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Reduction of the formation and toxicity of heterocyclic aromatic amines (PhIP, IQ, MeIQ, MeIQx) in food: potential of nucleophilic compounds as mitigating agents

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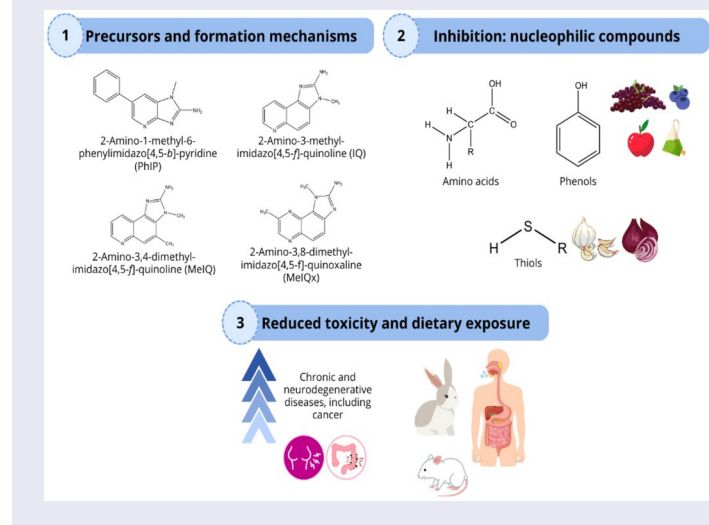
ABSTRACT

This review presents significant advances in the study of heterocyclic aromatic amines (HAAs), potentially carcinogenic compounds formed during the cooking of meat products. The main implicated precursors and carbonyl-amine formation pathways associated with the most common HAAs in highly cooked meats are analyzed: PhIP, IQ, MeIQ, and MeIQx. Furthermore, the use of nucleophilic compounds as a mitigation strategy is evaluated, detailing their proposed mechanisms of action and their efficacy in reducing these compounds. Emphasis is placed on the toxicology of HAAs and the importance of reducing both their toxicity and dietary exposure. Furthermore, the review identifies critical gaps in knowledge, such as the need to investigate alternative formation pathways and potentially implicated biomolecules, as well as the limited exploration of certain inhibitors, such as amino acids and thiols. Overall, this work offers an updated perspective that can guide future research and foster the development of safer food technologies.

KEYWORDS

Heterocyclic aromatic amines (HAAs); aminoimidazoarenes (AIAs); formation mechanisms; reactive carbonyls; nucleophilic compounds; inhibition; toxicity

GRAPHICAL ABSTRACT



1. Introduction

There is great interest in the health impacts of chemical compounds with mutagenic and carcinogenic properties that are produced during the storage or thermal processing of protein-rich foods. Polycyclic aromatic hydrocarbons, *N*-nitroso compounds, heme iron, macromolecular oxidation products, acrylamide, and heterocyclic aromatic amines (HAAs) are among the compounds involved. The formation of these compounds depends on factors, such as the type of meat and parameters of cooking/frying (time and

temperature) (Gao et al. 2021). The latter have been linked to an increased risk of several kinds of cancer in humans, including the colon, pancreas, breast, and prostate (Turesky and Le Marchand 2011).

HAAs have been identified in various meat foods, specifically more than 30 different molecules (cooked at temperatures above 100°C). Based on their formation temperature and chemical structure, these compounds are classified into two groups: thermic amines (aminoimidazoarenes; AIAs) and pyrolytic amines (aminocarboline) (Oz et al. 2023).