International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(REVIEW ARTICLE)

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Extraction: An important tool in the pharmaceutical field

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International Journal of Science and Research Archive, 2023, 10(01), 555–568

Publication history: Received on 13 August 2023; revised on 25 September 2023; accepted on 28 September 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.10.1.0768

Abstract

The present review discuss various extraction methods used in obtaining bioactive compounds from medicinal plants. It defines key terms like "medicinal plant," "menstruum," and "marc." The choice of solvent (menstruum) depends on plant type and bioactive compounds. Polar solvents (e.g., water) are used for polar compounds, while nonpolar solvents (e.g., hexane) are used for nonpolar compounds. Solvents are categorized by polarity from least polar (n-hexane) to most polar (water). Different extraction methods are detailed, including infusion, decoction, percolation, maceration, Soxhlet extraction, supercritical fluid extraction, microwave-assisted extraction, and ultrasound-assisted extraction. The advantages and disadvantages of each method are discussed. The abstract covers the properties and applications of different solvents, such as water, alcohol, chloroform, ether, and ionic liquids. Factors like selectivity, safety, cost, reactivity, and recovery are important in selecting solvents. The abstract concludes by discussing the advantages and disadvantages of different extraction methods, including hydro distillation. It emphasizes the importance of choosing the right method based on the nature of the plant material and desired compounds.

Keywords: Extraction; Percolation; PLE; Supercritical Fluid Extraction; Microwave Extraction

1. Introduction

A natural product is a chemical molecule or substance created by a living organism in nature. Phytochemicals are natural compounds that may be extracted or manufactured from plants. They are non-nutritive yet are required by plants for functions such as disease and pathogen defense and control. Phytochemicals have been found in studies to be vital in human health. This is due to its antioxidant, anti-inflammatory, anti-cancer, and anti-bacterial properties. The majority of these biochemicals are found in foods such as fruits, vegetables, and whole grains. This is why it is recommended that individuals consume more fruits and vegetables in order to avoid several health disorders such as cancer, diabetes, high blood pressure, and cell aging. Flavonoids and carotenoids are the two primary types of phytochemicals. However, because humans do not consume these plants, several key phytochemicals, particularly those found in traditional medicinal herbs, are not available to them[1].

In Extraction the mixture of substances is dissociated, by dissolving each component with one or other solvents which yields two phases – Raffinate Phase (rich in Feed Solvent) and Extract Phase (rich in Solute) [2] When the Relative Volatility is 1 the separation of the components in the mixture is not possible by Distillation and when relative Volatility is Greater than 1 Extraction method is used for the separation of the components. Also, when the Distillation Method used is too expensive, the Extraction process is opted [3].

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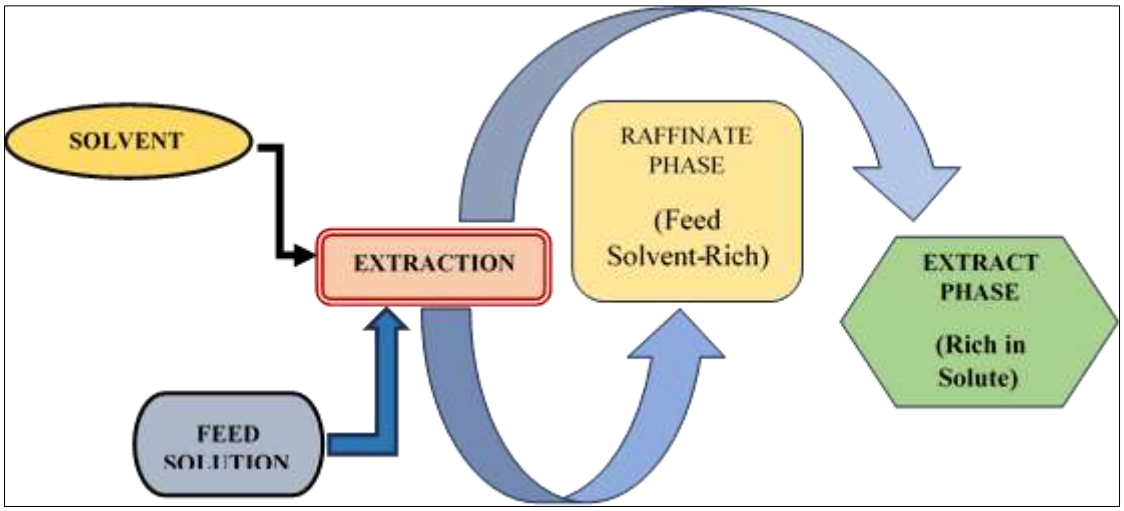

