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Exploration of deep eutectic solvent-based microextraction for quercetin monitoring in plant samples

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ABSTRACT

This study delves into utilizing a microextraction process based on deep eutectic solvents (DES) for determining quercetin (QUR) levels in plant samples. The preparation of the DES involves a choline chloride (CC) to 1, 2-propanediol (PR) in a 1:4 ratio for efficient quercetin extraction. Through multivariate procedures, critical microextraction variables such as extraction time, pH, solvent volume, salinity, and sodium chloride were optimized to enhance quercetin extraction efficiency. Using the proposed procedure, the best response was found with a DES volume of 149 μL, extraction time of 4 min, pH 3.3, and salinity 2.9 % W/V sodium chloride with Desirability = 1. The method exhibited a detection limit of 9.8 ng mL^{-1} and an enrichment factor of 61-fold for quercetin. The working range for detection was determined to be 30–5000 ng mL^{-1}. These findings highlight the efficacy of the developed microextraction method for accurately determining quercetin levels in plant samples with favorable recoveries in the range of 99.15 % −101.27 %.

1. Introduction

Quercetin (QUR), a prominent bioflavonoid abundant in various fruits and vegetables like onions, apples, peppers, and broccoli, has gained recognition for its potential health benefits (Ahmad, 2020; Deis et al., 2021). Extensive evidence suggests that its antioxidant properties are advantageous for human health. Quercetin's potent antioxidant activity is attributed to its ability to neutralize free radicals, offering a range of therapeutic effects, including anti-edema, anti-inflammatory, cell membrane stabilization, anti-cancer, antihistamine, anti-allergic, and antiviral activities (Ay et al., 2016; Jihwaprani et al., 2023). These properties are believed to contribute to preventing cardiovascular diseases. Given the compelling evidence, quercetin measurement has become a focal point for researchers in recent years. Consequently, there is a pressing need to develop an analytical system that is sensitive, selective, highly accurate, and cost-effective for monitoring quercetin levels.

Several techniques have been developed for quercetin determination, including UHPLC-MS (Mu et al., 2023), HPLC-UV (Umer et al., 2024), capillary electrophoresis (Gackowski et al., 2021), RP-HPLC (Patidar and Ramteke, 2024), fluorescence (Kadian and Manik, 2020), and GC-MS (Bhardwaj et al., 2020). While these methods offer sensitivity and efficiency, their widespread adoption is hindered by limited laboratory resources, operational complexity, high reagent consumption, and cost. Furthermore, despite advancements in analytical instrumentation, the low concentration of analytes in complex matrices like food necessitates a pre-concentration step to enhance detection sensitivity economically and rapidly (Selahle et al., 2021; Jafari et al., 2021; Câmara et al., 2022). Thus, there is a growing interest in developing fast, user-friendly, cost-effective, and efficient methods for quercetin analysis (Sharifi et al., 2023).

To fulfill these requirements, the pre-concentration step must offer ease of use, rapidity, high precision, automation capability, and compatibility with various analytical instruments (Elik et al., 2023).

Microextraction techniques are commonly employed for analyte separation and pre-concentration, typically involving two phases (Soylak et al., 2023). One notable subset of LPME is dispersive liquid-liquid microextraction (DLLME) (Farajzadeh et al., 2021). This method entails creating fine droplets of the extracting solvent within the sample solution by introducing another solvent. The extracting solvent is immiscible in water, while the dispersing solvent is a miscible organic solvent in water. This process facilitates the formation of fine droplets of the extracting solvent in the sample solution. Recent advancements in DLLME have introduced methods to eliminate the dispersing solvent, including ultrasonic-assisted DLLME, Vertex-assisted DLLME, and air-assisted DLLME (Lanjwani et al., 2023; Altunay et al., 2024). Among

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