Inhibition of the mutagenic/carcinogenic Heterocyclic Aromatic Amines using a canned sausage model system

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Introduction

Meat and meat products may contain undesirable mutagenic chemicals, such as polycyclic aromatic hydrocarbons, nitrosamines or heterocyclic aromatic amines, which are formed in these products subjected to thermal processes. A group of these compounds are the heterocyclic aromatic amines (HAA). These substances are produced in fried, broiled or cooked meat or fish. The formation of these compounds based on the Maillard reaction. Creatine or creatinine and the Maillard reaction products such as pyrazines, pyridines and aldehydes are assumed to condense to IQ-compounds. Since their discovery about 20 heterocyclic amines have been identified and quantified in cooked foods (FELTON and KNIZE, 1990). On the basis of results from long-term animal-studies on rodents and non-human primates (ADAMSON et al., 1990), several of these compounds have been classified as carcinogenic (IARC, 1993). For these reasons, the IARC give the recommendation, that human exposure to these substances should be reduced. Sulfur containing amino acids such as cysteine and N-acetylcysteine inhibit the Maillard reaction (FRIEDMAN and MOLNAR, 1990). The aim of this study was to reduced the formation of HAA. We describe the results of model experiments with canned products with different heating times and the addition of glucose and N-acytylcysteine (NAC). In addition, the effect of additives is evaluated by sensory tests and colour measurement.

Materials and Methods

Preparation of canned sausages: First, the sausages were prepared a batter of finely comminuted sausage consisting of 25 % coarsely defatted pork, 25 % coarsely defatted beef, 30 % pork backfat and 20 % ice. The meat and fat were chopped together in a chopper (Type K64 DC, Seydelmann, Aalen, D). Nitrite curing salt (17g/kg), sodium ascorbate (0.5 g/kg), spices (white pepper 1 g/kg, coriander 1 g/kg, nutmeg 0.5 g/kg, cardamom 0.5 g/kg) and half of the ice were added and the mixture was chopped until 12° C. Then the remaining half of the ice was added. Trial 1: Only batter. Trial 2: In 6-kg-batch, 0.2 % glucose was added to the batter. The mixture was chopped in a little chopper (Type UMC 12, Stephan, Hameln, D). Trial 3: In 6-kg-batch, 0.15 % NAC and 0.25 % phosphate was added to the batter. The mixture was chopped in a little chopper. Trial 4: In 6-kg-batch, 0.15 % NAC, 0.25 % phosphate and 0.2 % glucose was added to the batter. The mixture was chopped in a little chopper. Each batter of the trials were filled in cans with 250 g and the cans were heated separately for different times at 121 °C. The following heating times were used 40, 60, 80, 100,120 and 140 min.

Determination of HAA: The method of HPLC analysis based on the method described by GROSS and GRÜTER (1992).

Sensory tests: The task of the sensory panelists was to evaluate the cans with different heating times and additives for colour and flavor using the following 6 score scale (hedonic test): 6 = Like extremely; 5 = Like very much; 4 = Like moderately; 3 = Dislike slightly; 2 = Dislike moderately; 1= Dislike extremely

Colour measurement: The colour of the canned sausages products was measured with a Minolta Chroma Meter CR 200 with CIE-LAB-system (DIN 6174). The values are means of the L*, a*, b*- coordinates taken at 3 points on the surface.

Results and Discussion

The heterocyclic amine compound IQ were found at very low concentrations (0.33 and 0.25 ng/g) in the batches without additives and at the heating times of 120 and 140 min, respectively. Batches to which glucose was added, the compound MeIQ was only detected in trace amounts when heated for 140 min. Batches which contained NAC, phosphate or NAC, phosphtate and glucose, IQ-compounds could not be detected (Tab. 1).

The glucose concentration has a significant influence on the formation of mutagens, the optimum ratio for the formation of mutagens was 2:1 (creatine/glucose). Glucose can inhibit formation of IQ-compounds, if the ratio is lower than 2:1 or much greater (SKOG and JÄGERSTAD, 1990). In our study, also the compound NAC reduced the formation of HAA. In the above experiments the core temperatures did not exceed 120 °C, nevertheless HAA were formed. All analysed samples containing the β-carbolines Norharman and Harman (Tab.1). Norharman and Harman are not mutagenic with reference to *Salmonella typhimurium* TA 98 and TA 100, but Norharman enhances the mutagenic activity of Trp-P-1 and Trp-P2 (SUGIMURA et al., 1982).

The addition of NAC had a positive effect on the colour of the canned sausages. The lightness indicator L* value was higher and the b* value was lower, i.e. the yellow colour was less intensive compared to the control sample or to the sample with glucose addition at the same heating times (Fig.1). Our sensory tests showed that the addition of NAC improves the sensory characteristics of the canned sausages. The testers preferred the products with the addition of NAC. Especially the colour was positively influenced, but also the taste was better evaluated than the taste of control samples (Fig. 2). But the difference was not significant. An acid taste could be compensated by the addition of 0.25 % diphosphate (HILMES, 1996). FRIEDMAN and MOLNAR (1990) reported that unlike cysteine, NAC produced minimal or no off-flavour at concentrations that inhibit browning in protein-containing foods.

