A Review: Microwave Assisted Extraction of Bioactive Compounds from Plant Samples

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Abstract- Recently, bioactive substances derived from plant material have been removed with the aid of a microwave extractor. This is due to the fact that traditional methods for extracting use greater amounts dissolve heat-sensitive bioactive materials in solvents substance also it extract slowly. Therefore, a significance of the Microwave-Assisted Extraction (MAE) method within the extraction of bioactive chemicals or substances derived from plants is revealed in this chapter. The extraction processes involved must guarantee stable, heat-sensitive bioactive chemicals, recover greater yields more quickly, and use fewer extracted solvents. Additionally included are the variables influencing MAE while bioactive compounds are being extracted from plant sources. Furthermore, a few of the bioactive chemicals from plant samples that have already been described using MAE are noted.

Keywords: solvents, plants, bioactive chemicals, extraction, microwave heating, and microwave-assisted extraction.

INTRODUCTION

Extraction is the process of separating soluble components from insoluble residues by using solvents. Additionally, ancient and modern extraction are the two main categories. Traditional techniques include lengthy extraction durations, excessive solvent consumption, and the loss of heat-sensitive bioactive chemicals. Modern methods aim to overcome these issues. The most widely used current technique is microwave-assisted extraction (MAE), that include lower solvent consumption, shorter operation times, repeatability, better enhanced selectivity, reduced sample manipulation, and increased recovery yield. The initial studies were Gedye et al. and Giguere et al. group to use microwave energy in 1986. They did so for organic synthesis and biological sample extraction in order to analyse organic components. [1]

In the electromagnetic spectrum, non-ionizing electromagnetic waves are also referred to as microwaves that range in frequency from 300 MHz to 300 GHz, between X-ray and the infrared radiation. They serve two main purposes in modern science as vectors of energy and for communication.

Img:1Microwave oven Extraction. [2]

An electric and magnetic field make up a microwave, with the electric field responsible for heating. The extraction time is greatly shortened by MAE heating, which operates in a focused and selective manner as opposed to traditional heating, which depends upon the conduction and convection. When compared to Soxhlet procedures, This unique heating system can significantly decrease or overcome the extraction duration—typically less than 30 minutes. [3]

MICROWAVE HEATING:

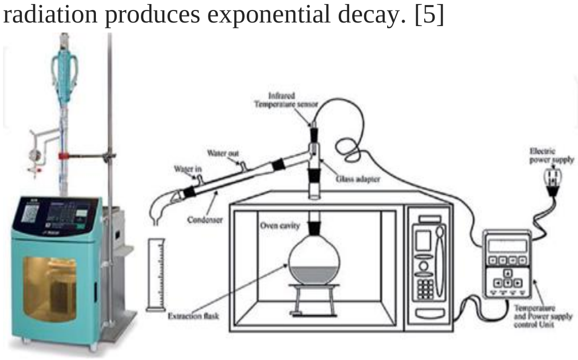
Solvent	Dielectric loss	Dielectric constant	Loss tangent
Ethylene glycol	49.950	37.0	1.350
Ethanol	22.866	24.3	0.941

Dimethyl formamide	6.079	37.7	0.161
Dimethyl sulfoxide	37.125	45.0	0.825
Chloroform	0.437	4.8	0.091
Toluene	0.096	2.4	0.040
Hexane	0.038	1.9	0.020
Water	12.3	80.4	9.889

Table 1: Solvents/chemicals are displayed in this table together with the corresponding dielectric loss, dielectric constant, and loss tangent. [4]

Operating Principles of MAE:

