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OVERVIEW ON DIFFERENT TYPES OF METHODS OF EXTRACTION

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ABSTRACT

This study explores various extraction techniques used to isolate bioactive compounds from plant materials, highlighting maceration, percolation, Soxhlet extraction, microwave-assisted extraction (MAE), and ultrasound-assisted extraction (UAE). The choice of method, solvent, and conditions significantly affects extraction yield, efficiency, and the nature of compounds obtained. Maceration, though cost-effective and simple, requires extended time, while Soxhlet extraction is more efficient but demands laboratory setups. MAE and UAE offer advanced alternatives with shorter extraction times, higher yields, and reduced solvent usage. Comparative analyses of extraction methods using soursop leaves and boldo leaves demonstrate varying efficiencies, with modern techniques like MAE and UAE providing notable advantages in extraction time and compound recovery. The findings underscore the evolution of extraction methods toward greater efficiency, cost-effectiveness, and sustainability.

KEYWORDS: *Extraction methods Maceration, Percolation, Soxhlet extraction, Microwave-assisted extraction (MAE), Ultrasound-assisted extraction (UAE), Solvent extraction, Phytochemicals, Solvent selection, Soursop leaves, Boldo leaves.*

INTRODUTION

Methods of extraction are essential techniques in chemistry, biochemistry, and various industries to separate and isolate desired compounds from mixtures. Each method leverages the unique physical or chemical properties of the components, such as solubility, boiling point, or density, to achieve separation. From simple mechanical techniques to advanced solvent and chromatographic methods, extraction allows for the purification, analysis, and production of substances in forms ready for use or study. These techniques play a crucial role in fields like pharmaceuticals, food and beverage production, environmental science, and natural product isolation, offering tailored solutions to different types of mixtures and compound. Sample preparation is most often a necessity as even the simplest samples are frequently unsuitable for direct analysis because of excessive dilution or concentration of the target analytes or incompatibility with instrument operation procedures

METHODOLOGY & MATERIAL

EXTRACTION

Extraction is the process of separating a substance from a mixture by transferring it from one source to another. Extraction may be defined as the removal of soluble constituents from a solid or liquid or semi-solid with means of suitable solvent.

It may be defined as the treatment of the plant or animal tissues with appropriate solvent, which would dissolve the constituents. medicinally active Extraction is the method of removal of a soluble fraction in the form of a solution from an insoluble matrix with the help of a suitable solvent

Extraction methods include solvent extraction, distillation method, pressing and sublimation according to the extraction principle. Solvent extraction is the most widely used method

Extraction Procedure

The general techniques of medicinal plant extraction include maceration, infusion, percolation, digestion, decoction, hot continuous extraction (Soxhlet), aqueous-alcoholic extraction by fermentation, counter current extraction, microwave-assisted extraction, ultrasound extraction (sonication), supercritical fluid extraction, and distillation techniques (water distillation, steam distillation, phytonic extraction (with hydro fluorocarbon solvents). For aromatic plants, hydro water and steam distillation), hydrolytic maceration followed by distillation, expression and effleurage (cold fat extraction) may be employed. Some of the latest extraction methods for aromatic plants include headspace trapping, solid phase micro extraction, protoplast extraction, micro distillation.

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Effect of extracted plant phytochemical depends on

- The nature of the plant material
- Its origin
- Degree of processing
- Moisture content
- Particle size

The basic parameters influencing the quality of an extract are

- Plant part used as starting material
- Solvent used for extraction
- Extraction procedure

The variations in different extraction methods that will affect quantity and secondary metabolite composition of an extract depend upon

- Type of extraction
- Time of extraction
- Temperature
- Nature of solvent
- Solvent concentration
- Polarity
- Plant material
- Plant based natural constituents

Choice of solvents

For Successful determination of biologically active compounds from plant material is largely dependent on the type of solvent used in the extraction procedure.

