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# FOCUSING ON BIOGENIC AMINES IN MEAT AND PROCESSED MEAT TO ENHANCE A ONE HEALTH APPROACH

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## I. INTRODUCTION

Biogenic amines (BAs) are low molecular weight biocompounds occurring in living cells, where they exhibit essential physiological functions. In meat and meat products, they could be associated to several factors, such as pH and chemical composition of raw materials, as well as temperature and time of storage of products, but also process conditions (fermentation, ripening) [1]. Due to their adverse health effects, BAs individually or in combined forms (BAs Index) can be used as important indicators of freshness, quality, and spoilage in meat and meat products [2]. Moreover, also due to the risk of nitrosamine formation, studies on BAs in meat and meat products has become increasingly important. According to the Commission Regulation EC No 2073/2005, and further amendments, maximum limits have been established only for histamine in fish and fish products, specifically in fish with high free histidine content in the muscle tissue, while no standards or guidelines are reported for meat products. This study argues if BAs content could ensure food safety from both the human and animal health side, in line with the so called One Health approach.

## II. MATERIALS AND METHODS

For this study, putrescine (PUT), cadaverine (CAD), histamine (HIS), tyramine (TYR), spermidine (SPD) and spermine (SPM) and other biogenic amines were investigated in raw meat and meat processed. They were detected, identified and quantified by means of high-performance liquid chromatography (HPLC), after amine extraction and derivatization according to Esposito et al. [3]; moreover, literature data concerning each single BA in meat products were elaborated for the aim.

Statistical analysis of data was performed using XLSTAT software version 2019.1 for Microsoft Excel (Addinsoft, New York, NY, USA). Results were considered statistically significant at $p<0.05$.

The study assessed also consumer preferences for beef meat quality attributes, with particular attention to the claim "Guaranteed freshness: low levels of biogenic amines", classified under the Safety dimension. Biogenic amines are chemical compounds whose accumulation is associated with spoilage and reduced freshness in meat products. After ethical approvals (Regulation EU n. 2016/679, art. 13), an online national survey (n=351) was conducted using the Best-Worst Scaling (BWS) methodology. Respondents were presented with randomized sets of meat quality attributes and were asked to select the most and least important attribute in each set.

The "low levels of biogenic amines" claim was included alongside other food safety attributes such as "antibiotic-free meat," "non-GMO feed," and "controlled and transparent supply chain."

Best-Worst scores (BWS) were computed to quantify the relative importance assigned to each attribute, allowing for the identification of consumer preferences regarding microbiological indicators of beef meat quality and safety.

## III. RESULTS AND DISCUSSION

Processed meat products were found to accumulate greatest amounts of BAs respect to raw meats (Table 1). SPM and SPD are constitutive in fresh meat, whilst the occurrence of CAD, PUT, TYR and HIS (even if in smaller quantities) are associated to microbial spoilage or chemical pathways, produced by the decarboxylation of amino acids or amination and transamination of aldehydes and ketones during the metabolic processes [4]. To better comprehend the qualitative state of the meat or meat products, PUT, CAD, HIS and TYR were summed, as BAs Index [3]. Poultry and beef meat seemed less susceptible to BAs accumulation in fresh meat, even if their content increases during shelf life. Dry fermented pork sausages showed the highest BAs amount, with TYR detected in concentrations ranged from undetectable to nearly 1000 mg $Kg^{-1}$ (Table 1). This result would represent a high risk for exposure to TYR, according to thresholds reported in the EFSA Scientific Opinion [5].

BWS results showed that claims related to origin and food safety were most valued by consumers. The attribute "low levels of biogenic amines" achieved an average B-W score of 0.0950, placing it in the mid-to-high range of evaluated claims and ranked higher than several environmental sustainability attributes (Figure 1).

These findings suggest moderate consumer awareness of microbiological quality markers like biogenic amines. While tangible claims such as origin and welfare were prioritized, microbiological freshness indicators were positively perceived when effectively communicated.

