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GREEN EXTRACTION TECHNIQUES BY USING VARIOUS HERBS

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ABSTRACT

The recovery of organic compounds has been made possible by the introduction of a number of green extraction procedures. Extraction techniques are widely used in a variety of industries to separate components. Various extraction methods have diverse applications, adaptable to different situations. The choice of solvent, procedural steps, and the inherent advantages and disadvantages determine the effectiveness of each method. green extraction methods, among others negative pressure cavitation withdrawal, ultrasound- assistance with extraction, subcritical extraction of water, and microwave-assisted extraction, offer specific approaches with unique benefits and drawbacks. The active ingredient that is frequently utilized as medicine for a variety of medical ailments can also be obtained using these techniques. Additionally, this environmentally friendly method of extracting phytoconstituents from natural sources reduces the number of solvents used as well as the amount of trash produced during the extraction. This approach uses a variety of plants, depending on the extraction method, such as Zingiber officinale Roscoe, papaya, moringa oleifera leaves, and Cinnamomum iners.With a variety of effects such as analgesic, anticancer, antiemetics, antitumor, etc.

KEYWORDS: Negative pressure cavitation extraction, microwave-assisted extraction, subcritical fluid extraction, supercritical fluid extraction Papaya, Zingiber officinale Roscoe, Catharanthus roseus, Cinnamomum iners.

INTRODUCTION

"Green extraction involves developing and designing extraction processes with the aim of minimizing energy consumption, enabling the use of alternative solvents and renewable natural products, and ensuring the production of a safe and high-quality extract or product," as per the description given by the Green Extraction Association. To devise and showcase eco-friendly extraction methods on both laboratory and industrial scales, with the goal of achieving optimal utilization of raw materials, solvents, and energy, three primary strategies have been recognized: (1) enhancing and fine-tuning existing processes; (2) employing versatile equipment; and (3) fostering innovation in procedures and processes, along with the exploration of substitute solvent.

The Six Green Extraction Principles

For professionals in both industry and scientific fields, the compilation of the "six principles of green extraction of natural products" is intended to function as a blueprint for establishing innovative and environmentally conscious benchmarks, charters, and standards. Moreover, it acts as a stimulus to foster innovation across all facets of extraction from solid-liquid.

1. Encouraging inventiveness by opting for a range of diverse varieties and employing renewable plant resources.
2. Utilizing substitute solvents, with an emphasis on water or agricultural solvents.
3. Implement vitality recovery and state-of-the-art technologies to reduce energy consumption.
4. Emphasize the production of co-products in the bio- and agro-refining sectors while minimizing the generation of trash.
5. Streamline unit activities as well as prioritize secure, reliable, and managed procedures.
6. Strive Regarding an extract that is non-denatured, free from contaminants, and biodegradable.[1]

Designing a procedure that reduces energy consumption, encourages the use of contemporary solvents, converts waste into co-products, and guarantees the creation of a safe and high-quality final product is necessary to create a sustainable extraction method or technique.[2,3] Extraction with the use of ultrasound (UAE), microwave (MAE), negative pressure cavitation-assisted extraction (NPCE), subcritical water extraction (SWE), and fluid extraction that is supercritical (SFE) are instances of

emerging unconventional methods of extraction currently when using.[4] Even though new extraction methods are proliferating like wildfire in response to rising client demand, they also present some difficulties. Additionally, combining several innovative extraction strategies will soon be essential for the efficient, secure, and safe manufacturing of bioactive chemicals.[5]

GREEN EXTRACTION TECHNIQUES

1. Supercritical Fluid Extraction

Due to ScCO2's high infusibility and low polarity, supercritical fluid extraction (SFE) is suited towards hydrophobic substances with high extraction efficiency. The target compound's solubility in the selected solvent, a property impacted by the solvent-solute interaction, determines how successful an extraction technique will be.

Example-Papaya

The perennial Carica papaya (CP), a member of the Caricaceae family, is grown in the United States mainly for its fruit. Over time, the leaves have been traditionally used for addressing issues such as parasitic worms, digestive problems, fever, burns, and asthma.[6,7,8] Carica papaya L. (C. papaya L.) is a prominently cultivated crop in tropical and sub-tropical regions.[9]

As the active ingredients in the leaves, including papain, tocopherol, ascorbic acid, glucosides, and chymopapain, have demonstrated potential therapeutic effects by stimulating the blood's antioxidant capacity and reducing levels of peroxidation.[10]

Fig. 1: Papaya.