A property of a good solvent in plant extractions includes:

- Low toxicity
- Ease of evaporation at low heat
- Promotion of rapid physiologic absorption of the extract
- Preservative action, Inability to cause the extract to complex or dissociate

The factors affecting the choice of solvent are:

- Quantity of phytochemical to be extracted
- Rate of extraction
- Diversity of different compounds extracted
- Diversity of inhibitory compounds extracted
- Ease of subsequent handling of the extracts
- Toxicity of the solvent in the bioassay process
- Potential health hazard of the extractants

The choice of solvent is influenced by what is intended with the extract. Since the end product will contain traces of residual solvent, the solvent should be nontoxic and should not interfere with the bioassay. The choice will also depend on the targeted compounds to be extracted.

Variation in extraction methods usually depends upon:

- Length of the extraction period,
- Solvent used,
- pH of the solvent
- Temperature
- Particle size of the plant tissues
- The solvent-to-sample ratio

The basic principle is to grind the plant material (dry or wet) finer, which increases the surface area for extraction thereby increasing the rate of extraction. Earlier studies reported that solvent to sample ratio of 10:1 (v/w) solvent to dry weight ratio has been used as ideal [1].

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Solvents used for active component extraction are:

- Water
- Ethanol
- Methanol
- Chloroform
- Ether
- Acetone

Water	Ethanol	Methanol	Chloroform	Ether	Acetone
Anthocyanins	Tannins	Anthocyanins	Terpenoids	Alkaloids	Phenol
Starches	Polyphenols	Terpenoids	Flavonoids	Terpenoids	Flavonols
Tannins	Polyacetylenes	Saponins		Coumarins	
Saponins	Flavonols	Tannins		Fatty acids	
Terpenoids	Terpenoids	Xanthoxyllines			
Polypeptides	Sterols	Totarol			
Lectins	Alkaloids	Quassinoids			
		Lactones			
		Flavones			
		Phenones			
		Polyphenols			

Table1: Solvents used for active component

DIFFERENT TYPES METHODS OF EXTRACTION

- Maceration
- Percolation
- Decoction

RECENTLY MOST USED METHODS

- Soxhlation Extraction
- microwave assisted extraction
- Ultrasound-assisted Extraction

Maceration

In this process, the whole or coarsely powdered crude drug is placed in a stoppered container with the solvent and allowed to stand at room temperature for a period of at least 3 days.

It is very simple and the chipest because it only requires a simple container as the place for extraction, but this method requires long time for extraction process[2].

This method can be done anywhere, the number of raw materials, the selection of solvents and the correct extraction time are things that affect the effectiveness of this method[3].
It could be used for the extraction of thermolabile components[4].

Solvents used

Water, hexane, vegetable oils, ethanol, methanol & glycerine

Categories obtained by extraction

Alkaloids, Terpenoids, Tannins, Flavonoids, Essential oils, Saponins, Glycosides, Phenolic compound, Resins, Vitamins, & Minerals

Form of drug

Solid-liquid type ⟶ Amorphous solids with solvents

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Fig.1. Maceration Extraction Apparatus

Percolation

Percolation is more efficient than maceration because it is a continuous process in which the saturated solvent is constantly being replace by fresh solvent.

This is more frequently used method to extract phytochemicals for the preparation of tinctures and fluid extracts. It allows the process to stand for approximately 4 hours in a closed container[5].

Solvents Used

Water, hexane, chloroform, ethyl alcohol, 75% ethanol, 55%alcohol & petroleum ethers

Categories obtained by extraction

Carbohydrates, Vasopressin, Alkaloids, Terpenoids, Flavonoids, & Sterols

Form of drug

Solid-Solid ⟶ Amorphous solid, Crystalline solid

Fig.2. Percolation Extraction Apparatus

Decoction

The decoction extraction method is a traditional technique used to extract active compounds from plant materials, particularly in herbal medicine. It involves boiling plant material in water for a specific period to draw out soluble substances

The extract from decoction contains a large number of water-soluble impurities. A decoction cannot be used for the extraction of thermolabile or volatile components.