Figure 1 Diagram of Extraction Modules

1.1. Definition of terms

- ***Medicinal plant***: Refers to a plant that contains active components or secondary metabolites with biological action. An entire plant or plant components can be medicinally active.[4,5,6]
- ***Menstruum***: It is a liquid or a suitable solvent that has been chosen for an efficient extraction operation.
- ***Marc***:- It is a drug substance that is insoluble or inert that is left remains after the extraction process.[7,8]

2. Solvents for Extraction

The solvent used to extract medicinal herbs is often known as the menstruum. The solvent used is determined by the type of plant, the section of the plant to be extracted, the nature of the bioactive chemicals, and the availability of solvent. In general, polar solvents such as water, methanol, and ethanol are used for polar compound extraction, whereas nonpolar solvents such as hexane and dichloromethane are used in nonpolar compound extraction. The traditional liquid-liquid extraction method uses two miscible solvents such as water-dichloromethane, water-ether, and water-hexane. Water is present in all of the combinations due to its high polarity and miscibility with organic solvents. To facilitate separation, the substance to be extracted via liquid-liquid extraction should be soluble in an organic solvent but not in water.[11] Furthermore, the extraction solvents are categorized according to their polarity, with n-hexane being the least polar and water being the most polar.[7,9,10]

Table 1 11 different extraction solvents grouped in increasing polarity order[7,12]

Sr No.	Solvents	Polarity
1.	*n*-Hexane	0.009
2.	Petroleum ether	0.117
3.	Diethyl ether	0.117
4.	Ethyl acetate	0.228
5.	Chloroform	0.259
6.	Dichloromethane	0.309
7.	Acetone	0.355
8.	*n*-Butanol	0.586
9.	Ethanol	0.654
10.	Methanol	0.762
11.	Water	1.000

During fractionation, the selected solvent is added in increasing polarity order, beginning with n-hexane and ending with water. If a researcher wants to use five solvents during fractionation, the standard practice is to use two low polarity solvents (n-hexane, chloroform), two medium polarity solvents (dichloromethane, n-butanol), and one high polarity solvent (water).

2.1. Properties of Solvent of Extractions[7,12,13,14]

2.1.1. Water

It is the most polar solvent and is used to extract a variety of polar substances.

- *Advantages*: It dissolves many different things; it is inexpensive, harmless, nonflammable, and extremely polar.
- *Disadvantages*: Promotes bacterial and mould growth; it may cause hydrolysis; and it takes a lot of heat to concentrate the extract.

2.1.2. Alcohol

It is also polar, miscible with water, and capable of extracting polar secondary metabolites. [12,13]

- Advantages: It is self-preservative at concentrations greater than 20%. It is harmless at low concentrations and requires very little heat to concentrate the extract.
- Disadvantages: It is combustible and volatile, and it does not dissolve fats, gums, or wax.

2.1.3. Chloroform

It is a nonpolar solvent that can be used to extract substances like terpenoids, flavonoids, lipids, and oils.

- Advantages: It is colorless, odorless, and soluble in alcohol. It's also easily absorbed and metabolized by the body.
- Disadvantages: It is both sedative and carcinogenic.

2.1.4. Ether

It is a nonpolar solvent that can be used to extract substances like alkaloids, terpenoids, coumarins, and fatty acids.

- Advantages: It is miscible with water, has a low boiling point, and has no taste. It is also an extremely stable molecule that is unaffected by acids, bases, or metals.
- Disadvantages: It is highly flammable and volatile in nature.

2.1.5. Ionic liquid (green solvent)

This is a unique extraction solvent that is both highly polar and exceedingly heat stable. It can remain liquid even at 3000^{o}C and is useful where high temperatures are applied. It has a high miscibility with water and other solvents, making it ideal for polar compound extraction.

- Advantages: It is good for microwave-assisted extraction because of its superior solvent that attracts and transmits microwaves. It is nonflammable, extremely polar and excellent for liquid- liquid extraction.
- Disadvantage: It is not suitable for making tinctures.

2.2. Factors to be considered in selecting solvents of extraction[7,12,15]

Various factors enumerated below should be taken into consideration when choosing a solvent of extraction.