General procedure

MARDI collected 50 grams each of fresh leaves, petiole, and fruit peel in triplicate. Exclusively healthy and disease-free specimens were chosen for subsequent extraction following a comprehensive wash using purified water. The samples were allowed to air dry at room temperature until they were totally dry. The dried materials were then crushed coarsely and used to extract alkaloids.[11]

Advantages of SFE

1. Considered safe and widely acknowledged as such by the FDA and EFSA.
2. Due to its non-polar characteristics, this solvent is not suitable for dissolving polar molecules. However, it is highly effective for extracting thermally labile and non-polar bioactive chemicals.
3. It shortens processing times, boosts yields, and enables the use of softer processing conditions.

Disadvantages of SFE

1. It complicates the thermodynamics of the system and raises investment costs.
2. The predominant use of non-polar extraction fluids, such as CO2, with SC-CO2 and many other supercritical fluids, represents a noteworthy drawback.[12,13]

2. Microwave-assisted extraction

Microwaves are a portion of light's electromagnetic spectrum, which has frequencies between 300 MHz and 300 GHz and wavelengths between 1 cm and 1 m.[14]

One of the modern, cutting-edge extraction methods being researched at the moment is microwave assistance. Plant metabolites are concentrated with the solvents in MAE using microwave energy.[15]

The principal application of microwaves is in their contact with particular materials that have the ability to partially absorb their electromagnetic energy and transform it into thermal energy. The standard operating frequency of commercial microwaves is 2450 MHz, or roughly 600–700 W.[16]

Example-Cinnamomum iners

A member of the Cinnamomum genus named Cinnamomum iners. This huge genus is a member of the Lauraceae family, and many of its members can be distilled to produce an essential oil.[17]

Numerous hundred species of the Cinnamomum genus are found natively in Asia. One such species that is common throughout South Asia is C. iners. This plant, which is called "Ob Chuei" in Thai, is primarily found in

Thailand's north. Traditional uses for its leaves include analgesic and antipyretic properties.[18]

Essential oils from eleven distinct species of Cinnamomum, comprising C. camphora, C. iners, C. microphyllum, C. mollisimum, C. porectum, C. pubescens, C. rhyncophyllum, C. scortechinii, C. sintoc, C. suvabenium, and C. zeylanicum, have demonstrated antifungal activities.[19]

Every type of cinnamon encompasses the compound cinnamaldehyde, constituting approximately 65 to 80% of the natural essential oil. Cinnamon is employed for addressing issues such as digestive atony, dyspepsia, gas, nausea, intestinal colic, and sluggish digestion.[20]

Fig. 2: Cinnamomum Iners.

General procedure

Through a Clevenger-style apparatus, 700 grams of fresh leaves were homogenized and hydrodistilled for 5 hours, resulting in the production of 0.12% yellowish oil with a potent scent. A modified microwave distillation arrangement was employed to extract a yellowish-colored oil with a potent aroma, constituting 0.12% of the total product, from 200 grams of freshly harvested leaves. The hydrodistillation process took place at 800 W for a duration of 30 minutes following homogenization. This experimental configuration involved the utilization of a microwave oven attached to a device similar to a Clevenger.[21]

Advantages of MAE

1. Low use of solvents.
2. Only a few milliliters of solvents are used by MAE.
3. A higher yield of extraction.
4. The procedure can be precisely automated, improving process accuracy and precision.
5. The technique works with phytoconstituents that are thermolabile.

Disadvantages of MAE

1. MAE use necessitates specific setup, which raises process costs.
2. This approach is still in the development stage.[22]

3. Ultrasound Assisted Extraction

Since the latter part of the 20th century, ultrasound-assisted extraction (UAE) has found application in diverse sectors, encompassing the cosmetics, pharmaceutical, chemical, and food industries.[23] Ultrasonic extraction is demonstrated as the quickest and most efficient approach, resulting in a substantial improvement in the phenolic content rate when compared to alternative methods under investigation.[24] Additionally, ultrasound assisted extraction uses ultrasound energy and solvents to extract tar.

