Survey of Residual Nitrite and Nitrate in Processed Meats from Small Processors and in Meat Analogues at Retail in the United States

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I. INTRODUCTION

Nitrite (NO_2^-) and Nitrate (NO_3^-) are most common meat curing ingredients that serve as antimicrobials to inhibit *Clostridium botulinum,* limit growth of spoilage organisms, retard lipid peroxidation, and provide the unique cured meat flavor. While the added NO_2^- and NO_3^- concentrations (NO_x^-) in processed meats are strictly regulated worldwide, NO_3^- in processed meats could be inadvertently introduced from various sources including water, non-meat ingredients, processing aids, and meat used. There is a lack of understanding of residual NO_x^- content in different processed meat categories and what factors affect NO_x^- content (Zhang et al., 2023). Therefore, the objectives of the study were to: 1) evaluate all major categories of cured meats for NO_x^- content from small and regional meat processors across three geographic locations in the United States, 2) evaluate the impact of how water source, species of meat, addition of non-meat ingredients and processing methods affect residual NO_x^-, and 3) provide a comparison of the NO_x^- content in plant protein meat analogues available at retail to traditional processed meat products.

II. MATERIALS AND METHODS

Processed meat samples were collected during product competitions hosted by three States' Meat Processor Associations from April 2023 to March 2024. Meat analogues were acquired at retail in Madison, WI in February 2024. Processed meat and meat analogues were homogenized using a polytron blender with phosphate buffer (pH 7.4) followed by methanol extraction prior to being injected into a HPLC analyzer (ENO-20 nitrite and nitrate analyzer with a reverse phase column) for measuring NO_x^-content. Data was collected using Powerchrome 16.0 and statistically analyzed by R studio (R package 4.3.3.). Multi-linear regression was used to assess factors that contributed to residual nitrite and nitrate levels in processed meats. One-way ANOVA test and Pairwise T-test were used to assess statistical differences among each processed meats classification. Correlation analysis (Pearson correlation) was conducted to evaluate the relationship for NO_3^- in potable water and meat samples in Wisconsin.

III. RESULTS AND DISCUSSION

A total of 973 samples of processed meat were collected from Wisconsin (*n*= 462), Pennsylvania (*n*=291), and California (*n*=220) and 53 meat analogue samples were acquired from retail. NO_2^- in processed meat from Wisconsin, Pennsylvania, and California averaged 13.8±1.7, 18.3±2.6, and 10.4±2.3 ppm, respectively. The NO_3^- in processed meat from Wisconsin, Pennsylvania, and California averaged 47.1±2.7, 30.3±2.6, and 8.3±1.0 ppm, respectively. These results were similar to the last survey conducted by González et al. (2012). For plant protein-based meat analogues the average residual NO_2^- was 1.9±0.2 ppm and the average NO_3^- was 7.3 ±0.7 ppm. Multi-linear regression indicated that NO_2^- was affected by geographic location ($P \leqslant 0.001$), fermentation or chemical acidification ($P \leqslant 0.001$), species of meat (pork and poultry, $P \leqslant 0.001$), dehydration ($P \leqslant 0.01$), and inclusion of variety meats ($P \leqslant 0.05$). NO_3^- content (Fig. 1) was affected by geographic location ($P \leqslant 0.001$), species of meat (pork and poultry, $P \leqslant 0.001$), dehydration ($P \leqslant 0.01$), inclusion of variety meats ($P \leqslant 0.05$) and fine or coarse ground ($P \leqslant 0.05$). Correlation analysis for Wisconsin samples indicated potable water usage did not affect the NO_3^- content in the processed meats when correlated ($|r| < 0.25$) with each county's potable NO_3^- levels (Education, 2023).