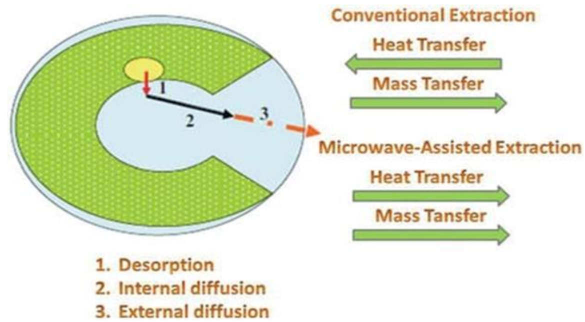
The method of Microwave-Assisted Extraction (MAE) technique differs from traditional methods due to the reliance on electromagnetic waves, which alter cell structure. By reacting with microwave radiation, polarizable materials and polar solvent dipoles produce quick changes in magnetic and electric components in MAE. Polar solvent molecules are heated when oriented in the changing field direction. However, non-polar solvents have poor heating. The samples' surface and just a small amount constitute the only areas where the thermal effect is present; the other half is heated by conduction. The inability to heat large samples or agglomerates uniformly is a significant disadvantage of MAE. High-power sources have the ability to increase penetration depth, but inside a substance that absorbs microwave radiation, the radiation produces exponential decay. [5]



Img2: Microwave assited Extraction[6]

Working mechanism of MAE:

The novel extraction technique known as microwave-assisted extraction (MAE) has been brought about by the structural alterations in cells carried out by electromagnetic radiation. As opposed to conventional methods that transmit heat from the exterior to the interior and mass from inside to the outside, this process includes A mutually beneficial arrangement of heat and mass transfers operating in same direction. The phenomenological steps during MAE are as follows.:



Img3: Mechanisms of in a microwave, mass and heat transfer and traditional extraction.

1.A solid receives the irradiation heat generated by a microwave via the transparent solvent of the microwave without absorption.

2.There is remaining microwave absorption into the substance being heated as a result of the above-mentioned high heating of (a).

3.As the heated liquid evaporates, a high vapor pressure is produced.

4.The substrate's cell is broken by the high vapour pressure, and

5.Breaking down cell walls promotes the extract's better release from the samples. [7]

Critical aspects affecting MAE and mechanisms of action

In order to achieve the highest plant yields, studies have concentrated on improving Microwave Energy (MAE) variables. Plant sample characteristics, solvent composition, and the ratio of solvent to feed, microwave energy density, extraction temperature, irradiation duration, stirring effect, and microwave power are some of the factors that affect MAE. Recognizing the impact of these variables on the extraction procedure is essential for effective MAE.

1]Solvent-to-feed ratio:

Microwave-assisted extraction is significantly influenced by the solvent selection, which is crucial for efficient extraction. Solubility, kinetics of mass transfer and solvent absorption are examples of unavoidable factors. And it ratio ranging from 10:1 to

20:1 is recommended for optimal yields. The extracting solvent's volume is also essential because a larger volume takes more energy and condensing time. Lower recoveries may be the outcome of MAE because of its inconsistent distribution and microwave exposure.[8,9].

2] Irradiation Time

MAE is a short-term extraction method that can be used to extract triterpene saponins from plants, preventing oxidation and heat deterioration. The plant matrix and the solvent's dielectric property determine how long the extraction takes to complete. Longer exposure can cause rapid heat up, resulting in the breakdown of substances that are thermolabile. A longer irradiation period can increase recovery yield, but it can decline with prolonged exposure. Several extraction cycles depends upon the plant sample as well as solute. According to a study, extracting triterpene saponins from yellow horn required three cycles of seven minutes each, while maximizing MAE produced cycles of five minutes each. [10,11]

3]Effect of Stirring:

Stirring speeds up the solvent phase's mass transfer processes, allowing the vapour and the liquid phases to reach equilibrium more quickly. Stirring increases the solubility and in the sample matrix's bioactive chemicals are desorbing, which speeds up extraction in MAE. Mass transfer barriers are minimized and the adverse effects of low solvent-to-solid ratios are reduced with thorough stirring.[12]

4] Microwave power and temperature:

When utilizing MAE, temperature as well as microwave power play critical roles in determining extraction yield. The extraction yield may rise with higher microwave power until it starts to decrease since it will raise the system temperature. A decrease in surface tension and viscosity caused by this temperature increase improves matrix wetting and penetration by increasing solvent power. High microwave power, however, may cause the plant matrix's heat-sensitive chemicals to degrade and result in a low extraction yield. Therefore, selecting the proper amount of microwave power is essential to overcome the extraction time and avoid a "bumping" phenomenon.