- Selectivity*: The ability of a chosen solvent to extract the active constituent and leave the inert material.*
- Safety*: The ideal solvent of extraction should be nontoxic and nonflammable.*
- Cost*: It should be as cheap as possible.*
- Reactivity*: A suitable solvent of extraction should not react with the extract.*
- Recovery*: The solvent of extraction should be quickly recovered and separated from the extract.*
- Viscosity*: To allow for easy penetration, the viscosity should be low.*
- Boiling temperature*: To avoid heat deterioration, the boiling point of the solvent should be as low as feasible.*

3. Commonly Used Methods in The Extraction Process [6,17,18,19]

3.1. Infusion

The infusion is performed by immersing the plant parts to be used in boiling water for 15 minutes before filtering through filter paper. Infusion is similar to maceration in that both are steeped in cold or boiled water. The maceration duration for infusion, on the other hand, is shorter, and the sample is cooked in a set volume of water (e.g., 1:4 or 1:16) for a specified time for decoction.

3.2. Decoction

It is an appropriate method for extracting components that are soluble in water and are not affected by heat.

A decoction is a water-based preparation used to extract active components from medicinal plants. The liquid preparation in this procedure is created by boiling the plant material with water. When working with stiff and fibrous plants, barks and roots, or plants that contain water-soluble compounds, decoction is the method of choice. In most cases, the plant material is split into small bits or powdered. For the preparation of decoctions, various procedures have been reported.

This method is commonly employed in the manufacture of Ayurvedic extracts. The initial crude drug-to-water ratio is fixed, for example, 1:4 or 1:16; the volume is subsequently reduced to one-fourth of its original volume by boiling during the extraction method. This method is commonly employed in the manufacture of Ayurvedic extracts. The initial crude drug-to-water ratio is fixed, for example, 1:4 or 1:16; the volume is subsequently reduced to one-fourth of its original volume by boiling during the extraction method.

3.2.1. Advantages:

- Heat-stable chemicals can be extracted using this method.
- This procedure does not require the purchase of additional or costly equipment.
- It is easy to perform.
- There is no need for a professional operator.

3.2.2. Disadvantage:

- Unfortunately, it is not recommended for extracting heat-sensitive components.

3.3. Percolation[18,20,21]

This is the most common method for extracting active substances in the creation of tinctures and fluid extracts. In most cases, a percolator (a narrow, cone-shaped vessel open at both ends) is employed. The solid components are moistened with a suitable amount of the solvent and left to stand for roughly 4 hours in a well-closed container, following which the mass is packed and the percolator's top is closed. Additional solvent is added to produce a shallow layer above the bulk, and the combination is macerated in the closed percolator for 24 hours. The percolator's outlet is then opened, allowing the liquid stored therein to trickle gently. Additional solvent is added as needed until the percolate measures about three-quarters of the necessary volume of the final product.

The extract is then squeezed, and the liquid is poured into the percolate. A sufficient amount of solvent is added to generate the appropriate volume, and the combined liquid is clarified by filtration or standing followed by decanting. The operation is continued until a drop of solvent from the percolator evaporates without leaving a residue.

3.3.1. Advantages

- This process takes less time than maceration.
- The extraction of thermolabile components is a possibility.
- Suitable for powerful and expensive medications.
- Shorter extraction time and more thorough extraction.

3.3.2. Disadvantages

- It takes more time than soxhalation.
- More solvent is needed.

- A skilled person is required.
- Throughout the procedure, special attention should be paid to particle size of the material.

3.4. Maceration

It is an ancient and extremely easy extraction procedure used in the manufacture of medicines. It has the potential to be employed for the extraction of thermolabile components.[18]

Maceration is a solid-liquid extraction process. This is an extraction method in which coarsely powdered drug material, such as leaves, stem bark, or root bark, is placed within a container, and menstruum is poured on top until the drug material is completely covered. After that, the container is sealed and maintained for at least three days.

The materials are mixed on a regular basis, and if placed within a container, it should be shaken occasionally to ensure total extraction. The micelle is removed from the marc at the end of the extraction process using filtration or decantation. Following that, the micelle is separated from the menstruum by evaporation in an oven or on top of a water bath. [5, 6, 7, 8, 9, 22]

Only molecular diffusion is responsible for the process. After the necessary time, the liquid is strained off, and the solid residue is pressed to recover as much solvent as possible. When the solvent is water and the maceration duration is long, a tiny amount of alcohol may be added to inhibit microbial development.[20]

Maceration consists of three main phases. To begin, plant materials are ground into powder form. This enables for good solvent-to-material interaction. After grinding, a solvent of choice is added to a closed vessel. The liquid is then strained, but the solid residue from the extraction process is pressed to recover a significant number of occluded solutions. During the maceration process, periodic shaking aids extraction by enhancing diffusion and removing concentrated solution from the sample surface, allowing additional solvent to enter the menstruum and increase extraction yield.[12]

3.4.1. Advantages:18

- Maceration is a simple procedure that requires few utensils and equipment.
- There is no need for a skilled operator.
- The process of conserving energy.
- Method suitable for less strong and less expensive medicines.

