was added to the mass to increase the acidity of the product, nitrite loss was still greater.

The effect of nitrite and certain other food additives on the quality of Finnish cooked sausage.

Esko Nurmi, Markku Raevuori, Pauli Hill

INTRODUCTION

The principal source of nitrite in our diet is cured meat and sausage, where it is used as a food additive. The action of nitrite in the curing process is threefold: 1. formation of the characteristic red colour, 2. production of the cured flavour, and 3. antibacterial activity.

The toxicity of nitrites due primarily to their interaction with hemoglobin to produce methaemoglobinaemia. Thus the normal ability of a red cell to transfer oxygen is altered. At present the problem of carcinogenic nitrosamine formation from the reaction of nitrites with certain amines is being investigated. Despite the use of relatively low concentrations of nitrite when used as a food additive, we cannot completely exclude the possibility of nitrosamine synthesis during the processing and in the human stomach.

Cooked sausage is a very important component of our meal preparation habits in Finland. An estimate of the total consumption of cooked sausages reaches 25 kg per a person and a year.

The aim of this investigation was to find out the minimum amount of sodium nitrite essential to give our cooked sausage good colour and flavour and to prevent bacterial spoilage. The influence of the additives sodium erythorbate, citric acid and glucono-delta-lactone on the normal loss of sodium nitrite during processing, and their effect on the characteristics of the sausage was also investigated.

MATERIALS AND METHODS

1. Sausage production

The following basic recipe was used throughout:

Beef 31.8 %, Pork 15.9 %, Skin (colloidal) 15.9%, Potato flour 4.8%, Milk powder 2.7 %, Sodium chloride 2.0 %, Ice 26.6 %, Phophate mixture (Glutamal S III s) 0.2 %, Spices 0.1 %.

The effect of varying concentrations of the following additives on the emulsion and the sausage produced was studied:
Sodium nitrite (Merck 6544), Sodium erythorbate (Pfizer US/FCC grade), Citric acid (Pfizer BP/USP grade), Glucono-delta-lactone (GDL) (Pfizer US/FCC grade).

The emulsion was prepared as follows: Coarsely cut fine salted meat was first comminuted in a Seydelmann K 41 cutter. The spices and phosphate mixture and some of the ice were then added, followed a few minutes later by the potato flour, milk powder and the remaining ice. The emulsion was then divided into portions of two kilograms and the additives were mixed in with a Kenwood blender. The resulting sausage emulsion was packed into commercial cellulose casings (Visko, Ø 65 mm), dried for half an hour between 50-60°C and immediately smoked for one hour in a Waxweiler owen at the temperature in the range 75-80°C. The sausages were transferred to a steam cooker kept at 78°C and cooked for 40 minutes.

2. Evaluation of the samples

a. Organoleptic estimation: The sausages were tested after storage for one day at 4°C. The evaluation was made by three taste specialists. Taste and color was analyzed separately. Point scores on a scale of 0-5 were assigned for the both properties, 5 being the score for exellent quality. The mean value of the scores given was used as an indicator of the organoleptic quality of a sample.

b. Bacteriological examination: The samples were taken from sausages three, four or five days at room temperature (21+ 3°C). They were homogenised in a Ultra-Turrax blender. The cultivation was done in bacterial count agar (Orion Pharmaceutical Co. Helsinki) as a plate count. The plates were incubated three days at 30°C.

c. Physical examination: The pH-value of the product was measured (Becman Zeromatic) simultaneously with the organoleptic evaluation.

d. Determination of the residual sodium nitrite of the product:
The determination was made according to the modified Griess´ and Ilosvay´s method (Nordic Committee on Food Analysis, 1963) after storage at 4°C for three days.

RESULTS AND DISCUSSION

1. Effects on organoleptic characteristics

The addition of nitrite was essential for normal colour development (Table 2). However, the addition of a relatively small amount of nitrite (0.01 %) alone did not yield adequate colour. Erythorbate had a very positive effect on colour development when used together with nitrite (Table 1).

The well-known role of nitrite in colour formation is to furnish nitric oxide, which reacts with myoglobin to give nitrosomyoglobin, the red pigment of cured meat and sausage products. To increase the amount of nitric oxide formed, other additives, such as antioxidants, acids, and chelating agents can be used. The antioxidants used in cooked sausages accelerate the reduction reactions in the direction of nitric oxide. They also retard oxidation and the fading of the cured colour which is developed. Antioxidants can also react directly with nitrous acid to form nitric oxide: (Dahn et al., 1960).

GDL lowers the pH of the product and favours the reduction reactions. The effect of the citric acid at the acid equivalency levels used was weaker relative to GDL. The addition of 0.05 % lowers the pH of the product only 0.1 pH units. Citric acid however, sequesters trace metals which can act prooxidant catalysts and cause discolouration of the product (Gardner 1972).