5] Characteristics of the plant sample and also water [H2O] content

The properties of plant sample and also the water content can impact on efficacy of MAE extraction process. Microwave radiation can penetrate deeper into the sample due to increased contact surface area and finer samples. Plant particle sizes range from 2 to 100 mm. Pre-leaching, where soaking the plant matrix prior to extraction can increase yield. Moisture in the plant matrix functions as a solvent, heating, evaporating, and dispersing through ruptured cell walls to increase or enhance the output of bioactive compounds.

Application**:**

- The plant source of nutraceuticals can be extracted by MAE with greater efficiency than with traditional solid-liquid extraction.
- With MAE, ginseng saporin extraction time could be drastically shortened from 12 hours using a traditional extraction method to a few sec/min.
- Extraction of taxaness from Taxus brevifolia.
- Limonoids from Azadirachta indices seed kernels associated with azadiractin.
- Extraction of Artemisia annua
- The anti-oxidative phenolic component in tomatoes is more effectively extracted with a higher microwave temperature and also in shorter extraction time.
- It has been established to be a viable substitute for the conventional process for removing phenols from green coffee beans, such as chlorogenic acid.

ADVANTAGES:

- It lowers the amount of solvent used.
- It operates for shorter time.
- Reproducibility is good, and there is limited sample manipulation done throughout the extraction procedure.
- When comparison with traditional extraction methods like Soxhlet, microwave-assisted extraction provides a number of benefits. MAE enables increased yields, quality, and time advantages.
- Moreover, it is simpler than Ultrasonic-Assisted Extraction (UAE) and less expensive than Supercritical Fluid Extraction (SFE).

DISADVANTAGES:

- Specialized setup is needed.
- During MAE, a second centrifugation and filter is required to get the clear of the solid residue.

- In addition, when the solvents or the target chemical are volatile or non-polar, the microwave's efficiency can be rather low.
- Less environmentally friendly than SFE since organic solvents are used.
- It is more expensive than UAE.
- Ineffective when the target molecule and/or extraction solvent are non- polar because they do not absorb energy from the source; not appropriate for thermo-labile compounds as the irradiation could stimulate a chemical reaction with the loss of the desired products. (13).