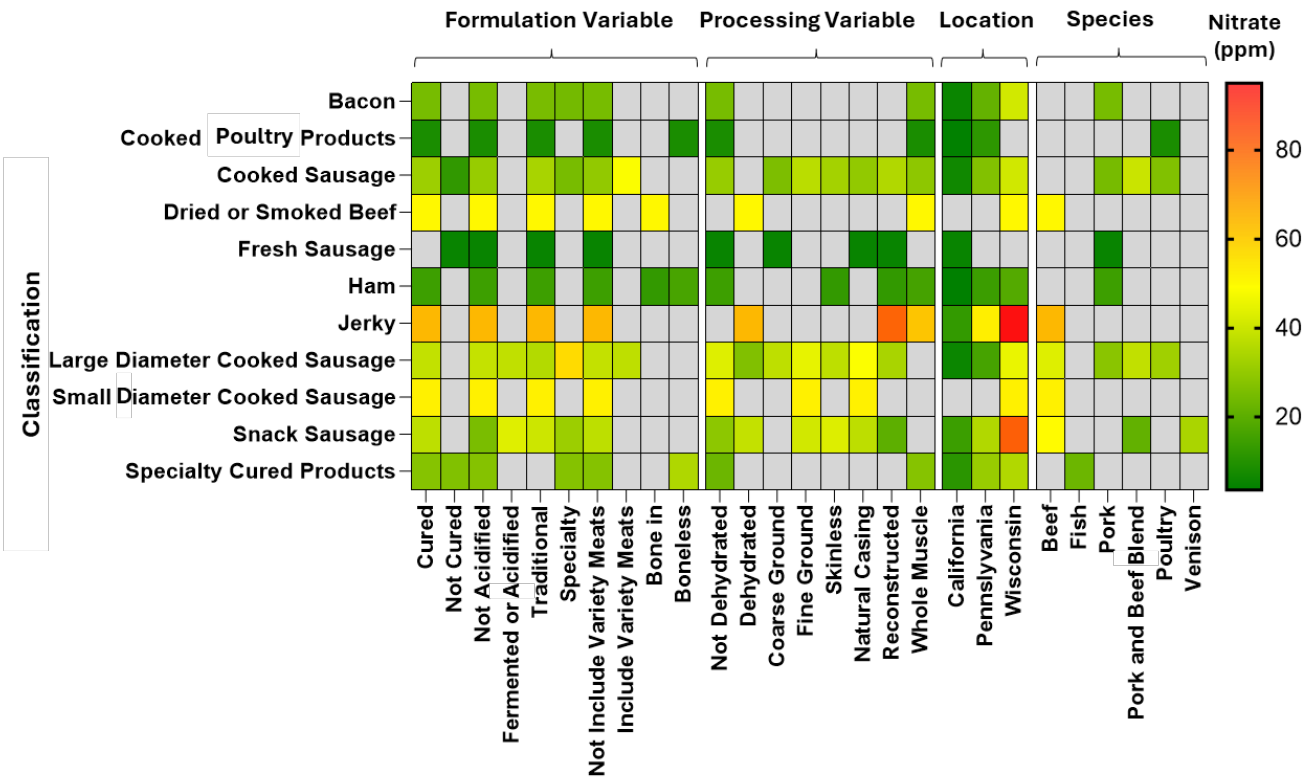

Figure 1. Residual nitrate concentration (ppm) associated with classification and variables in various processed meats.

IV. CONCLUSION

The study presented comprehensive information for consumers and researchers who have interest in residual NO_2^- and NO_3^- as well as evaluated how formulation and processing variables, species of meat, non-meat ingredients, water and geographic location correlated with NO_x^-in all common classification of processed meats. The study suggests that geographic differences of NO_3^- content perhaps was led by differences in spice blend usage in different regions of United States as all other variables (meat, water, other non-meat ingredients) demonstrated a high degree of variability. Moreover, this study provides a baseline that can be used to compare NO_x^- concentration between processed meats and meat analogues.

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REFERENCES

1. Zhang, Y.; Z hang, Y.; Jia, J.; Peng, H.; Qian, Q.; Pan, Z.; Liu, D. (2023). Nitrite and nitrate in meat processing: Functions and alternatives. Curr Res Food Sci, 6, 100470. https://doi.org/10.1016/j.crfs.2023.100470
2. Nuñez De González, M. T.; Osburn, W. N.; Hardin, M. D.; Longnecker, M.; Garg, H. K.; Bryan, N. S.; Keeton, J. T. (2012). Survey of residual nitrite and nitrate in conventional and organic/natural/uncured/indirectly cured meats available at retail in the United States. Journal of Agricultural and Food Chemistry, 60(15), 3981-3990. https://doi.org/10.1021/jf204611k
3. Education, C. f. W. S. a. (2023). Nitrate in Wisconsin's Public Water Systems. http://68.183.123.75/wisconsinwater/WI_NITRATE_TREND_2023/