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A REVIEW ON DIFFERENT EXTRACTION METHOD OF PLANTS: INNOVATION FROM ANCIENT TO MODERN TECHNOLOGY

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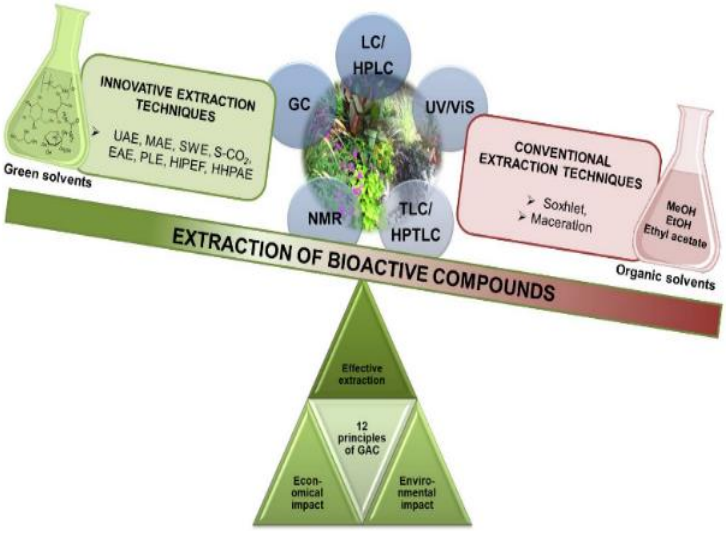
ABSTRACT

This review explores the evolution of plant extraction methods from ancient to modern times. It covers traditional techniques like maceration and infusion, leading to innovations such as steam distillation and solvent extraction. The transition to modern methods like supercritical fluid extraction, microwave-assisted extraction, and ultrasound-assisted extraction is discussed, highlighting their efficiency and sustainability. The integration of green extraction approaches and cutting-edge technologies is also emphasized. Overall, this review underscores the transformative journey of plant extraction, shaping diverse applications across industries.

KEYWORDS: Extraction, Modern Technology, phytochemical.

1. INTRODUCTION

Natural products, such as plant extracts, either as pure compounds or as standardized extracts, provide endless opportunities for new therapeutic discoveries due to their unrivalled chemical variability.[1] According to the World Health Organization, more than fixed oils, resins, phenols and flavonoids are among the active substances found in plants, which are deposited in specific areas such as leaves, flowers, bark, seeds fruits and roots.[2] In Asia, the use of herbal remedies reflects a long history of human interactions with the natural world. Traditional medicine plants offer a variety of chemicals that can be utilized to treat both chronic and infectious diseases.[3]



The first and most important step in the creation of plant formulations is extraction. Modern extraction procedures are useful in furthering the development of traditional herbal treatments. Modern sample preparation procedures with considerable benefits over conventional methods for the extraction and analysis of medicinal plantsare likely to play a key part in the overall endeavor to ensure the availability of high quality herbal products

to customers around the world.

The importance of choosing the best extraction method is demonstrated by the fact that when different procedures are used on the same plant material with the same solvent, extraction efficiency can differ dramatically. The most appropriate procedure must also be standardized in order to attain an acceptable level of reproducibility. It should be emphasized that selecting an appropriate solvent, as well as using a compatible extraction process, is critical. The'like dissolves like idea applies to solvent selection. Polar solvents will extract polar chemicals, while non-polar solvents will extract non-polar materials. The most common extraction method is solvent extraction.[4] Water, ethanol, chloroform, ethyl acetate, methanol, and other solvents are widely used to extract medically required active components. To improve extraction efficiency, solvent combinations aresometimes utilized.

Some extraction methods are used for medicinal plants like Microwave aided extraction (MAE), ultrasonication assisted extraction (UAE), supercritical fluid extraction (SFE), solid phase microextraction (SPME), Soxh wave, and other recent technologies are amongthem. Collection and pretreatment of plants, size reduction, extraction, and storage of extract at a specific temperature for later use are all part of extraction technology.

