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Natural deep eutectic solvent-assisted hydrodistillation as an emerging green technology for the simultaneous extraction of essential oils and phenolic compounds from hops (*Humulus Lupulus*)

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Summary: Essential oil extraction from aromatic plants is typically performed through hydrodistillation, which produces by-products rich in phenolic compounds requiring proper treatment to prevent environmental impact. This study investigates the use of green solvents, specifically natural deep eutectic solvents (NADES), to optimize the extraction process. A choline chloride: urea (1:2) NADES was synthesized using an ultrasound bath (75°C for 1 hour) and applied to the extraction of hops (*Humulus lupulus* L.) essential oil. The extraction (50 g of hops, 1700 mL of water, and 300 mL of NADES) was conducted using a Clevenger apparatus for 4 hours, with a control extraction using only water. All extractions were carried out in triplicate. Two fractions were recovered at the end of hydrodistillation: essential oil and liquid spent. The volatile fraction was analyzed by GC-MS, and the liquid spent was evaluated for total phenolic compounds (Folin-Ciocalteu method) and antioxidant activity (DPPH assay). The results showed that the use of NADES did not affect the essential oil yield compared to conventional hydrodistillation (1.2% vs. 1.3% v/w). However, GC-MS analysis revealed increased concentrations of ketones (2-tridecanone, 2-pentadecanone), terpenes (β -myrcene, limonene, linalool, geraniol), and sesquiterpenes (caryophyllene, humulene) when NADES was used. The liquid spent from hydrodistillation with NADES contained higher levels of total phenolics (963.70 mg GAE·L⁻¹) compared to water-only extraction (483.32 mg GAE·L⁻¹). In DPPH analysis, NADES showed 29.57% inhibition, compared to 17.61% inhibition with water-only. These findings suggest that choline chloride NADES helps dissolve lignin from plant tissues, increasing phenolic compounds, antioxidant activity, and enhancing volatile components of hops essential oil. Further research is recommended to identify phenolic compounds using HPLC-MS.

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