3.4.2. Disadvantage

- Unfortunately, the extraction procedure is lengthy, often taking weeks.
- The substance was not extracted completely.
- It is a time-consuming and slow process.
- More solvent is required.

Table 2 Physical nature of drug

Sr. No.	Physical Nature of the Drug	Extraction Procedure
1.	Hard and woody	Through percolation
2.	Soft drugs	Through maceration
3	Unorganized drug	By maceration rather than percolation because it has the potential to clog the percolator

Table 3 Examples of maceration, percolation, infusion, and decoction

Sr. No	Extraction Methods	Example
Maceration		
1.	Simple maceration	Tincture of Orange
		Tincture of Lemon
		Tincture of Squill
2.	Maceration of unorganized drug /Maceration with adjustment	Tincture of Tolu Balsam
		Compound Tincture of Benzoin
Multiple Maceration		
a.	Double maceration	Concentrated Infusion of orange
		Concentrated Infusion of chirata
		Concentration Infusion of gentian
b.	Triple maceration	Concentrated Infusion of Quasela
		Concentrated Infusion of Senna
Percolation		
1.	Simple percolation	Tincture of Belladonna
		Compound tincture of cardamom
		Strong tincture of ginger etc Liquid extract of Liquorice
2.	Reserved percolation	Cantharidin from cantharides
3.	Continuous hot percolation/Soxhlation	Alkaloids from seed
Infusion		
1.	Fresh Infusion	Concentrated compound Infusion of chirata
2.	Concentrated Infusion	Concentrated compound Infusion of gentian
D.	DECOCTION	No official preparations in IP or BP

4. Soxhlet extraction

It is named after the German agricultural scientist 'Franz Ritter von Soxhlet' and is the best method for continuous extraction of a solid by a hot solvent.[10]

It is either a continuous solid/liquid extraction or a continuous heat extraction. The glass equipment is known as a Soxhlet extractor. It has a spherical bottom flask, an extraction chamber, a siphon tube, and a condenser on top. A dried, ground and finely powdered plant material is snugly packed within a porous bag (thimble) composed of a clean cloth or strong filter paper.

The extraction solvent is poured into the bottom flask, and then the thimble is placed in the extraction chamber. The solvent is then heated from the bottom flask, evaporates, and flows down to the extraction chamber, where it condenses and extracts the drug by coming into contact. As a result, when the amount of solvent in the extraction chamber reaches the top of the siphon, the solvent and the extracted plant material flow back to the flask.

The entire procedure is repeated until the medication is entirely extracted, at which time a solvent pouring from the extraction chamber leaves no residue behind. This approach is appropriate for plant materials that are partly soluble in

the selected solvent as well as plant materials containing insoluble contaminants. However, it is not appropriate for thermolabile plant materials.[5,7,8,9,11,13,22]

Soxhlet Extractor consists of the following apparatus.[13]

- Soxhlet Extractor
- Mantle Heater (Electric)
- Water Condenser
- Flash Evaporator

4.1. Advantages

- Using heat from the distillation flask to maintain a relatively high extraction temperature.
- The extract does not need to be filtered.
- When compared to maceration, this process uses less solvent.
- A large quantity of medication may be extracted using a little amount of solvent.

4.2. Disadvantages

- The Soxhlet equipment does not allow for agitation.
- Disadvantages such as exposure to toxic and combustible organic liquid solvents.[14,15]
- This process is thought to be harmful to the environment.7
- The procedure is not suited for thermolabile materials and cannot be shaken on a regular basis.[7,8,9,22]

5. Supercritical fluid extraction

People are currently focused on green technologies to build novel extraction procedures that use renewable natural resources or non-hazardous solvents while keeping high-quality and safe extracts, as opposed to standard solvent extraction methods.