2. Extraction

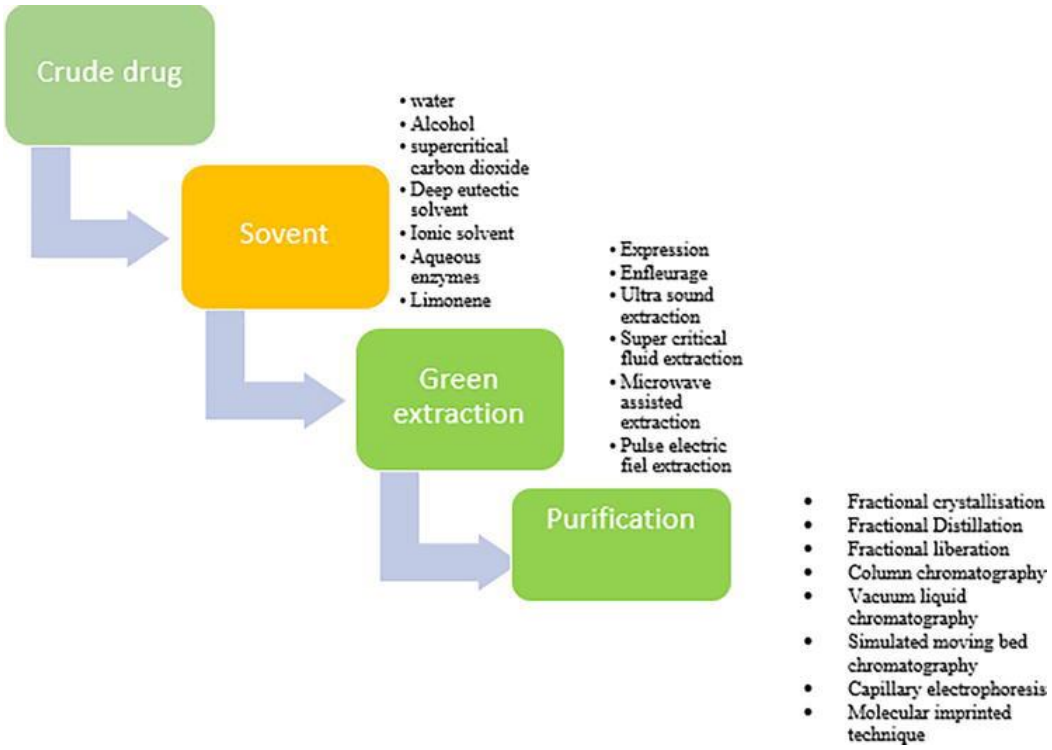
A. COLLECTION

Collectors and collection managers should follow these guidelines for harvesting the medicinal plants.

I. Quality concerns during plant collection: Medicinal plant harvesting should be done in such a way and at such a rate that the species can continue to exist in its native habitat indefinitely. Collectors should adopt techniques that not only meet their commercial requirements but similarly ensure that the goods they create are of high quality. Collectors and collection managers should follow these principles when harvesting medicinal plants.

II. Ecological consideration

The collection of medicinal plants from the wild in the absence of adequate preventative measures may disrupt theecosystem in a variety of ways. The overutilization of any plant species may frighten the existence of the species in natural habitat. Ignorance of the adverse source managers or botanists who are familiar with the local ecology before environmental impact of over-exploitation may affect the environmental balance and loss of genetic assortment of the surrounding habitats. Collection practices should be used to ensure the long term survival of wild populations and their natural habitats. Collectors should consult local collecting plant samples.[9]



B. DRYING

Medicinal plant produce should be properly dehydrated before being packed for shipping or storage. National pharmacopoeias can provide information on the optimal moisture content of specific produce. To guarantee adequate drying, medicinal plant products such as rhizomes, fleshy roots, fleshy stems (Cissus), fleshy leaves (Aloe), pulpy fruits, woody parts, fleshy petals and those containing polysaccharides require additional attention.

The following suggestions for improving medicinal

plant processing and drying may be useful: If the gathered produce is morphologically thick, meaty or large, it should be cut or sliced into small, thin pieces to ensure adequate drying. The productshould be sliced into sections in such a way that the drying process is aided while the aesthetic appearance of the produce is preserved.

Air-drying: Depending on the sorts of samples dried, air drying might take anywhere from 3 to 7 days to months or even a year (eg. Leaves or seed). The fragile plant portions and aromatic parts that make up the food should only be dried in the shade. If a medicinal plant produce that needs to be dried in the dark is wet, it can be dried in the sun first to remove any external moisture before being moved to the shadow. Plant samples, mainly leaves and stems were tied together and hung in the open to expose the plant to air at room temperature. Heat labile chemicals are maintained since this drying method does not force dried plant components to be dried at high temperatures. Air drying, on the other hand takes longer than microwave or freeze drying and can lead to contamination if the temperature into covered/partly covered spaces during the nighttime hours. This method avoids exposure to night fog, unplanned night drizzles, and other unpleasant conditions.

