Journal of Food Quality and Hazards Control 12 (2025) 160-162

Editorial

A Review of the Benefits and Drawbacks of New Plant Extraction Methods: Ultrasound, Supercritical Fluid, and Natural Deep Eutectic Solvents

B. Alizadeh Salmani, M. Arab *, J. Sadeghizadeh-yazdi

Department of Food Sciences and Technology, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

*Corresponding author (M. Arab)
E-mail: Arab.sepideh@gmail.com
ORCID ID: https://orcid.org/0000-0001-6369-9718

As the world becomes increasingly aware of the environmental impacts of industrial practices, it is crucial to re-evaluate the methods used to extract valuable compounds from plants. Traditional extraction techniques often rely on harsh solvents, high temperatures, and lengthy processes that can be detrimental to both the environment and the quality of the extracted compounds. However, recent advances in extraction technology have paved the way for more sustainable and efficient methods (Da Silva et al., 2022). One promising approach is the use of Ultrasound-Assisted Extraction (UAE). UAE is a nonconventional extraction technique that utilizes ultrasonic waves to induce cavitation in the extraction medium. This cavitation generates microbubbles that implode, creating localized high temperatures and pressures. These phenomena enhance solvent penetration, disrupt cell walls, and improve mass transfer, thereby facilitating the release of target compounds from plants or microbial matrices. The cavitation process disrupts cellular structures, increasing the contact surface between the solvent and the sample, thus minimizing solvent usage and shortening the extraction time compared to traditional methods, which typically require hours to days. This time-saving aspect, combined with the relatively simple equipment, makes UAE widely applicable on large industrial scales. Disadvantages of this method include reduced efficiency of ultrasound in propagating highly viscous or dense matrix samples, as well as the generation of free radicals and initiation of unwanted side reactions such as oxidation, and the increasing vulnerability of ultrasound probes over time. Despite the advantages and disadvantages of the ultrasound method, it is important to mention that the efficiency of the extraction process depends on various parameters such as ultrasonic power, temperature, extraction time, and solvent selection (Santos and Martins, 2023). Accurate optimization of these parameters is very important to ensure maximum extraction efficiency and maintain the integrity of the extracted compounds (Islam et al., 2023).

Another innovative method is Supercritical Fluid Extraction (SFE), which uses carbon dioxide in its supercritical state as a solvent. Supercritical CO_2 is non-toxic, non-flammable, and easily separated from the extract, making it an environmentally friendly alternative to traditional organic solvents. SFE also allows selective extraction of specific compounds by adjusting pressure and temperature parameters, making it more effective than traditional methods that use organic solvents and high temperatures, which may damage heat-sensitive compounds. Despite its many advantages, SFE presents several limitations that must be considered when evaluating its applicability for industrial and research purposes. A principal drawback of SFE is the high capital investment required; the specialized high-pressure equipment and stringent safety measures necessary to maintain supercritical conditions lead to increased initial and maintenance costs. Furthermore, SFE demands precise control of operating parameters, particularly temperature and pressure, since minor deviations can

To cite: Alizadeh Salmani B., Arab M., Sadeghizadeh-yazdi J. (2025). A review of the benefits and drawbacks of new plant extraction methods: ultrasound, supercritical fluid, and natural deep eutectic solvents. *Journal of Food Quality and Hazards Control.* 12: 160-162.

DOI: 10.18502/jfqhc.12.3.19779 Journal website: http://jfqhc.ssu.ac.ir

significantly alter the solvent's density and solvating power, thereby impacting extraction efficiency and reproducibility. Another notable limitation arises from the intrinsic non-polar nature of supercritical CO_2, the most commonly used supercritical fluid. While this property is advantageous for extracting non-polar compounds, it limits the solubility of polar analytes. To overcome this, co-solvents (or modifiers) such as ethanol are often introduced, which can improve the extraction of polar compounds but simultaneously complicate the extraction process by potentially co-extracting unwanted impurities. Additionally, the requirement to remove these modifiers post-extraction may add extra processing steps, potentially diminishing the overall efficiency of the method. (Bitwell et al., 2023; Khaw et al., 2017; Wrona et al., 2017).