This process is mainly used for vegetable drugs of hard and woody nature having thermostable water-soluble constituents[6].

Solvents used:

Water, hexane, ethanol, methanol

Categories obtained by extraction:

Alkaloids, flavonoids, and tannins

Form of drug:

Solid- solid & solid-liquid ~~Amorphous~~ solid

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Fig.3. Decoction Extraction Apparatus

Soxhlation Extraction

It is very useful tool for preparative purposes in which the analyte is concentrated from the as a whole or separated from particular interfering substance, Solvent extraction of solid samples which is commonly known as solid liquid extraction.

It is one of the oldest methods for solid sample pretreatment Soxhlet extraction has been the most frequently used technique for isolation of organic compounds from environment for the last twenty year[8].

In this method, the finely ground crude drug is placed in a porous bag or "thimble" made of strong filter paper, which is placed in chamber E of the Soxhlet apparatus.

The extracting solvent in flask A is heated, and its vapors condense in condenser D.

The condensed extractant drips into the thimble containing the crude drug, and extracts it by contact. when the level of liquid in chamber E rises to the top of siphon tube C, the liquid contents of chamber E siphon into flask A.

This process is continuous and is carried out until a drop of solvent from the siphon tube does not leave residue when evaporated. The advantage of this method, compared to previously described methods, is that large amounts of drug can be extracted with a much smaller quantity of solvent.

This effects tremendous economy in terms of time, energy and consequently financial inputs.
At small scale, it is employed as a batch process only, but it becomes much more economical and viable when converted into a continuous extraction procedure on medium or large scale [7].

Solvents used

Ethanol, Methanol, Acetone, Hexane, Ethyl acetate, and Dichloromethane (DCM).

Categories obtained by extraction

Mentha oil, tannins, resin, eugenin.

Form of drug

Solid ⟶ Flowers, stems, leaves.

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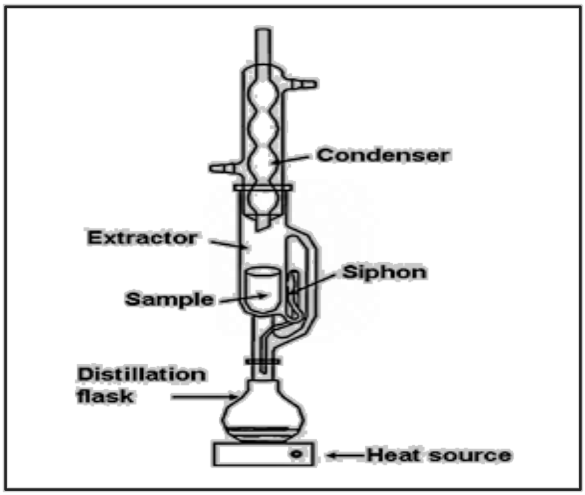

Fig. 4. Soxhlet Apparatus

Microwave Assisted Extraction

It is an advanced technique used to extract bioactive compounds from various matrices such as plant food, or environmental samples. This method uses microwave energy to heat the solvent and the sample, which enhance mast transfer and reduce extraction time. Compared to conventional extraction method microwave assisted extraction offers several advantages including shorter extraction time, lower solvent consumption and improves yield of desired compounds.

Microwave interacts with polar molecules in the solvent and the sample, causing them to rotate and align with the rapidly alternating electromagnetic field.

This leads to the generation of heat to molecular friction and enhances the solvent ability to penetrate the matrix, there by improving the extraction efficiency [8].

Solvents used

Ethanol, Methanol, Acetone, Hexane, Ethyl acetate, and Dichloromethane (DCM), Petroleum ether, Dimethyl formamide (DMF), Dimethyl sulfoxide (DMSO), Acetonitrile, Butanols,

For nonylphenol ⟶ Dichloromethane, acetone-petroleum ether (1:1) [10]tial oils, Flavones, Terpenoids Phenones, Polyphenols.