Example-Moringa oleifera leaves

The Moringa oleifera plant is a member of the Moringaceae family and is mainly found in tropical and subtropical areas, especially in Asia and Africa. It goes by a number of names, such as the drumstick tree, ben oil tree, and horseradish tree.[25] Apart from protecting organs include the heart, testes, liver, kidneys, and lungs, this plant possesses various properties, including anti-disease, antiulcer, antihypertensive, radioprotective, and immunomodulatory effects.[26]

Vitamin A, vitamin C, calcium, potassium, iron, and protein are among the phytochemicals present in M. oleifera.[27] Common phenolic chemicals found in M. oleifera include rutin, chlorogenic acid, isoquercetin, and quercetin glucoside. This group includes several derivatives of gallic acid, coumarin acid, caffeic acid, and salicylic acid, all of which are important contributors to the presence of AA.[28,29]

Fig. 3: Moringa oleifera leaves.

General procedure

The Elma Transsonic TI-H-15, an ultrasonic cleaning bath with a nominal power of 100 W and a frequency of 35 kHz, was used for the extraction procedure. As per the experimental plan, 20 grams of the dried plant powder were introduced into a 100 ml tube with a cap, along with the appropriate volume of the extraction solution. For the duration of the designated extraction time, the tube containing the suspension was submerged in water and subjected to ultrasonic radiation. The material was extracted ultrasonicantly, filtered through Whatman paper, and vacuum-dried at 40°C in a rotary evaporator.[30]

Advantages of UAE

1. This irradiation method has the benefits of being inexpensive and distributing energy evenly across the vessel without the need for any additional modifications to the reaction vessel.[31]
2. Despite some studies pointing out that both procedures produce comparable results, these systems are more effective than an ultrasonic bath at irradiating the reaction liquid.[32]
3. Once optimized, UAE is a low-cost, straightforward, and effective replacement for traditional extraction methods.[33]
4. In addition, UAE can be employed in combination with any solvent to extract numerous natural chemicals from algae, including lipophilic molecules.[34]

Disadvantages of UAE

1. The placement of the vessel containing the matrix and solvent within the bath presents a common challenge in all ultrasound baths, attributable to differences in the impact of ultrasound waves based on the positioning.[35,36]
2. Less effective than alternative methods.
3. This technique is not appropriate for use in commerce.

4. Negative Pressure Cavitation Extraction

The Engineering Research Centre of Forestry Biopreparation at Northeast Forestry University in Harbin, China (CN 2597047) supplied the apparatus used in the NPCE experiment. The NPCE works by continuously creating and collapsing small bubbles that are created in response to a vacuum. Antioxidant action is demonstrated by genistein and genistin, which were isolated from the roots using pressure cavitation.[37,38]

A novel extraction technique called negative-pressure cavitation extraction (NPCE), has attracted interest for its heightened efficiency relative to conventional extraction methods like three methods of extraction: heat reflux, maceration, and ultrasonic assistance. This is particularly notable when carried out at consistently lower temperatures and intensities.[39,40]

Example-Catharanthus Roseus

The Madagascar periwinkle, or Catharanthus roseus (L.) G. Don, is a member of the Apocynaceae Family. The synthesis of terpenoid indole alkaloids (TIA) is its most notable characteristic. This plant has been extensively investigated, establishing its prominence as a model species in research focusing on secondary metabolism in plants. Being the source of the anticancer alkaloids vinblastine (VLB) and vincristine (VCR), Catharanthus roseus is significant medicinally.[41,42]

The bisindole antitumor alkaloids, vinblastine (VLB) and vincristine (VCR), have vindoline (VDL) and catharanthine (CTR) as their monomeric precursor molecules. Despite their closely related chemical structures, vinblastine and vincristine elicit distinct effects on the body. Since its introduction in 1960, vinblastine has been used to treat a number of malignancies, including non-small cell lung cancer, breast, testicular, and Hodgkin's disease.[43]

In 1963, vinblastine's oxidized derivative vincristine became available. It's used to treat ALL, or acute lymphoblastic leukemia.[44]

Fig. 4: Catharanthus roseus.

