



Review

Acrylamide: An approach to its knowledge and importance for roasted coffee

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ABSTRACT

Acrylamide (AA) has been classified as a toxic, harmful, and carcinogenic substance since 2002, and therefore it is currently widely studied. When functional amino and carbonyl groups of asparagine and reducing sugars are condensed into Schiff bases, they are transformed into AA molecules at temperatures >120 °C. This mechanism is known as the Maillard reaction and is considered the main AA pathway. Simultaneously, desired browning and sensory properties are developed. However, changes in chemical composition of the matrix, properties, and secondary reactions trigger intermediary synthesis, destabilizing the medium and leading to new AA molecules. Coffee has become the most consumed beverage worldwide. Therefore, the World Health Organization established recommended benchmark levels of AA concentrations that could be detected in roasted coffee beans and by-products (<850 µg/kg). Trace levels of AA can differ between samples due to roasting and brewing conditions, and the analytical and extraction methods chosen for sample analysis.

1. Introduction

A wide variety of food products are transformed by thermal processes to ensure their microbiological safety, maintain nutritional quality, develop sensory properties, or extend their shelf life (Galuch et al., 2019). However, food contaminants such as acrylamide (AA) appear during these processes (Pennisi et al., 2013). This molecule was declared for the first time in 1994 as a “probable carcinogen for humans” by the International Agency for Research on Cancer (IARC). Later, in 2002, the Swedish National Food Authority confirmed its presence in many carbohydrate-rich food products at low levels with the support of Swedish researchers at Stockholm University (Mousavi Khaneghah

et al., 2022). Since then, numerous studies and researchers have focused on understanding the formation pathways, properties, and carcinogenic effects of this substance, as well as its precursors, behavior during storage, and potential mitigation strategies (Guenther et al., 2007; Michalak et al., 2016; Strocchi et al., 2022; Taeymans et al., 2005; Yashin et al., 2017).

Human exposure to AA can occur through different routes, including ingesting food or liquids (e.g., water contaminated with polyacrylamide flocculants), through skin contact, and inhalation. The health risks of some instances of neurotoxicity resulted from prolonged exposure to AA have been previously documented (Mohammadi et al., 2015; Pennisi et al., 2013; Yamamoto et al., 2023). Previous studies on the behavior of

Abbreviations: AA, Acrylamide; ASP, Asparagine; RS, Reducing Sugars; IARC, International Agency for Research on Cancer; GLU, Glucose; FRU, Fructose; MR, Maillard Reaction; SUC, Sucrose; HMF, 5-Hydroxymethylfurfural; Aw, Water Activity; 3-APA, 3-Aminopropionamide; GC, Gas Chromatography; LC, Liquid Chromatography; MS, Mass Spectrometry; LLE, Liquid-Liquid Extraction; SLE, Solid-Liquid Extraction; SPE, Solid Phase Extraction; HPLC, High-performance Liquid Chromatography; DAD, Diode Array Detector; DLLE, Dispersive Liquid-Liquid Extraction; SPME, Solid Phase Micro-Extraction; PIL, Polymeric Ionic Liquid; DI, Direct Infusion; ILs, Ionic Liquids; LOQ, Limit of quantification; LOD, Limit of detection; HCl, Hydrochloric Acid; H₂SO₄, Sulfuric Acid; BF₃, Boron trifluoride; CH₃COCl, Acetyl Chloride; FAME, Fatty Acids Methyl Esters; NaOCH, Sodium Methoxide; KOH, Potassium Hydroxide; TMSH, Tri-Methyl Sulfonium Hydroxide; FID, Flame Ionization Detector; NP, Normal Phase; RP, Reverse Phase; CE, Capillary Electrophoresis; FASI, Field Amplified Sample Injection; PFE, Pressurized Fluid Extraction; SFE, Supercritical Fluid Extraction; DES, Deep Eutectic Solvents; HBA, Hydrogen-Bond Acceptor; HBD, Hydrogen-Bond Donor; ICO, International Coffee Organization; GCB, Green Coffee Beans; WHO, World Health Organization; HRMS, High-Resolution Mass Spectrometry; GMP, Good Manufacturing Practice; PTC, Potentially Toxic Compounds.

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