There is a growing interest in the use of Natural Deep Eutectic Solvents (NADES) for the extraction of plant extracts. NADES are formed by mixing a Hydrogen Bond Acceptor (HBA) with a Hydrogen Bond Donor (HBD), resulting in a eutectic mixture with a melting point lower than of its individual components. This unique property allows NADES to remain liquid at room temperature, making them ideal for various extraction processes. Their versatility and ease of preparation make them attractive for extracting valuable bioactive compounds from plant materials. These solvents are biodegradable and recyclable and can be designed to target specific compounds based on their polarity and solubility (Abranches and Coutinho, 2023; Długosz, 2023; Liu et al., 2018). For example, studies have shown that NADES can efficiently extract many bioactive compounds including phenolics and flavonoids (Socas-Rodríguez et al., 2021). Despite the promising results, there are challenges in the widespread adoption of NADES. The lack of standardized protocols and a comprehensive understanding of their long-term stability and recyclability are critical areas that require further investigation. As researchers continue to explore the full potential of NADES, it is essential to develop clear guidelines and methods to facilitate its wider application in the extraction of plant bioactive substances. One of the primary challenges associated with NADES is their elevated viscosity. High viscosity can impede mass transfer rates, obstructing the diffusion of target analytes from solid matrices into the solvent. This may require interventions such as dilution or heating, which can compromise extraction selectivity or lead to the degradation of thermolabile compounds. Another significant limitation is the restricted polarity range of NADES. Although these solvents can be designed for a range of polarities, many formulations are predominantly highly polar. This trait aids in extracting polar compounds but can hinder the extraction of non-polar or less polar molecules. The incorporation of a co-solvent may be necessary to expand the extraction range; however, this complicates the process and may diminish the environmental advantages of using pure NADES. Water content is a critical determinant. While minimal water can enhance mass transfer by reducing viscosity, excessive water can disrupt the solvent's structure and weaken its hydrogen bonding network. This alteration may reduce extraction efficiency and reproducibility, especially for compounds that depend on specific solvation conditions (Liu et al., 2018).

As we move toward a more sustainable future, it is imperative to prioritize the development and implementation of green extraction technologies for plant-derived compounds. By adopting these innovative methods, we can reduce the environmental impact of extraction processes while ensuring the availability of high-quality natural products for a variety of applications, from pharmaceuticals to cosmetics and even food products.

References

Abranches D.O., Coutinho J.A.P. (2023). Everything you wanted to know about deep eutectic solvents but were afraid to be told. *Annual Review of Chemical and Biomolecular Engineering.* 14: 141-163. [DOI: 10.1146/annurev-chembioeng-101121-085323]

Bitwell C., Indra S.S., Luke C., Kakoma M.K. (2023). A review of modern and conventional extraction techniques and their applications for extracting phytochemicals from plants. *Scientific African.* 19: e01585. [DOI: 10.1016/j.sciaf.2023.e01585]

Da Silva R.F., Carneiro C.N., De Sousa C.B.C., Gomez F.J.V. , Espino M., Boiteux J., Fernández M.A., Silva M.F., Dias F.S. (2022). Sustainable extraction bioactive compounds procedures in medicinal plants based on the principles of green analytical chemistry: a review. *Microchemical Journal.* 175: 107184. [DOI: 10.1016/j.microc.2022.107184]

Długosz O. (2023). Natural deep eutectic solvents in the synthesis of inorganic nanoparticles. *Materials.* 16:627. [DOI: 10.3390/ma16020627]

Islam M., Malakar S., Rao M.V., Kumar N., Sahu J.K. (2023). Recent advancement in ultrasound-assisted novel technologies for the extraction of bioactive compounds from herbal plants: a review. *Food Science and Biotechnology.* 32: 1763-1782. [DOI: 10.1007/s10068-023-01346-6]

Khaw K.-Y., Parat M.-O., Shaw P.N., Falconer J.R. (2017). Solvent supercritical fluid technologies to extract bioactive compounds from natural sources: a review. *Molecules.* 22: 1186. [DOI: 10.3390/molecules22071186]

Liu Y., Friesen J.B., McAlpine J.B., Lankin D.C., Chen S.-N., Pauli G.F. (2018). Natural deep eutectic solvents: properties, applications, and perspectives. *Journal of Natural Products.* 81: 679-690. [DOI: /10.1021/acs.jnatprod.7b00945]

Santos L.G., Martins V.G. (2023). Optimization of the green extraction of polyphenols from the edible flower Clitoria ternatea by high-power ultrasound: a comparative study with

[DOI: 10.18502/jfqhc.12.3.19779]

conventional extraction techniques. *Journal of Applied Research on Medicinal and Aromatic Plants*. 34: 100458. [DOI: 10.1016/j.jarmap.2023.100458]

Socas-Rodríguez B., Torres-Cornejo M.V., Álvarez-Rivera G., Mendiola J.A. (2021). Deep eutectic solvents for the extraction of bioactive compounds from natural sources and agricultural by-products. *Applied Sciences*. 11: 4897. [DOI: 10.3390/app11114897]

Wrona O., Rafińska K., Możeński C., Buszewski B. (2017). Supercritical fluid extraction of bioactive compounds from plant materials. *Journal of AOAC International*. 100: 1624-1635. [DOI: 10.5740/jaoacint.17-0232]