Microwave-drying: Electromagnetic radioactivity with both electric and magnetic fields is used in microwave drying. During dipolar rotation, alignment on the electric field of molecules with a stable or induced dipole moment (eg. Solvents or samples) and ionic induction, the electric field induces simultaneous heating and oscillation of the molecules. Vacillation causes molecules to collide, resulting in rapid heating of the samples at the same time. This approach can save drying time, however it can also cause phytochemical deterioration.[12]

Oven-drying: Alternative pre-extraction procedure that employs thermal energy to remove moisture from samples is oven- drying. Before being used in the field, the procedure must be standardized and validated for their overall effect on the quality of medicinal plant production. It's important to keep track of the temperature range and duration of such drying. This sample preparation is thought to be one of the simplest and fastest thermal processes for preserving phytochemicals.[13] This approach resulted in a shorter duration of extraction time.[14]

Freeze-drying: Freeze-drying is a process built on the sublimation concept. Sublimation is the transformation of a solid into a gasphase without passing through the liquid phase. Prior to lyophilization, the samples are freezing at -80°C to -20°C to solidify any liquid (eg. Solvent, moisture) in the samples. The sample is promptly lyophilized after an overnight (12h) freeze to prevent the frozen liquid in the sample from melting. To prevent sample loss throughout the process, the outlet of the test tube or any container embracing the sample is enveloped with needle-poked- parafilm. The majority of the time, the sample splattered out into the freeze-flask and was lost. When compared to air-drying, freeze-drying produced higher levels of phenolic content because most phytochemicals are maintained. However, as compared to ordinary air drying and microwave drying, freeze-drying is a time-consuming and expensive way of drying. As a result, the use is limited to high-value, delicate, heat-sensitive materials.

Fresh *vs.* dried samples: In medicinal plant research, both fresh and dried samples are used. When it comes to the time required for experimental design, dried samples are usually selected. Fresh samples are fragile and deteriorate faster than dried samples, so the time between harvest and experimental work should be kept to a maximum of three hours to retain freshness.

C. GRINDING

Dry grinding plants are commonly working in the mining industry when the downstream preparation process demands dry material or when water conservation is a priority.

In addition to the mills, the scope of supplies and services includes the upstream and downstream plant sections, electrical equipment and instrumentation and erection and commissioning. The design criteria are dictated by the needs of customer and the best grinding system for those needs is then designed using laboratory test processes, computer simulations and calculations.

Surface contact between samples and extraction solutions is increased when particle size is reduced. Grinding produced coarser, smaller samples; powdered samples, on the other hand, have a more homogenized and smaller particle size, resulting in greater surface contact with extraction solvents. This step is critical because efficient extraction requires the solvent to come into touch with the target analytes, and particles smaller than 0.5 mm are optimum for good extradtion.[15] To lower the particle size of a sample, traditional mortar and pestle or electric blenders and mills are typically utilised.

D. STORAGE

The storage containers for medicinal plant production must protect the produce from heat, humidity and temperature while also avoiding contaminating it. Each variety of produce has its unique packing requirement. The containers of the medicinal plant produce should not be corss-used, while the containers of same species and produce may be used. Make an effort to "compress" bulk items using manually or mechanically operated compactors when processing them. This technique aids communities in reducing storage space requirements and facilitating primary transportation. Every container containing therapeutic plant output should be appropriately labeled. All necessary information about medicinal plant products should be included on the label.

Containers carrying medicinal plant yield should be kept cool and dry, preferably on wooden pallets, after being securely sealed and labeled. Never stack containers directly on the floor, specially gunny bags, jute bags, woven sacks, corrugated boxes, and so on. Never stack containers containing two or more medicinal plant products on top of eachother.[16]

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The shelf life of each lot of food should be clearly written on the label and the fruit should be consumed within the legitimate shelf life period. Medicinal plant produce should be supplied or consumed on a FIFO (first in first out) basis to the greatest extent possible to reduce storage of outdated material. The FIFO system permits produce to be used in the order that it arrives in the storage. Separate climate (temperature and humidity) regulated storage facilities for hygroscopic and volatile materials should be provided. Resins, gum-resins, oils and other flammable products should be sorted inclosed containers in a safe location (combustible resources should be properlylabelled as such on each container).

E. SELECTION OF SOLVENT SYSTEM

The solvent used for the extraction of medicinal plants is also known as the menstrum.