A novel extraction approach that requires less energy than the previous one is preferable. [23,24]

As a result, the SFE technique is introduced to the extraction sector, with the hope of reducing organic solvent use in the classic solvent extraction process and increasing throughput.[25]

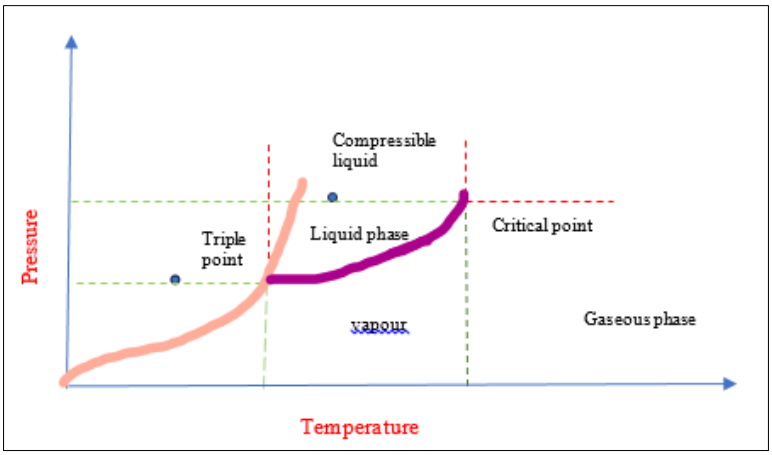

Figure 2 Pressure versus Temperature profile for Supercritical fluids

A component is extracted from a matrix using a solvent in this form of extraction. However, in this case, the solvent is Supercritical Fluid. Supercritical Fluid Extraction (SCF) is often used for solid extraction, but it may also be used for liquid extraction. This sort of extraction is employed in analytical laboratories to prepare samples. On a bigger scale, it is utilized to remove undesirable material (decaffeination) from the product stream (oil).[26, 27]

The separated substances or chemicals are mixed with supercritical fluids in this Extraction process, giving birth to a mobile phase. The solvating characteristics of the mobile phase are improved at temperatures and pressures close to the critical temperature and pressure conditions [28].

Supercritical Fluid: These fluids have a high density and are non-compressible. The Pressure Versus Temperature curve for fluids is shown in Fig 2. Supercritical fluids have a greater pressure and temperature than the critical point. These fluids have a strong thermal motion and a wide range of density. As a result, density-related parameters may be controlled. Carbon dioxide is a common solvent in the decaffeination process, whereas water is a supercritical fluid utilized in power generation.[29, 30]

Table 4 Critical properties of the solvents.[27]

Solvents	**Parameters**			
	Molecular Weight (g/mol)	**Critical Temperature (°C)**	**Critical Pressure (atm)**	**Critical Density (kg/m3)**
CO2	44.01	31.2	73	467.6
CH4	16.04	-82.6	45	162.7
Ethylene (C2H4)	28.05	9.2	50	214
CH3OH	32.04	240.2	81	281
Acetone (C3H6O)	58.08	235	46.3	273

The Supercritical Fluid Extraction Method is a straightforward process. Quick extraction takes roughly 30-60 minutes per sample, which is 1/3rd to 1/4th of the time required by traditional procedures. This method removes trace pesticides, and the extract is collected in a trap column. In the trap column, the minimum extract can also be separated. After each set of operations, the trap column and pipes are cleaned to verify that there are no obstructions or contaminants in the column. Carbon dioxide is utilized as an extracting solvent since it is exceedingly pure and cheap. Because carbon dioxide is non-toxic and non-flammable, this technology is both safe and environmentally benign. Because the physical and thermal characteristics of SFFs are intermediate between pure liquid and gas, they are also known as "compressible liquids" or "dense gases."[30]

5.1. Advantages

- It can remove organic solvents, therefore lowering storage concerns.
- Low-volatility chemicals are appropriate for extraction and purification.
- It is also prone to heat deterioration.

5.2. Disadvantage

- The initial cost of equipment is really high.

6. Microwave-assisted extraction[31,32,33]

6.1. Principle

Electromagnetic waves are made up of two perpendicularly oscillating fields: an electric field and a magnetic field, which is also known as a microwave. These waves serve as energy vectors or data carriers. The material absorbs electromagnetic waves and converts them to heat energy. This is Microwave Power.

The frequency range of microwave energy is 300 MHz to 300 GHz. These are non-ionizable radiation waves.

There are two processes for converting electromagnetic energy to calorific energy or heat: Ionic Conduction and Dipole Rotation.

