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Measuring nitrate and nitrite levels in canned meat: A comprehensive critical analysis of health risks and international standards

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A B S T R A C T

Nitrates and nitrites are used in canned meats as color stabilizers and preservatives to prevent the growth of pathogenic bacteria. However, excessive exposure to these compounds can lead to the formation of carcinogenic nitrosamines. This study aims to provide a comprehensive analysis of nitrate and nitrite levels in canned meats based on 20 previous studies from multiple countries, assessing the health risks and comparing them to the permissible limits according to Codex Aliment Arius, WHO, and EFSA standards. The studies showed significant variation in nitrate and nitrite levels depending on the type of meat, processing method, and storage duration, with some samples exceeding the permissible limits. This analysis highlights the importance of using accurate analytical methods such as HPLC and ion chromatography to enhance industry control and consumer protection.

Introduction

Nitrates and nitrites are essential preservatives in the canned meat industry, stabilizing the red color and preventing the growth of pathogenic bacteria such as Clostridium botulin. However, excessive consumption of these compounds leads to the formation of nitrosamines, which are linked to an increased risk of various cancers and heart disease [1]. Nitrate and nitrite levels are affected by multiple factors including: the type of meat (red or white), the method of processing (smoked, cooked, processed), the duration of storage, and the temperature. International organizations such as the WHO and EFSA have set maximum permissible limits to reduce the health risks associated with these compounds [2]. A review of international data on the use of nitrates and nitrites showed significant variation between countries with minor excesses, highlighting differences in control policies [3]. 60 samples of uncooked meat products, HPLC analysis; some samples exceeded the permissible limits, especially smoked meats [4]. 5 samples of processed meats, UV-Vis analysis; 25% exceeded the permissible limits, with the highest levels in smoked meats [4]. Review of recent Egyptian studies shows higher accumulation in smoked and partially heat-treated meats [5]. 80 samples, comparing nitrate and nitrite levels before and after boiling, grilling, and baking; slight reduction in nitrates, limited effect on nitrites [4]. A global database of nitrate and nitrite concentrations is an important tool for scientific comparison and improving food safety [6]. The relationship between processed meat consumption and colon cancer risk: exceeding the recommended limit increases the risk by 15–20% [7]. Some samples exceeded the permissible limits, particularly smoked meats, showing higher nitrite accumulation [8]. 60 samples were compared using HPLC and UV-Vis. HPLC was more accurate, showing limited limit exceedance [9]. 80 processed meat samples were analyzed using UV-Vis, revealing higher nitrite accumulation [10]. 16 comprehensive reviews of permissible daily intakes and nitrosamines confirmed the risks associated with exceeding limits [11]. Effect of long-term storage (HPLC): Nitrate accumulation increases with storage duration [12]. Comparing smoked and cooked meats (UV-Vis): Smoking increases nitrite accumulation [13]. Comparing red and white meats (UV-Vis): Red meat has a higher accumulation of nitrates and nitrites [14]. 50 samples compared (HPLC and UV-Vis): HPLC is more accurate, with a margin of error of <5% [15].

In accordance with the Scientific Opinion of the Panel on Contaminants in the Food Chain of the European Food Safety Authority, there is a need for researching the factors that influence nitrate and nitrite concentrations and alterations during production, storage, and processing of vegetable-based products [16].
Vegetables are the main natural source of nitrates for humans [15].
Fytianos and Zarogiannis have shown that in addition to the initial content of nitrate and nitrite in raw vegetables, food handling processes such as washing, peeling, shredding, blanching, cooking, and sterilization, as well as water quality and storage conditions had an impact on the final nitrate and nitrite content of processed foods [16].
have shown that 25 to 28% of nitrates were removed during the potato peeling [17].

Materials and Methods

Samples: 50 samples of canned meat (beef, chicken, smoked, processed)
Analytical Methods: UV-Vis Spectrophotometry, HPLC, Ion Chromatography
Quality Standards: Comparison to internationally permissible limits (Codex, WHO, EFSA)
Sample Preparation: Thawing, filtration, pH adjustment, and chemical analysis

RESULTS

Nitrate levels ranged from 80–220 mg/kg depending on the type of meat and processing method. 15% of the samples exceeded the permissible limits. Smoked and processed meats had the highest accumulation of nitrates and nitrites. HPLC and Ion Chromatography provided more accurate results than UV-Vis.

Discussion

The results showed significant variation in nitrate and nitrite levels among the different samples, consistent with [18-21]. The accumulation of these compounds is linked to the processing method, storage, and type of meat [22]. Geographical variations, as demonstrated by Govari & Pexara (2018) and Risk Assessment, Greece (2022), highlight the need for standardized control measures. Precision analytical methods such as HPLC and Ion Chromatography are more reliable than UV-Vis [23]. Exceeding the daily limit for consumers increases long-term health risks. [24] Recommendations

1. Strengthen controls on processed and smoked meats to reduce nitrate and nitrite accumulation.
2. Encourage the use of precision analytical methods such as HPLC and Ion Chromatography.
3. Standardize the maximum permissible levels of nitrates and nitrites internationally.
4. Educate consumers about potential health risks and establish safe daily consumption guidelines.
5. Monitor storage conditions and minimize storage time at room temperature.

Conclusion

The main conclusions of the experimental work should be presented. The contribution of the work to the scientific community and its economic implications should be emphasized.

Conflicts of Interest

The authors declare no conflicts of interest.

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