SRNO	PLANT SAMPLE	RESULT OBTAINED (MAE)	BIOACTIVE COMPOUND	REFRANCE
1	Coriandrum sativum	M.P.:- 200 W; solvent used:-ethanol/water (50:50 v/v); solvent/feed :-20; temperature:-50 °C; extraction time ;-18 min.	Phenolic content (0.082% db) is extract	(18)
2	Artemisia annua L.	M.P. :-700 W; solvent :-ethanol; solvent/feed ratio:-10; temperature :-85–90 °C; extraction time:-4 min	Artemisinin(92.1% db)	(14)
3	Cinnamomum zeylanicum	M.P. ;-200 W; temperature :- 50 °C; solvent used :- ethanol/water (50:50 v/v); solvent/feed ratio :- 20; extraction	Phenolic content (1.159% db)	(19)
4	Roots of Morinda citriflora	Microwave power :- 720 W; solvent ;-ethanol ,water (80:20 v/v); solvent/feed ratio ;-100;Temperature :- 60 °C; extraction time :-15 min	Global yield (95.91% db)	(20)
5	Licorice roots	M.P. :-700 W; solvent :- ethanol/water (1:1 v/v); solvent/feed ratio :-10; temperature :- 85-90 °C; Extraction time :- 4 min	Glycyrrhizic acid (GA) (2.26%)	(15)
6	Leaves of green tea	M.P. :-700 W; solvent used :- ethanol/water (1:1 v/v); solvent/feed ratio :-20; temperature :- 20 °C; Extraction time :- 4 min.	Tea polyphenols (30%), tea caffeine (4%)	(16)
7	Soyabeans	M.P.:- 500 W, Temperature :- 50 °C, Solvent :-25 mL of ethanol (50%), Extraction time :- 20 min	Isoflavones (75%) is extract	(22)
8	Turmeric herb	Microwave power :-60 W; solvent :- acetone; solvent/feed :- 3; temperature :-50 °C; extraction time :- 5 min.	Curcumin (90.47% db) is extract	(17)
9	Dried cells of Saussurea medusa	M.P.:- 460 W, Solvent :-10 mL of ethanol (80%), Extraction time :-6 min with 15 s power-on and 30s power-off	Flavonoids (4.1%) is present	(23)
10	Ipomoea batatas (L.) Lam., sweet potato	M. P. :- 123 W; Solvent :-ethanol:water (53:47 v/v); Solvent/feed ratio :-25; Extraction time :- 2 min.	Total phenolics (6.115% db) is extract	(21)
11	Saussurea medusa Maxim	M.P. :-1200 W, Solvent used :- 2 L of ethanol (80%), Solvent/feed ratio :- 50, Extraction time :- 60 min.	Flavonoids (4.97%)is extract.	(26)
12	Allium cepa L., or onion	M.P.:-500 W, Extraction time :- 23 min	Total phenolic content (58.29 mg GAE/DW) Yield (81.5%) Flavonol (41.9%)	(29)
13	Longan peel	M.P.:500W,Temperature :- 80 °C, Solvent :- 50 mL of ethanol (95%), Solvent/feed ratio :- 10,Extraction time :- 30 min	Total phenolic content (TPC = 96.78 mg/g) is extract, excellent scavenging ability comparing to synthetic antioxidant BHT	(27)
14	Astragali Radix	M.P.:1,000W, Temperature; -110 °C, Solvent:- Ethanol (90%), Solvent/feed ratio :- 25, Extraction time :- 25 min.	Flavonoids is extract	(24)
15	Platycladus orientalis (book-leaf pine))	M.P :-80 W, Solvent :- 5 mL methanol (80%), Solvent/feed ratio :- 500:1, Extraction time :-5 min	Flavonoids (1.72%) is extract	(25)
16	olive foliage	M.P. :- 200 W, Solvent :-8 mL ethanol (80%), Solvent/feed ratio :- 8:1, Extraction time :- 8 min	Biophenols	(30)
17	Herba epimedii	M.P. :-80 W, Solvent :-ethanol(60%), Extraction time :- 6 min	Flavonoids is extract	(28)
18	Hibiscus sabdariffa	M.P. :- 450 W, Solvent :-ethanol/water (52/48%, v/v), Solvent/feed ratio :- 15, Extraction time :- 4 min.	Total flavonoid content = 94.32 mg QE/g extract	(33)
19	Paste derived from tomatos	M.P. :- 98 W, Frequency :-40 KHz of ultrasonic processing, Solvent/feed ratio :- 10.6, Extraction time :- 367 s	Lycopene (97.4%) extract	(32)
20	Grape seed and skns	Pressure :-1–10 atm, M.P.:- 500 W, Temperature :- 65–140 °C, Solvent :- 20 mL of methanol (100%), Extraction time :- 20 min .	Phenolic compound is extract	(31)

Table2:Extraction of biological compound from plant sample by microwave assisted extraction technique in which Microwave Power shows as M.P.

CONCLUSIONS

This chapter describes the research and numerous developments in the MAE of various plant chemicals. Many discussions have been held regarding the variables affecting the MAE approach's efficacy as well as some of the bioactive chemicals that have been previously discovered from the plant samples using the MAE technique. In comparison to other extraction techniques, MAE can be recover mostly the larger yields of bioactive chemicals, according to previously published studies. Because MAE is more important than other procedures, it is a promising method for producing significant amounts of bioactive chemicals from plant sources.

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