General procedure

Different amounts of extraction solvents were combined with 25 grams of powdered C. roseus leaves in the extraction chamber. Negative pressure was established by connecting the extraction pot through a condenser to a vacuum pump. By modifying the airflow rate supplied from the device's base, the pressure was kept track of. The findings section provides more information about the conditions under which the extraction process was conducted. The extraction solutions were combined and dried at 45 °C in a rotary evaporator (RE-52AA, Shanghai Huxi Instrument, Shanghai, China) after each extraction. An HPLC-grade methanol volume that was consistently added was used to prepare the RP-HPLC analysis.[45]

Advantages of NPCE

1. A possible green technology.
2. Reduced energy usage.
3. Compared to other extraction methods, it has a great potential for use in industrial production.
4. It can slow down or stop substances that are susceptible to heat from degrading.

Disadvantages of NPCE

1. Expensive equipment.

5. Subcritical Water Extraction

Pressurized hot water extraction, or SWE for short, is a process that is mostly used to extract medicinal plants and is thought to be environmentally benign. Between the critical point (374°C, 22.1MPa) and the boiling point (T=100°C, 0.1MPa) of water, subcritical water extraction operates.[46,47]

Under atmospheric conditions, water is a polar solvent with a large dielectric constant due to the presence of hydrogen bonding in its structure. Since it cannot dissolve non-polar molecules, it is an inappropriate solvent. The physicochemical properties of water changed as a result of the temperature increase. The most crucial variable affecting the solvency of water is the fall in the dielectric constant. This occurrence is a result of the disruption of hydrogen bonds, leading to a decrease in water's dielectric constant to a magnitude comparable to that of organic solvents. Consequently, under these conditions, water can dissolve molecules with low to medium polarity, exhibiting behavior akin to organic solvents.[48,49]

The bioactive ingredients of ginger were extracted using a subcritical water extraction method. Studies were conducted to determine how various factors, such as temperature, particle size, extraction duration, and the addition of a co-solvent, affected the extraction yield.[50]

Example-Zingiber officinale Roscoe

Ginger, the actual Roscoe, sometimes referred to as ginger, is a monocotyledon in the Zingiberaceae family. A thin perennial plant, ginger grows to a height of 2 feet. Ginger bears blossoms that are greenish yellow and resemble orchids. Ginger is believed to have originated in tropical South East Asia and afterwards expanded to other ecological zones.[51,52]

Ginger is a widely used herb, serving purposes both as a spice in culinary applications and as an herbal remedy. Renowned for its distinctive and potent medicinal properties, ginger is acknowledged for its chemoprotective potential, anticancer, antioxidant, anticoagulant, cardiovascular effects, antibacterial properties, as well as its antiemetic and antipyretic potential.[53,54]

Ginger's pharmacological effects are attributed to the presence of many active compounds. The pharmacological actions of ginger are said to be attributed to the chemicals paradol, shogaol, and gingerol.[55] Gingerols, a class of phenolic chemicals, of which 6-gingerol is the main component, are primarily responsible for the therapeutic benefits of ginger. At high temperatures, these thermolabile chemicals are transformed into shogaols, which are their dehydrated form.[56,57]

Multiple studies have substantiated the pharmacological properties of gingerols and shogaols, encompassing their antioxidant, anti-inflammatory, anti-cancer, anti-tumor, analgesic, and anti-emetic attributes.[58]

Fig. 5: Zingiber officinale roscoe.

General procedure

The extraction cell, constructed from stainless steel and equipped with a heating jacket, was loaded with 40 grams of ground ginger. To eliminate dissolved oxygen, deionized water was placed in a water tank and nitrogen was purged for one hour. A high pressure pump delivers water to the extraction cell. After the temperature hits the predetermined point and the extraction time is set, the extracts are sent via a heat exchanger and gathered for further examination. One aspect at a time was used to create the ideal conditions. To assess the influence of co-solvent addition, a single Subcritical Water Extraction (SWE) was conducted on two occasions. In the first instance, 2% ethanol was added to deionized water, and in the second, 2% acetone was added. Previous studies that evaluated the solubilities of bioactive components in ginger using hot compressed water with ethanol as an entrainer[59] served as the foundation for the choice to employ a 2% dosage.