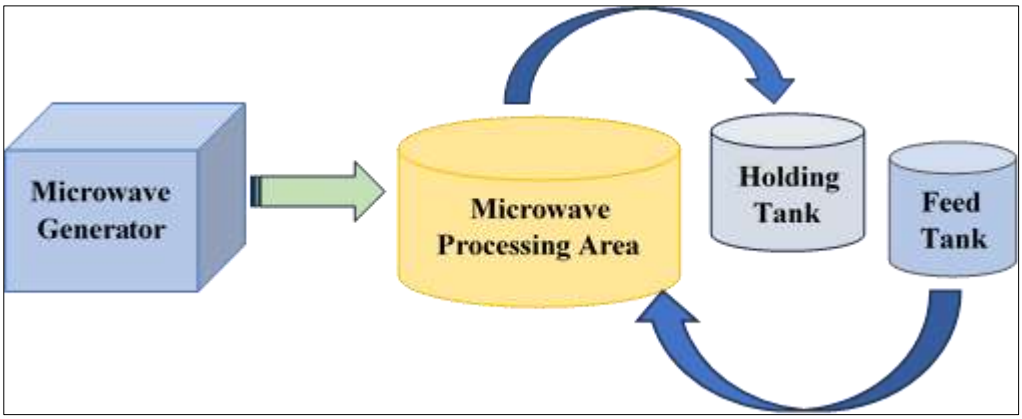

Figure 3 Diagram of pilot scale microwave-aided extraction system configurations

7. Process of Microwave Extraction

The flowchart below depicts the processes involved in the Microwave Extraction process.

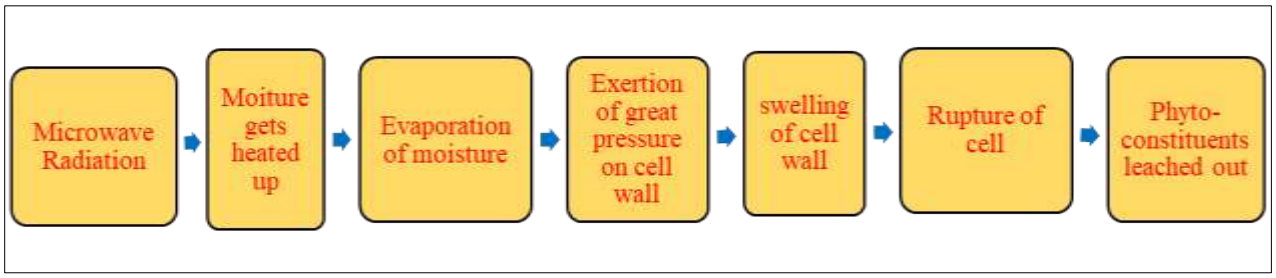

Figure 4 Process of Microwave Extraction[1]

7.1. Advantages

- This procedure requires less solvent and requires less extraction time.
- For this method, the equipment cost is modest, and solvent recovery is reasonably high.

7.2. Disadvantages

- Non-polar solvents cannot be used for processing.
- Volatile solvents are not permitted for use in this method since they degrade the effectiveness of the Microwave extraction process.34

8. Ultrasound-assisted extraction (UAE) or sonication extraction

8.1. Principle

This procedure employs ultrasound with frequencies ranging from 20KHz to 2000KHz, which improves cell permeability and causes cavitations.

Although this procedure is effective in many circumstances, such as the extraction of anthocyanins and antioxidants, and it is also valuable in the field of nanotechnology, it is restricted due to its high cost.[31]

The mechanical impact of acoustic cavitation caused by ultrasound improves surface contact between solvents and samples as well as cell wall permeability. The physical and chemical characteristics of the materials treated with ultrasound are changed, and the plant cell wall is disrupted, enabling compound release and increasing mass transport of the solvents into the plant cells.[35]

The process is a straightforward and low-cost technology that may be used for both small and large-scale phytochemical extraction.[7]