Table 1. Biogenic amines (mg $Kg^{-1}$): minimum-maximum (median) content of BAs detected in fresh meat and meat products.

| Meat species | Cut/ product (N° of samples) | PUT | CAD | HIS | TYR | SPD | SPM |
|---|---|---|---|---|---|---|---|
| Beef | *Longissimus lumborum* (10) | n.d-10.5 (1.9) | n.d-6.5 (1.8) | n.d.-2.3 (1.1) | n.d.-3.2 (n.d.) | 0.3-5.1 (1.7) | 0.2-12.3 (8.3) |
| Chicken | Breast (24) | n.d. | n.d. | n.d. | n.d. | n.d-29.1 (22.0) | 23.6-153.9 (106.4) |
| | Drumstick (24) | n.d. | n.d. | n.d. | n.d. | n.d-21.3 (15.2) | n.d-181.0 (56.4) |
| | Leg (24) | n.d. | n.d. | n.d. | n.d. | n.d-26.7 (n.d.) | n.d-93.6 (n.d.) |
| Goat | Dry fermented sausages (8) | n.d.-5.3 (2.9) | n.d.-7.1 (n.d.) | n.d. | n.d.-24.2 (3.3) | 6.6-13.3 (9.6) | 34.1-47.6 (41.0) |
| Pork | Dry fermented sausages (313) | n.d-523.0 (25.2) | n.d-678.0 (12.7) | n.d-381.3 (1.3) | n.d-879.2 (98.1) | n.d-30.9 (4.2) | 1.84-87.8 (20.9) |
| | Dry cured ham (26) | n.d-21.6 (1.8) | n.d-298.0 (2.0) | n.d-50.5 (0.2) | n.d-142.9 (1.2) | 5.3-40.3 (5.2) | 19.7-139.2 (36.0) |
| | Cooked ham (10) | n.d-41.6 (n.d.) | n.d-7.6 (n.d.) | n.d-0.6 (n.d.) | n.d-21.6 (0.8) | n.d-6.2 (0.5) | 1.1-6.9 (1.5) |

*Legend:* n.d., not detectable.

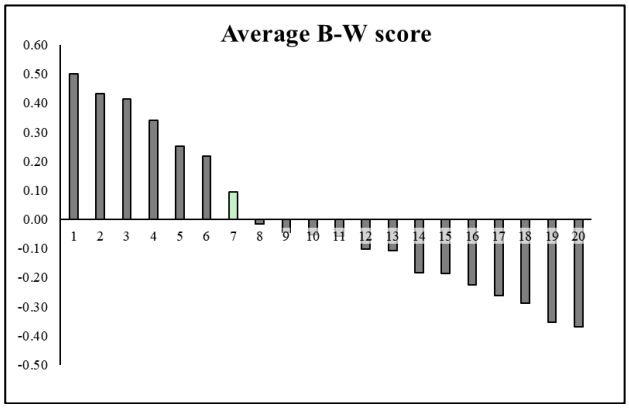



**Figure 1.** *Results of the BWS analysis ranking 20 product attributes. The left panel displays frequency-based counts and standardized scores for each item. Attribute #7, "Guaranteed freshness: low levels of biogenic amines," was selected 181 times as 'Best' and 81 times as 'Worst', yielding a standardized score of 0.0950. The right panel shows the relative importance scores derived from the BWS analysis*

## IV. CONCLUSION

BAs content in meat and meat products, above all fermented ones, represent a substantial concern in food hygiene, regarding food quality and safety. It would be desirable new investments in research for offering cheap and easy-to-use devices for rapid BAs assessment in meat and meat products, but also for BAs degradation, too. Furthermore, we cannot ignore the almost total ignorance of consumers about this risk. Strengthening consumer education could further enhance the perceived value of such safety attributes and support market differentiation for microbiologically superior meat products.

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