A property of a good solvent in plant extractions includes

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

When selecting an extraction solvent, the considerations listed below should be taken into account.

Elements to be considered in selecting solvents of extraction

A. Selectivity: The capacity of a solvent to extract the effective ingredient while leaving the inert stuff behind.
B. Extraction solvent safety: The ideal extraction solvent should be non-hazardous and nonflammable.
C. Cost: It must be as low-cost as viable.
D. Recovery: The solvent of extraction should be rapidly recovered and separated from theextract.
E. Viscosity: It should be of low viscosity to permit ease of penetration.
F. Boiling temperature: Solvent boiling temperature should be as low as possible to avoiddegradation by heat.
G. Reactivity: Appropriate solvent of extraction should not react with the extract.[17]

Selection of extraction on the basic of polarity

The solvent choice is influenced by the nature of plant, the portion of the plant to be extracted, the nature of the bioactive components, and the availability of solvent. Polar solvents like water, methanol, and ethanol are used in polar compound extraction, while nonpolar solvents like hexane and dichloromethane are used in nonpolar chemical extraction. The traditional method for liquid-liquid extraction is to use two miscible solvents such as water- dichloromethane, water-ether, or water-hexane. Water is present in all of the mixtures due to its high polarity and miscibility with organic solvents.[18]

During fractionation, the selected solvent is added in order of increasing polarity, starting with the least polar n-hexane and ending with the most polar water. If investigator wants to use five solvents during fractionation, the standard procedure is to use two low-polarity solvents (n-hexane, chloroform), two medium-polarity solvents (dichloromethane, n-butanol) and one high-polarity solvent(water).

Properties of solvent for extraction	
Water	It is the highly polar solvent, and it is utilized to extract a variety of polar substances.[19] **Advantages**: It dissolves a wide range of compounds and is inexpensive, nontoxic, nonflammable, andextremely polar.[20] **Disadvantages**: It stimulates the growth of germs and mould; it may cause hydrolysis; and it requires a lot ofheat to concentrate the extract.
Alcohol	It is polar, water miscible and capable of extracting polar secondary metabolites.[21] **Advantages**: At concentrations greater than 20%, it is self-preservative. At low concentrations, it is harmless,and just a modest quantity of heat is necessary to concentrate the extract. **Disadvantages**: It is combustible and volatile, and it does not dissolve fats, gums, or wax.

Chloroform	It is a nonpolar solvent that may be used to extract terpenoids, flavonoids, lipids, and oils, among otherthings.[22] **Advantages:** It has a colourless appearance, a sweet odour, and is soluble in alcohols. In addition, it is easilyabsorbed and processed by the body. **Disadvantages:** It contains sedative and carcinogenic properties
Ether	It is a nonpolar solvent that good for extracting alkaloids, terpenoids, coumarins, and fatty acids. **Advantages.** It has a low boiling point, is miscible with water, and has no taste. It is also an extremely stablemolecule that is unaffected by acids, bases, or metals. **Disadvantages**. It is extremely flammable and volatile in nature.
Ionic liquid (green solvent)	This is exclusive solvent of extraction and is very polar and extremely heat stable.[23] It can continue in aliquid state even at 3,000^{o}C and working where high temperature is applicable. It has intense miscibility with water and other solvent and is highly suitable in the extraction of polar compounds.[24] **Advantages**: It is appropriate for microwave-assisted extraction because it has an excellent solvent that attracts and transmits microwave. It is nonflammable and very polar, making it ideal for liquid-liquid extraction. **Disadvantage**: It is not suitable for the formulation of extracts.

A property of a good solvent in plant extractions includes

- Quantity of phytochemicals to be extracted
- Extraction rate
- Diversity of compounds extracted
- Diversity of inhibitory compounds extracted
- Ease of extract subsequent handling
- Toxicity of the solvent in the bioassay process
- Potential health hazard of the extractants

[C] Extraction method

The differences in extraction procedures that affect the quantity and secondary metabolite composition of an extract are determined by:

1. **EXTRACTION METHODS:** Appropriate plant extracts usually occur as a combination of various type of bioactive compounds or phytochemicals with different polarities, their separation still remains a huge challenge for the method of identification and characterization of bioactive compounds.