The extractions were conducted at a constant temperature of 130 °C for 20 minutes, with a particle size of 0.71 mm and 20 bars of pressure maintained. The extraction process involved temperatures ranging from 110 to 150°C, employing the suitable co-solvent, while keeping the pressure constant at 20 bars and using a particle size of 0.71 mm for 20 minutes to evaluate the impact of temperature on the extraction yield. In addition, the effects of retention time were evaluated using Subcritical Water Extraction (SWE) with a particle size of 0.71 mm, for 10, 20, and 30 minutes, using the proper co-solvent, at the ideal temperature, and under constant pressure of 20 bars. The ideal conditions derived from earlier phases were used to extract ginger with particle sizes of 0.6, 0.71, and 1mm in order to take into account the impact of particle size. Every experiment was run twice to guarantee the validity of the results.[60]

Total Polyphenol Content

The Folin-Ciocalteu technique was used to determine the extracts' total polyphenol content. Specifically, 1 ml of the Folin-Ciocalteu reagent solution—which had been diluted at a ratio of 1:10 with deionized water—was mixed with 0.2 ml of the extract. After 4 minutes, a 75 mg/ml sodium carbonate aqueous solution (in 0.8 ml) was introduced. Following that, the mixture was incubated for a period of two hours at room temperature. A UV-vis spectrophotometer (Analytik Jena AG, Germany) was then used to detect the absorbance at 765 nm. Results were expressed in milligrams of gallic acid equivalent per ginger gram.

Advantages of SWE

1. Subcritical water is an environmentally friendly extraction method for a range of organic species.
2. As temperature rises, polarity might drop significantly.
3. Subcritical water might act like methanol or ethanol.

Disadvantages of SWE

1. Some thermolabile analytes thermally degrade at high temperatures.
2. Water has the potential to become exceedingly reactive and oxidize or catalyze the hydrolysis of some substances when it is exposed to extremely high temperatures and pressures.

RESULT

Sr. No	Green Extraction Techniques	Conventional Extraction Techniques	Herb	Chemical constituents	% yield of green extraction techniques
1)	Supercritical fluid extraction	Decoction / soxlet extraction	Papaya	Alkaloid, phenol, flavonoid	0.0806%
2)	Microwaveassisted extraction	Solvent extraction	Cinnamomum iners	Essential oil	0.12 %
3)	Ultrasound assisted	Maceration	Moringa	Phenolic,	0.0466%

	extraction		oleifera leaves	flavonoid	
4)	Negative pressure cavitation extraction	Maceration	Catharanthus roseus	Vindoline, catharanthine	0.57%
5)	Subcritical water extraction	Steam distillation /solvent extraction/soxlet	Zingiber officinale roscoe	Gingerols	5%

CONCLUSION

Supercritical fluid extraction makes it possible to efficiently and sustainably extract bioactive substances from waste and by-products in the food sector, as well as from sustainable source materials. using microwave-assisted extraction to separate the essential oil from the leaves of Cinnamomum iners. The benefits of employing microwave radiation as a heat source to isolate essential oils are. With microwave irradiation, the extraction process takes much less time and yields an equivalent amount of oil. The essential oil extracted from the leaves of C. iners was found to be high in linalool, with a content of between 30 and 50 percent. In comparison with maceration, ultrasound-assisted extraction produced a higher yield of bioactive chemicals in less time and with less energy. As such, it is a technique that benefits the food and pharmaceutical sectors. VDL, CTR, VCR, and VLB were initially extracted from C. roseus leaves using negative pressure cavitation extraction (NPCE), and the results were contrasted with those of other traditional extraction methods. The findings suggest that the vinca alkaloid production process can be expedited, made ecologically friendly, and simplified via Negative Pressure Cavitation Extraction (NPCE). As such, this method is a great substitute for identifying and measuring the four primary Cs. The use of subcritical water as the extraction medium for separating gingerol from ginger rhizomes has been demonstrated as a superior technique, yielding high gingerol content, both in pilot- and industrial-scale applications.

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