Nitrite was essential to preserve the traditional taste of cured sausage. It was improved by the addition of erythorbate (0.05 %) or even better by addition in combination with citric acid (0.05 %) and GDL (0.15 %) (Table 1). The addition of more than 0.20 % GDL had an adverse effect on the taste of the sausage (Table 3).

The mechanism of flavour production by nitrite with natural meat components is not understood, but is an established fact even for low levels of nitrite addition (Wolff and Wasserman, 1972). To produce the characteristic flavour, some 50 mg of nitrite per kg of cured meat are necessary (Ingram, 1973). In a Norwegian study (Skjelkvale et al., 1973) no significant differences were observed between sausages with 80 or 40 mg/kg, and in an other work (Wasserman and Talley, 1972) no difference could be detected between frankfurters cured with 150 or 75 mg/kg of nitrite.In our study excellent sausage was made

by an addition of 75 mg/kg. Erythorbate and GDL improve the taste of the product. GDL at more than 0.2 % becomes too acid and erythorbate at more than 0.05 % gives a slightly metallic taste.

2. Antibacterial effects

The antibacterial effect of nitrite was chanced by the addition of erythorbate alone or in combination with citric acid (Table 4). Sufficient bacterial inhibition could be achieved with 0.0075 % $NaNO_2$, as shown in Table 5, provided erythorbate (0.5 %) together with citric acid (0.05 %) was also used.

The antibacterial effects of nitrite were first studied by Tarr in the early 1940´s (Tarr 1940). He showed that the inhibitory effect against bacteria was depended upon the pH of the medium and increased markedly at pH-values below 6.0. The inhibitory effect of sodium nitrite is due to the formation of nitrous acid in water solutions. The amount of undissosiated HNO_2 is higher in an acid medium. Nitrous acid is a highly reactive agent and can react with several cell components such as nucleic acids, dehydrogenases and heme pigments of the cytochromes. The inhibition of anaerobic bacteria, especially Clostridium botulinum, has also been studied extensively, but the mode of action of nitrite is still unknown. The inhibition is a complex phenomenon, involving interaction of the following parameters: number of spores present, amount of heat applied, pH of the product, and concentration of sodium nitrite used (Wolff and Wasserman, 1972).

In our investigation the effect of nitrite on the total bacterial count was studied. The antibacterial effect of nitrite increases when it is used with either erythorbate alone or both citric acid and erythorbate. When we used the latter mixture, with both of the components at 0.05 %, sufficient inhibition was achieved by adding only 0.0075 % (75 mg/kg) $NaNO_2$ to the meat mass (Table 5). Theoretically the inhibitory effect of nitrite could be increased further by adding some GDL; this was not tested in these investigations. On the other hand it has been stated that larger nitrite concentrations must be used to avoid possible growth and toxin formation of Clostridium botulinum in sausages. Grever (1973) reported a safety limit of an addition of 200 mg/kg of nitrite into emulsion of cooked sausage pH of which is not above 6.2. For a heat treatment resulting in a F_0 value of 0,5, clostridia were found to be inhibited by 100 mg/kg nitrite, provided that the brine percentage was 3.5 %. The effects of lower salt percentages and F_0 values was not studied in that investigation.

3. The effect on the residual sodium nitrite content of the product

Nitrite takes part in many reaction in the sausage mass. Volatile substances are also formed: for instance, nitrous oxide and nitrogen gas (Van Slyke´s reaction). Reduction of nitrite by the sulphydryl groups of the meat protein has also been suggested as a mechanism of the nitrite depletion (Olsman, 1973). Nitrite is always lost during the processing period. When only nitrite is used, the residual content of the product is about 60 % (Table 7). When erythorbate and citric acid are also used, the residual sodium nitrite content is about 50 % of the amount added. When mixing GDL into the mass to increase the acidity of the product, nitrite loss increases. For example, when 0.2 % GDL is added the residual $NaNO_2$ content of the sausage is only 32 % of the amount added (Table 7).

In Finland the pH-value of a cooked sausage is usually about 6.2. The amount of

residual sodium nitrite allowed in meat products is 150 mg/kg (0.015 %). As seen in this investigation, it is possible to make sausages of high quality by adding only 75 mg/kg sodium nitrite; if erythorbate and citric acid are also added the residual sodium nitrite level will be about 40 mg/kg. This amount can be decreased still further by adding GDL to the mass.

REFERENCES

Dahn, H., Loewe, L. and Bunton, C.A. 1960. Über die Oxydation von Ascorbinsäure durch salpetrige Säure. Teil VI: Übersicht und Diskussion der Ergebnisse. Helv. Chim. Acta 43: 320-330.

Cardner, W.H. 1972. Acidulants in food processing. In "Handbook of Food Additives", ed Furia, T.E., 2nd ed. pp. 225-270. The Chemical Rubber Co., Ohio.

Grever, A.B.G. 1973. Minimum nitrite concentrations for inhibition of clostridia in cooked meat products. Proc. Int. Symp. Nitrite Meat Prod., Zeist, Pudoc, Wageningen. pp. 103-109.