Soxhlet extraction Percolation Decoction Extraction leachingMeceration

Accelerated Solvent ExtractionSteam distillation
Thermal desorptionInfusion
Membrane process Phytonic desorption
Surfactant mediated extraction Pressurized liquid extraction Sample disruption method

1. Maceration

Maceration has long been a popular and cost- effective home method for creating tonic. In addition, this method is utilised to extract essential oils and active chemicals from plant matter. In most cases, the maceration method entails many extraction phases. Grinding increases the surface area of the entire or coarsely powdered crude medication, allowing for optimal mixing of powdered components with the solvent. This procedure is carried out in a closed tank with the addition of a suitable solvent (menstruum). The solvent is then strained outand the solid residue of the extraction process known as marc, is pressed to recover the maximum amount of occluded solution. The acquired pushed out liquid and the strained solvent are combined and filtered to remove any undesirable elements. Extraction is aided by frequent agitation during maceration by two processes: (1) promote diffusion, and (2) separation of concentrated solution from the sample surface by introducing additional solvent to the menstruum to increase extraction yield.[25]

2. Infusion, Percolation and Decoction

Infusion and decoction are similar to maceration in that they are both steeped in cold or boiling water. For infusion, the maceration duration is reduced and the sample is cooked in a specific amount of water (eg. 1:4 or 1:16) for a specific time. When compared to maceration and infusion, decoction is only suitable for extracting heat- stable chemicals from hard plant materials (eg. Roots and barks) and usually results in more oil-soluble compounds. Percolation, another approach with a similar core concept,employs specialised equipment known as a percolator. Dried powdered samples are placed in the percolator, boiled water is added and the mixture is macerated for two hours. Percolation is often carried out at a modest rate (eg. 6 drops per minute) until the extraction is complete before evaporation to obtain concentrated extracts.[26]

3. Soxhlet extraction or hot continous extraction

This procedure involves placing finely powdered sample in a porous bag or “thimble” made of sharp filter paper or cellulose, which is then placed in the thimble chamber of soxhlet. Extraction solvents are heated in the bottom flask, vaporised in the sample thimble, condensed in the condenser and dripped back into the flask. The liquid content is drained into the bottom flask again when it reaches the syphon arm and the procedure is repeated.

In comparison to maceration, this process requires less solvent. However, the Soxhlet extraction has drawbacks, including exposure to hazardous and flammable liquid organic solvents, as well as the possibility of harmful

emissions during the extraction process. The extraction system requires high-purity solvents, which may increase the cost. When compared to advanced extraction methods such as supercritical fluid extraction (SFE), this approach is deemed unfriendly to the environment and may lead to pollution. The optimum sample for Soxhlet extraction is also a dry, finely divided solid and numerous variables such as temperature, solvent-to-sample ratio and agitation speed must be taken into account.[27]

4. Solid-phase microextraction(SPME)

Solid-phase microextraction (SPME) is a sample preparation process that extracts target analytes from examined sample matrices using small amounts of extraction phases. SPME, like solid-phase extraction (SPE), includes the partitioning of analytes from sample matrices to extraction phases, which is determined by chemical potential gradients between the sample matrices and extraction phases. The amounts of analytes extracted by the extraction phases are at their highest when the analytes attain partition equilibrium between the sample matrices and the extraction phases. When the extracted analyte is close enough to its theoritical equilibrium extraction quantity, the equilibrium state is frequently deemed reached in practise (for example, no less than 95 percent of the theoretical equilibrium extraction amount). Before that, SPME is thouht to be in a state of preequilibrium. SPME can be halted during the preequilibrium stage, specially if sufficient sensitivity can be guaranteed but the time efficiency sample preparation step is the primary issue.[28]

The extraction stages in SPME are often mounted on supporting substrates or manufactured as monolithic fibres or thin films. Since SPME commonly uses relatively small amounts of extraction phases, absolute recoveries are typically low. As a result, SPME is considered a non-exhaustive extraction technique. SPME can be used to determine the free concentrations of analytes in biological and environmental samples when the extracted amount is small in comparision to the total amount of the analyte in the sample matrix and does not significantly alter the distribution of the analytes in the sample matrix. Since large portions of the extracted analytes can be successfully transferred to the analytical instruments for analysis, even though the absolute recoveries of SPME are often extremely low, very satisfactory sensitivities can still be reached when coupling SPME with chromatography or directly with mass spectrometry. In comparisionto SPE, other advantage of SPME is that it requires no or very little solvent. This makes SPME intriguing in light of the current push to develop green sample preparation approaches.