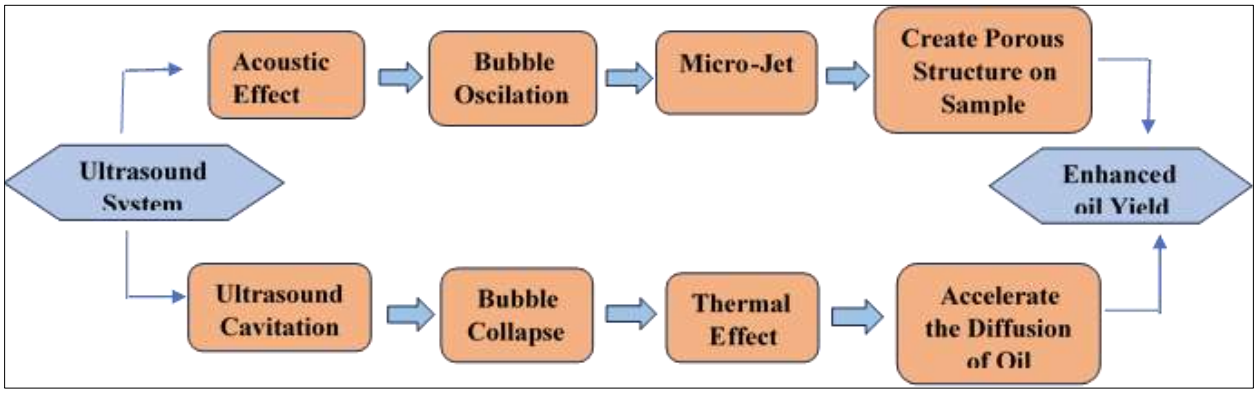

Figure 5 Ultrasound-assisted extraction mechanism for edible oil

8.1.1. Advantages [36, 32]

- The advantages of UAE are mostly attributable to reduced extraction time and solvent use.
- The ultrasound extraction process is very effective in recovering and purifying active compounds.[43]

8.1.2. Disadvantages[36]

- The use of ultrasonic radiation over 20 kHz may have an influence on active phytochemicals via free radical production.

8.2. Application[7]

In crude oil desulfurization and cell disruption, ultrasound extraction is employed. Sonication can also be utilized to initiate and regulate polymorphic crystallization processes. This technology is also employed in the manufacturing of biofuels, the creation of nanoparticles such as nano-emulsions and liposomes, and the extraction of plant oil from waste water.

9. Pressurized liquid extraction (PLE) or accelerated solvent extraction

9.1. Principle

High temperature and high pressure are used in pressurized liquid extraction. Under these circumstances, the solvent remains liquid. The solvent temperature and pressure are less than the critical temperature and pressure.[37] This method is also known as pressurized hot solvent extraction or pressurized fluid extraction.

PLE is a faster extraction approach than traditional extraction techniques. The amount of solvent used is much less than in a routinely utilized procedure. The characteristics of solvents alter at high temperatures and pressures. There is an increase in mass transfer rates, an increase in analysis solubility, and a decrease in surface tension and viscosity. Such circumstances lead to higher extraction rates.[7]

Accelerated solvent extraction (ASE) is a solid-liquid extraction technique that is carried out at extreme temperatures, typically between 500 and 200oC, and pressures ranging from 10 to 15 MPa. Accelerated solvent extraction is, therefore, a type of pressurized solvent extraction. Increased temperature speeds the extraction kinetics, while increased pressure maintains the solvent liquid, resulting in safe and quick extraction. Furthermore, high pressure permits the extraction cell to be filled faster and aids in forcing liquid into the solid matrix. Fig 6 is an example of an accelerated solvent extraction system. Although the solvent used in ASE is typically organic, pressurized hot water can also be employed. In these circumstances, one is referring to pressurized hot water extraction or sub-critical water extraction.

9.1.1. Advantage

- When compared to standard Soxhlet extraction, ASE uses significantly less solvent and takes significantly less time.

9.1.2. Disadvantage

- Particular attention should be taken to ASE performed at high temperatures, which may result in thermolabile chemical degradation.15