Ingram, M. 1973. The microbiological effects of nitrite. Proc.int.Symp. Nitrite Meat Prod., Zeist, Pudoc, Wageningen. pp. 63-75.

Nordic Committee on Food Analysis. 1963. Determination of nitrite. Method number 49.

Olsman, W.J. 1973. About the mechanism of nitrite loss during storage of cooked meat products. Proc.int.Symp.Nitrite Meat Prod. Zeist. Pudoc, Wageningen. pp. 129-137.

Skjelkvale, R., Valland, M. and Russwurm, H. 1973. Effekt av natriumnitritt på sensorisk kvalitet av kjøttvarer. Norsk Institutt for Naeringsmiddel-forskning Informasjon No 1: 1-15.

Tarr, H.L.A. 1941. The action of nitrites on bacteria. J. Fish. Res. Bd Can. 5: 265-275.

Wolff, L.A. and Wasserman, A.E. 1972. Nitrates, Nitrites and Nitrosamines. Science N.Y. 177: 15-19.

Wasserman, A.E. and Talley, F. 1972. The effect of sodium nitrite on the flavour of frankfurters. J.Fd Sci. 37: 536-538.

Table 1: Results of the organoleptic evaluation of sausages when using $NaNO_2$ 0.01% (scale 0-5). The results indicate the mean values of a sample score.

	Other food additives used:				
	None	Na-erythorbate 0.05%	citric acid 0.05%	Na-erythorbate 0.05% citric acid 0.05%	Na-erythorbate 0.06% GDL 0.15% citric acid 0.05%
Taste	2.5	3.5	2.2	3.8	4.3
Colour	1.3	4.2	1.6	4.0	4.0
Number of sausage samples analyzed	5	3	5	7	2

Table 2: The effect of sodium nitrite, sodium erythorbate and citric acid on the organoleptic characteristics of sausages (scale 0-5).

$NaNO_2$ used%	sodium erythorbate 0.05% and citric acid 0.05% used	scores of the organoleptic analysis Taste	Colour
0	-	2	0
0	+	2.5	0
0.0025	+	3.5	2
0.005	+	4	3.5
0.0075	+	4.5	4.5
0.01	+	4.5	4.5
0.0125	+	4.5	4.5
0.015	+	4.5	4.5

Table 3: The effect of GDL addition on the organoleptic characteristics of sausage. $NaNO_2$ 0.01 %, sodium erythorbate (0.05%) and citric acid (0.05%) was added to the emulsion (scale 0-5).

GDL used %	scores of the organoleptic analysis Taste	Colour
0.05	4	3.8
0.1	4.3	4.3
0.15	4.4	4.3
0.2	4	4
0.25	3.8	4
0.3	3.5	4
0.5	2.5	4
1.0	0	3.5

Table 4: The effect of sodium nitrite, sodium erythorbate and citric acid on log of bacterial counts of sausages, after storage for three days at room temperature (+21 ± 3°C).

	Food additives used:		
$NaNO_2$%	Na-erythorbate 0.05%	citric acid 0.05%	logarithms of the bacterial counts/g
0.02	-	-	7.78
0.02	+	-	6.18
0.02	+	+	6.30
0.01	-	-	8.00
0.01	+	-	7.48
0.01	+	+	6.48
-	-	-	7.85
-	+	-	7.48
-	+	+	7.30

Table 5: The effect of sodium nitrite, sodium erythorbate and citric acid on log of the bacterial counts of sausages after storage for two days at room temperature (+21 ± 3°C).

Food additives used:

$NaNO_2$%	sodium erythorbate 0.05% and citric acid 0.05%	logarithms of the bacterial counts/g
0	-	5.98
0	+	6.22
0.0025	+	5.90
0.005	+	5.78
0.0075	+	4.60
0.01	+	4.30
0.0125	+	3.30
0.015	+	4.30

Table 6: The effect of sodium nitrite and sodium erythorbate on pH and log of bacterial counts of sausages. The samples had been kept five days at room temperature (+18°C).

Food additives used:

$NaNO_2$%	sodium erythorbate%	pH	logarithms of the bacterial counts/g
0	-	6.15	6.85
0.02	-	6.25	5.78
0.004	-	6.20	7.30
0.004	0.1	6.35	6.18
0.004	0.05	6.20	5.60
0	0.1	6.35	6.00
0	0.05	6.30	6.30

Table 7: The effect of sodium erythorbate, citric acid and GDL on the residual sodium nitrite content of sausage when sodium nitrite was used 0.02% (200 mg/kg).

Food additives used:

Na-erythorbate 0.05%	citric acid 0.05%	GDL%	Residual $NaNO_2$ mg/kg	per cent of the amount added	pH
-	-	0	120	60	6.35
-	+	0	120	60	6.25
+	+	0	96	48	6.20
+	+	0.2	63	32	5.85
+	+	0.3	42	21	5.75
+	+	0.5	30	15	5.60
+	+	0.75	13	7	5.25
+	+	1.0	9	5	5.05