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Deep eutectic solvents for pesticide residue extraction from tomatoes using mini-QuEChERS

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Highlights

Mini-QuEChERS enables fast, safe, and green analysis; DES-based Mini-QuEChERS as a greener alternative was evaluated; LC-DAD ensures reliable pesticide determination in tomatoes.

Abstract

Tomato is one of the most consumed vegetables in Brazil and plays an important role in the national diet. However, pesticide residues above regulatory limits have been reported, raising concerns about food safety and public health (1). Thus, efficient and sustainable sample preparation techniques are essential for monitoring complex food matrices. QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) is widely applied for pesticide residue analysis, relying on extraction, salt-induced partitioning, and dispersive solid-phase cleanup, providing high recovery with minimal manipulation (2). Deep eutectic solvents (DES) have emerged as green alternatives to conventional solvents, offering low toxicity, easy preparation, and reduced environmental impact (3). Their use improves analytical performance while aligning with sustainable chemistry by minimizing hazardous waste. This study investigated a mini-QuEChERS method using DES for extracting pesticide residues in tomato, determined by liquid chromatography with diode array detection (LC-DAD). The method was evaluated based on the 12 principles of Green Analytical Chemistry (4) and represents a sustainable approach for food residue monitoring, contributing to consumer safety and environmentally responsible practices. Initial LC-DAD tests identified carbendazim, imidacloprid, tebuconazole, and profenofos as target compounds. Chromatographic separation was performed on a C18 column (250 x 4.6 mm, 4 μ m) with a gradient elution with methanol and water, totalling 18 min of analysis. A mix standard solution (10 mg L⁻¹ in MeOH) of the four pesticides was combined (1:1, v/v) with four DES: Choline chloride:Urea (ChCl:U), ChCl:Glycerol (ChCl:Gly), ChCl:Citric acid (ChCl:Cit), and ChCl:Lactic acid (ChCl:Lac). Poor chromatographic performance and non-detection of carbendazim were observed with ChCl:Lac and ChCl:Cit, whereas ChCl:U and ChCl:Gly provided improved chromatographic results. Subsequently, a miniaturized QuEChERS procedure (5x reduction) with acetonitrile was applied to samples spiked at 1 mg kg⁻¹, yielding recoveries between 71.8% and 114.4%, with RSD values below 6.5%, confirming good accuracy and precision. Preliminary extractions using ChCl:Gly resulted in recoveries of 35.6% for carbendazim and 51.1% for imidacloprid with RSD below 5%, while tebuconazole and profenofos were not extracted. Further tests with alternative DES will focus on enhancing extraction efficiency in the mini-QuEChERS approach.

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