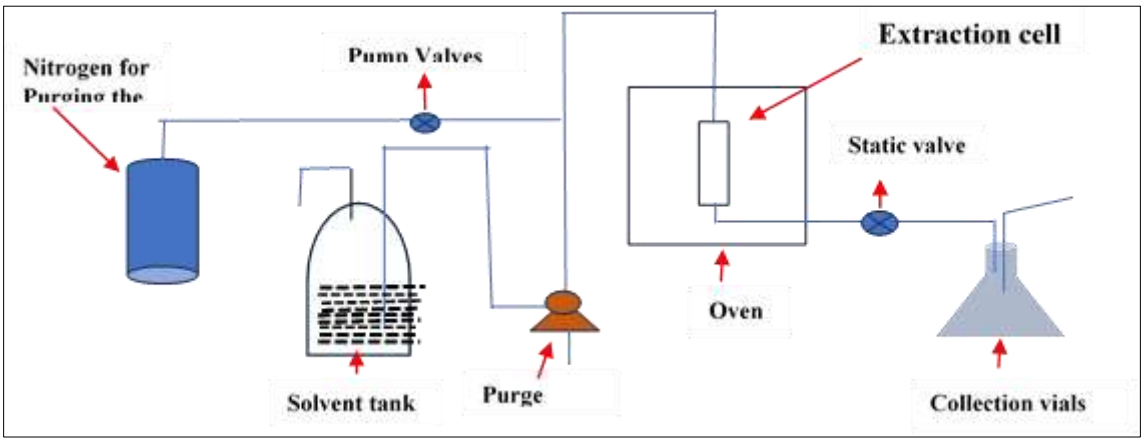

Figure 6 Accelerated solvent extraction

10. Hydro distillation

Hydro distillation is an ancient method of extracting plant components that do not rely on organic solvents. Plant materials are packed in a still chamber and adequate water is added before being heated to a boil. Direct steam is also introduced into the plant sample. Hot water and steam are the most critical elements in the release of bioactive chemicals from plant tissue. Water condenses the vapor combination of water and oil during indirect cooling. Hydro Distillation has the potential to be a highly beneficial process for extracting essential oil from diverse plants and their varied sections. The yield is affected by factors such as raw material weight, volume of water, raw material size, and raw material type.

Hydro distillation entails three major physiochemical processes: hydro diffusion, hydrolysis, and heat decomposition. Some volatile components may be lost at high extraction temperatures. This limitation limits its use to thermolabile chemical extraction.

There are three forms of hydro distillation used to extract essential oils from plant materials

- Water distillation
- Water and steam distillation
- Direct steam distillation

10.1. Advantages

- Higher oil yield.
- The loss of polar molecules is minimized when refluxing is regulated.
- The grade of oil generated by steam and water distillation is more consistent.
- Because no organic solvent is used, this procedure is both inexpensive and environmentally beneficial.

10.2. Disadvantages:[18]

- No complete extraction is possible.
- It is difficult to manage the temperature.
- It needs more stills, more room, and more gasoline. As a result, the procedure becomes unprofitable.

11. Pulsed electric field extraction

Because it accelerates mass transfer during extraction by breaking membrane structures, pulsed electric field extraction significantly boosts extraction yield while decreasing extraction time. PEF treatment efficacy is affected by a variety of

factors, including field strength, specific energy input, pulse number, and treatment temperature. PEF extraction is a non-thermal approach that reduces thermolabile chemical degradation.

Hou et al. got the maximum ginsenoside yield (12.69 mg/g) via PEF employing 20 kV/ cm electric field intensity, 6000 Hz frequency, 70% ethanol-water solution, and 150 l/h velocity. The PEF extraction technique yields more ginsenosides than the MAE, heat reflux, UAE, and PLE extraction methods. The complete PEF extraction procedure took less than 1 second, which was much less than the other evaluated techniques.[43]

Bouras discovered that PEF treatment increased phenolic content (eight times) and antioxidant activity (30 times) in a study of antioxidants isolated from Norway spruce bark compared to untreated samples.[44]

12. Conclusion

In conclusion, the paper presents a comprehensive overview of extraction methods for obtaining bioactive compounds from medicinal plants. It covers solvent selection, extraction techniques, solvent properties, and their applications. The abstract underscores the importance of tailoring extraction methods to plant material and desired compounds, highlighting both traditional and modern approaches. Overall, it provides a valuable resource for researchers seeking effective ways to extract bioactive compounds for various applications. The comparative chart of all extraction methods reported is summarized in Table No. 5

Table 5 Comparison of various extraction methods for natural products

Sr No.	Methods	Solvent	Temperature	Pressure	Time	Volume of solvent
1.	Maceration	Water, aqueous and nonaqueous solvents	Room temp.	Atmospheric pressure	Long	Large
2.	Percolation	Water, aqueous, and nonaqueous solvents	Room temp. occasionally under heat	Atmospheric pressure	Long	Large
3.	Decoction	Water	Under heat	Atmospheric pressure	Moderate	None
4.	Soxhlet	Organic Solvents	Under heat	Atmospheric pressure	Long	Moderate
5.	Hydro distillation	Water	Under heat	Atmospheric pressure	Long	None
6.	Ultrasound-assisted extraction	Water, aqueous and non-aqueous solvents	Room temperature, or under heat	Atmospheric pressure	Short	Moderate
7.	Microwave-assisted extraction	Water, aqueous and non-aqueous solvents	Room temperature	Atmospheric pressure	Short	None or moderate
8.	Pulsed electric field extraction	Water, aqueous and non-aqueous solvents	Room temperature, or under heat	Atmospheric pressure	Short	Moderate
9.	Pressurized liquid extraction	Water, aqueous and non-aqueous solvents	solvents Under heat	High	Short	Small
10.	Supercritical fuid extraction	Supercritical fuid (usually S-CO2), sometimes with modifer	Near room temperature	High	Short	None or small

Compliance with ethical standards

Disclosure of conflict of interest

None of the authors declared conflicting interest.

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