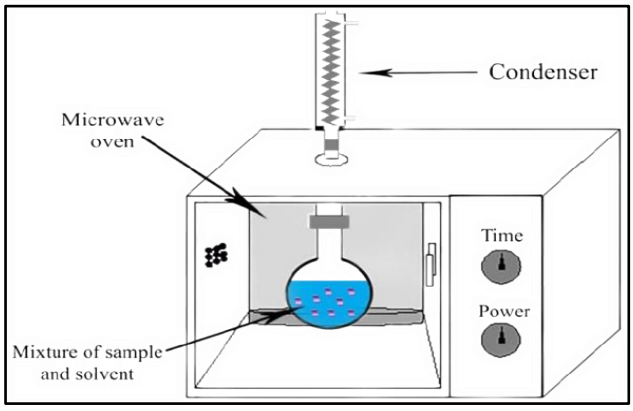

Fig.5. Microwave Oven

Ultrasound-assisted Extraction

Ultrasounds are electromagnetic waves with higher frequencies than sound waves audible to the human ear.

The range of ultrasound utilized is from 20 kHz to 2000 kHz. It travels through a medium involving expansions and contractions following the wave nature.

The mechanical effect of acoustic cavitation from the ultrasound increases the surface area of contact between solvents and plant samples and the permeability of cell walls. The bubble formation, its growth and collapse is termed as cavitation.

Some studies observed that frequency used can modify and favorably influence the extraction of compounds from the sample.

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Although the process is useful in some cases, like extraction of rauwolfia root, its large-scale application is limited due to the higher costs.
One disadvantage of the procedure is the occasional but known deleterious effect of ultrasound energy (more than 20 kHz) on the active constituents of medicinal plants through formation of free radicals and consequently undesirable changes in the drug molecule [9,10].

Solvents used
Ethanol, Methanol, Acetone, hexane, Ethyl acetate, Isopropanol, Acetonitrile.

Categories obtained by extraction
Polysaccharides, Pectin, Caffeine and polyphenols.

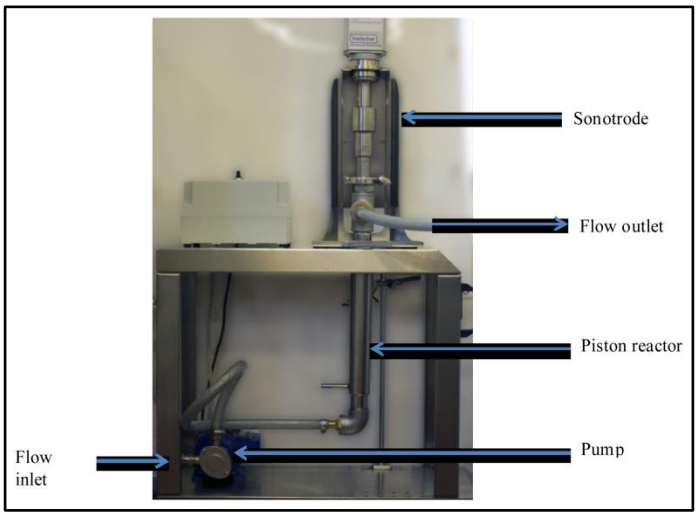

Fig.6. Ultrasonic pilot continuous

RESULT & DISCUSSION

Percolation and maceration are two distinct methods used in the extraction of active compounds from plant materials, often in pharmacology, perfumery, or the preparation of tinctures. While both involve soaking plant materials in a solvent, they differ in procedure and efficiency. **Table** 1[26].

Table 1: Difference between maceration and percolation procedures.

Maceration	Percolation
A process of becoming softened by soaking in a liquid	A process of liquid slowly passing through a filter
Main purpose is to obtain softer substances in a liquid medium	Main purpose is to extract particular substance into liquid
Results in liquid with waste and has to be purified further	Results in liquid that only contains desired substances dissolved in it. Hence no further purification is required
Takes long time	Takes less time
Do not require equipment	Takes less time Requires equipment's such as filter

Soxhlet extraction has for more than a century demonstrated its advantages, which have surpassed in most cases its shortcomings. Table 1, Table 2, and Table 3 show the results of the work of several researchers who extracted soursop leaves by the maceration method, soxhletation method, and MAE

Table 2. Results of soursop leaf extraction by maceration method.