SPME in combination with gas chromatography (GC) has evolved into one of the best efficient and practical technologies for analyzing volatiles and semivolatiles from a variety of sources. SPME has also been used to extract polar analytes and even to extract a wide range of analytes with different polarities simultaneously by designing extraction phases with appropriate polarities and functional groups. SPME is also an exciting in vivo sampling method for studying status and processes in living systems due to its low invasiveness to living animals and plants.13 Sulfur compounds in air samples are measured using solid phase microextraction (SPME), a solvent free sample preparation method that allows sampling, isolation and enrichment in a single step. Three types of SPME fibers were evaluated for the extraction of different VSCs: polydimethylsiloxane (PDMS), Carboxen- polydimethylsiloxane (CAR-PDMS) and Divinylbenzene-polydimethylsiloxane (DVD-PDMS).

5. **Supercritical fluid extraction** Supercritical fluid extraction (SFE) is a green method that can be used as an alternative to traditional solvent extraction.[29] It has a lower environmental impact and satisfies consumer desire for safe, natural and high-quality components. SFE technology is being used by an increasing number of businesses and it is said to provide a competitive advantage.

SFE is a method in which a gas is delivered to an extraction vessel at a temperature and pressure above its critical temperature and pressure in order to extract the desired component or mixture of compounds from a product matrix. The fluid possessed both the qualities of a gas and a liquid in the supercritical state, as it has the density of a liquid and the viscosity of a gas. This feature boosts the rate of extraction of the targeted chemicals by increasing the diffusivity of the fluid in the product-containing matrix. SFE isa selective extraction method in which process factors such as pretreatment of plant material, temperature, pressure, particle size, moisture content, solvent flow rate, extraction time and co-solvents are changed depending on the target component to be extracted.[29]

The pretreatment of plant materials is a crucial step in the preparation process and has an impact on SFE extraction. Due to the numerous process variables that influence SFE extraction effectiveness, comprehensive lab-sclae investigations are required for each product, which may have a unique set of optimum process variables for the extraction of the target molecule. There are a variety of solvents that can be used in the SFE process, including pentane, ethanol and other, but CO2 is the greatest extensively employed in industry due to its numerous benefits. These include a low critical pressure (72.8 bar) and temperature (30.9 °C) as well as the fact that it is non toxic, non flammable, inexpensive and can be quickly removed from the extract with little residue. With recent advantages in SFE technology, it is now possible to recycle CO2 after decompression, lowering renning costs and reducing CO2 emissions into the atmosphere.

6. Microwave assisted extraction (MAE)

Microwave energy is used in MAE to help analytes partition from the sample matrix into the solvent. When microwave radiation interacts with the dipoles of polar and polarizable materials (such as solvents and samples), heat is generated near the surface of the materials, which is then transported by conduction. Microwave electromagneticdipole rotation breaks hydrogen bonding, allowing dissolved ions to migrate faster and promoting solvent penetration into the matrix. Poor heating occurs in non polar fluids because energy is only transmitted by dielectric absorption. MAE can be thought of as a type of selective approach that favours polar molecules and solvents with a high dielectric constant.[30]

This technique reduced extraction time and solvent volume as compared to conventional method (maceration and soxhlet extraction). The MAE approach showed improved analyte recovery and repeatability, however it was cautioned to use suitable setting to minimise thermal degradation.[8] This technique is limited to small molecule phenolic compounds such as phenolic acids (gallic acid and ellagic acid), quacertain, isoflavin and trans-resveratrol since they are stable at microwave heating settings of up to 100°C for 20 minutes. Further MAE cycles (eg. From 2 10 s to 3 10 s) resulted in a significant drop in the yield of phenolics and flavonones, mainly caused by the oxidation of compounds.[31] Tannins and anthocyanins may not be suited for MAE since they are susceptible to thermal deterioration.

7. Ultrasound assisted extraction (UAE) or sonication extraction

Ultrasound frequencies ranging from 20 to 2000 kHz are used in UAE. The mechanical effect of ultrasound induced acoustic cavitation improves surface contact between solvents and samples, as well as cell wall permeability. The physical and chemical properties of materials treated to ultrasound ae altered and the plant cell wall is disrupted, allowing chemicals to be Released and increasing the mass transit of solvents into plant cells. The process is a simple and low cost technology that can be utilised to extract phytochemicals on a small or large scale.[32] The advantages of UAE are mostly attributable to the reduced extraction time and solvent depletion. Conversely, the generation of free radicals by ultrasonic energy greater than 20 kHz may have an effect on active phytochemicals.

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