In commercial canned products, the sterilisation temperatures were normally lower and the heating times shorter than in this study (HILMES, 1996). Therefore the concentration of HAA is generally lower than in fried or grilled food (FELTON and KNIZE, 1990).

Conclusions

In canned meat products, the HAA were formed in very low concentrations. The addition of the combination of NAC and phosphate can inhibit the formation of HAA and has especially a positive effect of colour and flavour of the canned products.

References

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Tab. 1 Concentration of Heterocyclic Aromatic Amines in cans without and with the additives at different heating times

Trial	Material	Batch	Heating time	Heterocyclic Aromatic Amines [ng/g] IQ*	MeIQ**	Norharman	Harman
1	100 % batter of sausage	1	40			0.80	0.20
1	100 % batter of sausage	2	60			0.66	0.25
1	100 % batter of sausage	3	80			0.39	0.37
1	100 % batter of sausage	4	100			0.61	0.48
1	100 % batter of sausage	5	120	0.32		1.29	0.98
1	100 % batter of sausage	6	140	0.26		1.14	0.85
2	batter + 2 g/kg glucose	1	40			0.85	0.28
2	batter + 2 g/kg glucose	2	60			0.78	0.33
2	batter + 2 g/kg glucose	3	80			0.62	0.50
2	batter + 2 g/kg glucose	4	100			0.87	0.67
2	batter + 2 g/kg glucose	5	120			0.79	1.32
2	batter + 2 g/kg glucose	6	140		0.07	0.87	1.33
3	batter + 0.15 % NAC + 0.25 % phosphate	1	40			0.64	0.15
3	batter + 0.15 % NAC + 0.25 % phosphate	2	60			0.58	0.16
3	batter + 0.15 % NAC + 0.25 % phosphate	3	80			0.79	0.26
3	batter + 0.15 % NAC + 0.25 % phosphate	4	100			0.71	0.32
3	batter + 0.15 % NAC + 0.25 % phosphate	5	120			0.72	0.15
3	batter + 0.15 % NAC + 0.25 % phosphate	6	140			0.79	0.29
4	batter + 0.15 % NAC + 0.25 % phosphate + glucose	1	40			0.64	0.14
4	batter + 0.15 % NAC + 0.25 % phosphate + glucose	2	60			0.72	0.21
4	batter + 0.15 % NAC + 0.25 % phosphate + glucose	3	80			0.89	0.34
4	batter + 0.15 % NAC + 0.25 % phosphate + glucose	4	100			0.87	0.50
4	batter + 0.15 % NAC + 0.25 % phosphate + glucose	5	120			0.94	0.71
4	batter + 0.15 % NAC + 0.25 % phosphate + glucose	6	140			0.86	0.74

* IQ: 2-amino-3-methylimidazo[4,5-f]quinoline; ** MeIQ: 2-amino-3,4-dimethylimidazo[4,5-f]quinoline

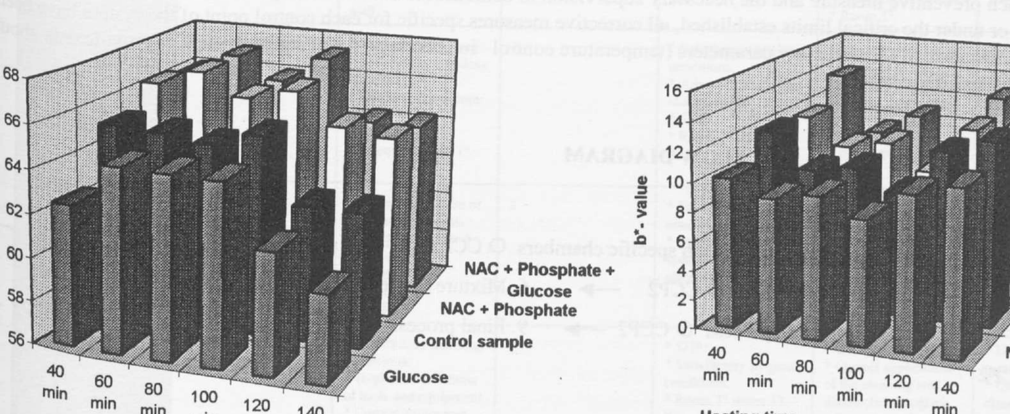

Fig. 1: Effect of N-actetylcysteine on the colour (L*- und b*-value)

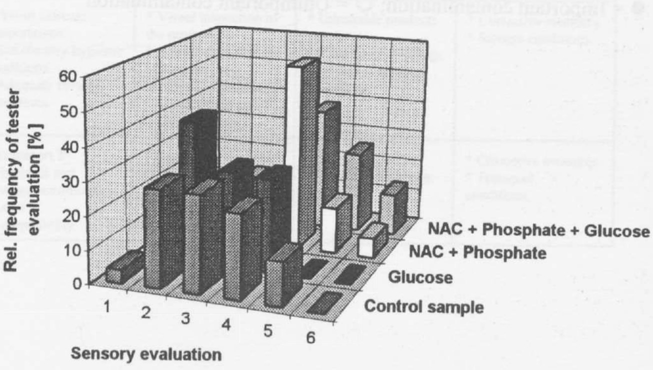

Fig. 2: Relative frequency of tester evaluation (taste/flavour) for the canned sausages at 60 min heating time.