Weight (g)	Solvent	Immersion Time (days)	Yield (%)	Active Compound	References
5000	Methanol	1	10	Acetogenins	[11]
500	Methanol	2	7.26	Alkaloid and sterols	[12]
6.5	Methanol	5	6.6	Acetogenins and Alkaloid	[10]

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1000	Ethanol 98%	3	12.5	Phenolics and Flavonoid	[13]
1981	Ethyl Acetate	4	4.1	Terpenoid	[14]
1190	Distilled water	1	32.96	Alkaloid	[15]
1000	Distilled water	2	3.62	Tannins and Polyphenolic	[16]

Table 2. Results of soursop leaf extraction by soxhletation method.

Weight (g)	Solvent	Immersion Time (days)	Yield (%)	Active Compound	References
60	Methanol	72	29.13	Phenolics and Flavonoid	[17]
201	Methanol	6	24.9	Flavonoid	[18]
0.03	Water	16	4	Flavonoid	[9]

Table 3. Results of soursop leaf extraction by MAE.

Weight (g)	Solvent	Immersion Time (days)	Yield (%)	Active Compound	References
20	Ethanol 70%	600	33.98 %	Phenolic	[19]
Unknown	Ethanol	850	20g	Unspecified / whole extract content	[20]

Based on the research results in Table 2, Table 3, and Table 4, it can be seen that the maceration method is the easiest method to do and uses cheaper equipment, but requires a long extraction time.

Soxhletation method is a method that is generally carried out on a laboratory scale because it uses tools that are usually found in a laboratory. Both of these methods are conventional methods that need to be developed. One of the new methods is MAE which offers a shorter extraction time because it uses electromagnetic waves. This MAE method is a modification of the soxhletation extraction method which obtains a heat source from electromagnetic waves by using a microwave.

Table for comparison of conventional and ultrasound assisted extraction method on boldo leaves

Table 4. Summary and comparison of extractions [27].

Method of extraction	Time of extraction (min)	Yield of extraction (% of leaves Boldo solubilized in the extract)	Boldine (µg of boldine/g of boldo leaves)
UAE	30	21.8	100
Conventional	30	18.0 5	1.7
UAE	120	26.7	148
Conventional	120	21.5	99.5

CONCLUSION

The pharmacopoeial standards in the Ayurvedic Pharmacopoeia of India are insufficient to ensure the quality of plant materials, as the materials received in manufacturing facilities are often unsuitable for effective microscopic examination. Consequently, quality assessment should rely on chemical methods, instrumental techniques, and thin-layer chromatographic analysis to ensure the proper quality of plant materials. Non-standardized extraction procedures can lead to the degradation of phytochemicals in plants, resulting in variations and a lack of reproducibility. It is crucial to produce batches with as consistent quality as possible, within a narrow range, and to develop and adhere to optimal extraction processes.

There are three methods for extracting active compounds from soursop leaves: maceration with solvent immersion, soxhlet extraction using a solid-liquid extraction system, and microwave-assisted extraction (MAE) with electromagnetic waves. Each method has its own advantages and disadvantages. Among these, MAE is the most efficient, yielding 33.98%.

In the case of the maceration method, polar solvents were found to extract higher phenolic yields from olive leaves compared to non-polar solvents, indicating that most phenolic compounds in olive leaves are polar. MAE with polar solvents, especially water, offers a comparable phenolic content yield to that of maceration with alcoholic solvents. MAE is advantageous over conventional

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methods, such as maceration, because it reduces extraction time, increases efficiency, requires less labor, and provides high selectivity, making it a preferred method for extracting phenolic compounds from olive leaves.

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