

Evaluation of N-Nitrosamine Levels in Processed Meat Products from the Croatian Market

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INTRODUCTION

N-nitrosamines (NAs) are a group of compounds, some of which exhibit mutagenic and carcinogenic properties. They may be found in processed meat products due to reactions between nitrosating agents, especially nitrites, and naturally occurring amine precursors in meat. Various processing methods, including fermentation, ripening, smoking, drying, and heat treatment, can further influence the formation of N-nitrosamines. This study aimed to determine N-nitrosamine levels in processed meat products from the Croatian market and assess their relationship with residual nitrate and nitrite.

MATERIALS AND METHODS

A total of 100 processed meat products from the Croatian market were analysed, including 48 heat-treated (semi-dry) products and 52 unheated fermented (dry) products. Fifteen volatile and non-volatile N-nitrosamines were determined using gas chromatography coupled with tandem mass spectrometry (GC–MS/MS). Residual nitrate and nitrite concentrations were also measured. The results were evaluated using descriptive statistics, product-category comparisons and correlation analysis.

RESULTS: TOTAL N-NITROSAMINES

Clear differences in total N-nitrosamine concentrations were observed among the analysed product categories. Dry sausages had the highest mean concentration (**52.67 µg/kg**), followed by dry-cured meat products (**38.19 µg/kg**). Lower concentrations were measured in semi-dry sausages (9.70 µg/kg), semi-dry cured meat products made from a single piece of meat (7.62 µg/kg), minced meat products (4.97 µg/kg) and semi-dry products made from pieces of meat (1.42 µg/kg). NHPYR, NPYR and NDMA were the predominant N-nitrosamines. NHPYR had the highest occurrence (61 %), followed by NDMA (56 %) and NPYR (55 %). NHPYR and NPYR predominated in fermented dry products, whereas NDMA was more frequently associated with heat-treated products. Residual nitrate and nitrite concentrations were generally low. Only a weak correlation was observed between residual nitrate/nitrite and total N-nitrosamine concentrations (**r ≈ 0.1**).

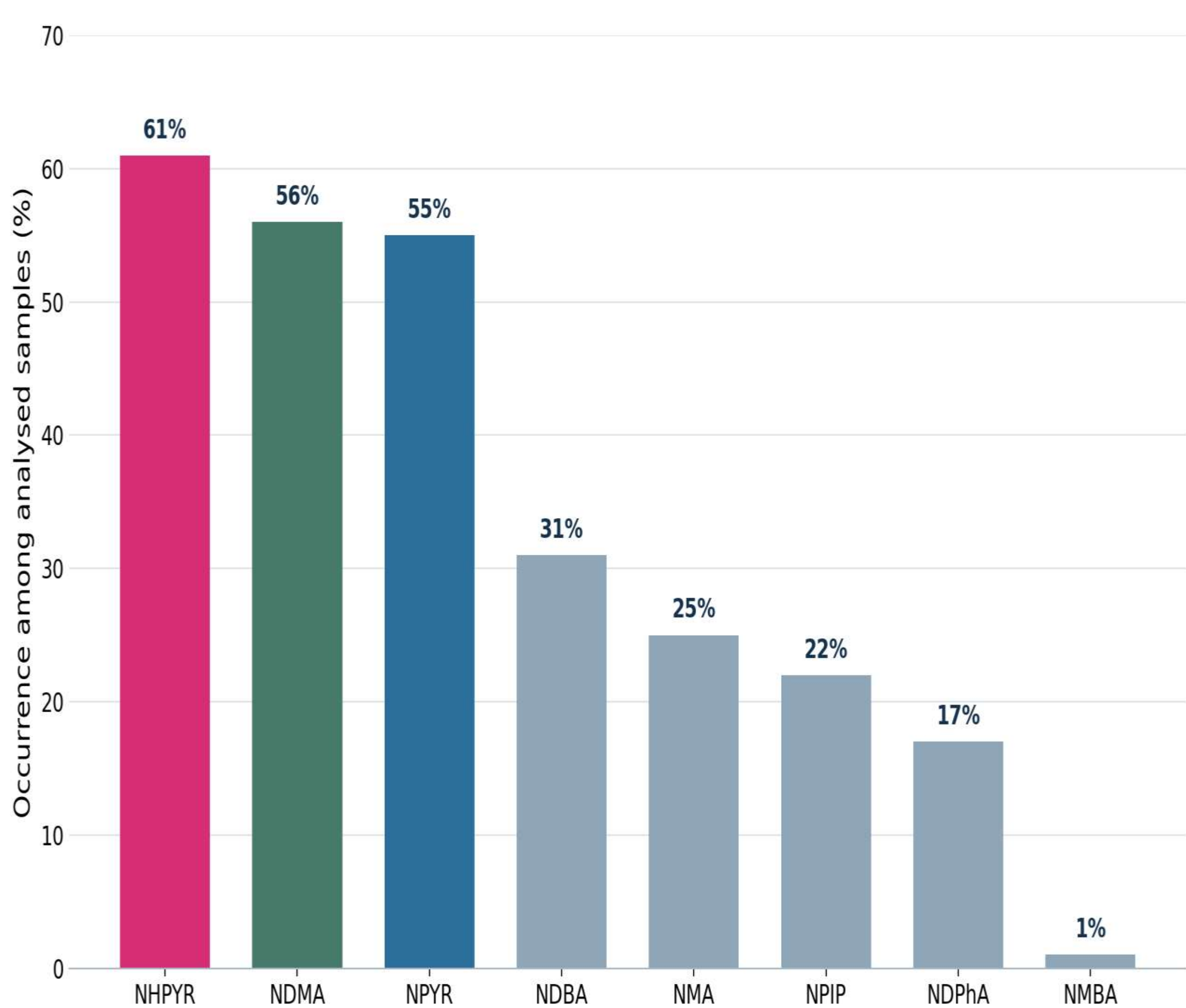


Figure 1. Occurrence of individual N-nitrosamines in the analysed meat products

Abbreviations: NHPYR, N-nitroso-3-hydroxypyrrolidine; NDMA, N-nitrosodimethylamine; NPYR, N-nitrosopyrrolidine; NDPA, N-nitrosodiphenylamine; NMA, N-nitrosomethylaniline; NPIP, N-nitrosopiperidine; NDPhA, N-nitrosodiphenylamine; NMBA, N-nitroso-N-methyl-4-aminobutyric acid.

DISCUSSION

Higher N-nitrosamine levels in dry products may be associated with prolonged fermentation, ripening and drying. The weak correlation with residual nitrate and nitrite suggests that processing conditions and precursor availability have a greater influence on N-nitrosamine formation than residual curing agents alone.

Table 1. Total N-nitrosamine concentrations in processed meat products

Product group	n (samples)	Mean ± SD (µg/kg)	Median (µg/kg)	Maximum (µg/kg)
Semi-dry cured meat – single piece	14	7.62 ± 17.42	2.47	61.60
Semi-dry products – meat pieces	2	1.42 ± 0.11	1.42	1.50
Minced meat products	10	4.97 ± 4.20	2.99	10.00
Semi-dry sausages	22	9.70 ± 8.87	6.89	16.70
Dry-cured meat products	24	38.19 ± 28.01	35.25	93.00
Dry sausages	28	52.67 ± 45.58	43.67	123.60

Values are expressed as µg/kg. The highest concentrations were observed in dry sausages and dry-cured meat products.

CONCLUSIONS

Dry fermented sausages and dry-cured meat products contained the highest total N-nitrosamine levels. Processing conditions appear to play a more important role than residual nitrate and nitrite levels, supporting the need for continued monitoring.

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