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A Comparative Study on Conventional and Advance Techniques for Plant Extraction and Effect on the Extract Yield

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Abstract

Medicinal plants are bringing so much attention from the researchers, nutritionists and consumers due to their potent nutritional value and ethno-medicinal properties. Extraction plays a critical role to study the medicinal properties of plants, herbs and spices. The present review was conducted to elaborate the advance method of extraction with small use of solvent and better yields of extract in short time duration. Nowadays purity is a major concern for the researcher to evaluate effective analysis. To obtain the phytochemicals from the plant majorly depends on the extraction procedure. Inappropriate extraction may cause loss in quantitative phyto-components. Advance methods like Microwave Assisted Extraction (MAE), Accelerated Solvent Extraction (ASE), Solvent Phase Extraction (SPE) and Ultrasound Assisted Extraction (UAE) are studied on compare with conventional methods on the basis of yield, efficacy and purity of extracts. In this review, advance extraction techniques have briefly discuss based on their strength to obtain high yields and better purity of extract to assess the economical attainability of these methods and further used in chemical, biological and pharmaceutical analysis.

Keywords: Accelerated solvent extraction, Conventional methods, Medicinal plants, Soxhlet extraction, Ultrasound assisted extraction

1. Introduction

Medicinal plants are naturally obtained plant products which are used since ancient era to cure the specific diseases (Goswami and Chatterjee, 2014). Being a large source of therapeutic phytochemicals, medicinal plants are strongly in demand in pharmaceutical industries to the development of novel drugs (Venugopal and Liu, 2012). The urge to use natural products in the skin benefits as an alternative to conventional medications and synthetic products is leading an interest in medicinal plant research and industrial purpose for their formulation (Mukherjee et al., 2011). The purpose of extracting phenolic compounds from their plant sources is to liberate them from the vascular structures where they are found, either through rupturing plant tissue or through a diffusion process (Crozier, 2003). Nowadays consumers preferably demanding natural ingredients based products instead of artificial one because organic products are safe, reliable and eco-friendly. Manufacturers are incorporating green and organic compounds in their products to attain the

attention of consumers. Natural compounds are progressively searched by researchers to replace the synthesized compounds. Plants are the major sources of natural compounds on earth. Alkaloids, phenols, flavonoids, essential oil and polysaccharides are the active compounds that plants produce depends on their environmental growth. Such bioactive compounds have been used in the pharmaceutical, nutraceutical, cosmetic, and food processing and pesticide industries (Mykhailenko et al., 2019; Hosseini et al., 2018; Mohd-Setapar, 2018; Saucedo-Pompa et al., 2018; Nandhini et al., 2013).

To obtain bioactive constituents from plant materials conventional method of extraction are based on Solid Liquid Extraction (SLE) technique. Maceration, soxhlet extraction and hydro-distillation are some commonly used extraction methods. Although conventional methods of extraction are reliable to use, they are frequently under criticize for excess amount of solvent consumption and take a time for the extraction (Idham et al.,2017). Extracts obtained by different extraction procedures probably possess different composition and properties (Abuduwaili et al., 2019).

Therefore, to obtain desired extract, extraction techniques must be chosen carefully. Optimization of extraction parameters should be conducted to enhance extraction efficacy, reduce solvent and energy consumption (Chemat et al., 2019; Perino and Chemat, 2019). Afterwards, plant by products from food processing unit used as a starting materials might be helpful to enhance the sustainability in extraction process (Barreira et al., 2019; Andrade et al., 2019).

This review emphasized the comparative study in conventional and recent advancement in numerous extraction techniques acquire bioactive components from plant and effect in the extract yield.

2. Pre-treatment method of plants

2.1 Grounding of sample

Before extraction, pre-treatment methods are used to prepare samples for the extraction by washing, drying and grinding of the plant material. To obtain active constituents from plant materials, extraction often involves soak the material in solvent for a certain time period. Now, extracts are kept for further processing. Extraction involves separation of medicinally active part of plants using selective solvents through standard methods (Handa, 2008). The main aim of extraction is to separate the soluble plant metabolites, leaving behind the insoluble residue. To make the extraction efficient, solvent must have contact with the target analytes and particle size 0.5 mm is ideal for efficient extraction (MOA, 2013).

2.2 Drying methods of plant

Sample takes usually 3-4 months for air drying, and it depends on which part of plant are used fruits, leaves and bark. In the air drying method, heat labile components of plant are maintained. However, this method takes long time to dry in comparison to other methods and is more vulnerable to contamination at unstable temperature condition. Oven-drying method consumes thermal energy to get rid of moisture content from the sample. This method is considered as finest and fast thermal process for preserving phytochemicals. The maximum antioxidant activity was reported in *Cosmos caudatus* after oven-drying at 44.5 °C upto 4 hours using 80% methanol, and in optimum 80% methanol extracts at 44.12 °C (Mediani et al., 2013). This method takes a short time period to complete the extraction. Oven drying at 65 °C temperature leads to increase in total phenolic content of sage plants (0.66 mg of GAE/g of DM) (Hamrouni-Sellami et al., 2013).

Microwave drying technique uses electromagnetic radiation. The electric field generates simultaneous heating via dipolar

rotation; alignment towards the electric field of the molecules exhibiting an induced dipole moment which creates oscillation of the molecules (Kaufman and Christen, 2002). Oscillations vigorously generate collision between molecules and resulting in rapid heating of the samples. This drying method can take lesser time but may be caused damage in phytoconstituent present in the sample.

Freeze drying method is based on the sublimation process. Plant samples are freeze-dried (lyophilized) for analysis. There is a presumption that freeze-drying is better to other preservation techniques and effectively retains the therapeutic properties of plants (Abascal et al., 2005).

2.3 Extraction methods

Extraction is the separation of medicinally active components using various solvents from the plant sample followed by different procedures (Handa, 2008). Extraction method should be reliable, cost effective, environmentally friendly and with high yield value. The objective of extraction methods is to separate out the active components leaving behind the residue. Various extraction methods for the plants are presented in Fig. 1 and discussed below.

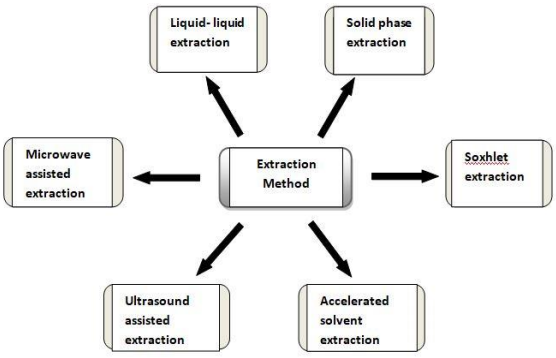

Figure 1. Extraction methods for plants

2.3.1 Liquid-liquid extraction

This method is particularly used to extract two immiscible liquid on the basis of their respective solubility presented in Fig. 2. Opium alkaloid was extracted using liquid–liquid extraction process (Yoshimatsu and Shimomura, 1992) with a small modification. Capsule powder sample (ca. 50 mg) was extracted with 5 ml acetic acid (5%) via sonication and further allows mixing in vortex mixer. Then, filter the sample and 3 ml of it washed with chloroform (3 ml). Using 28% ammonia, the aqueous phase made alkaline and extracted with chloroform and isopropanol mixture (3:1) up to three times (2ml, 1ml and 1 ml). The organic-base extract was concentrated to dry under nitrogen stream, and the residue obtained was dissolved in an accurate volume of 50% methanol and examined by HPLC. The chloroform solvent phase employed to wash 5% acetic acid extract, was recover, concentrated and dissolved in an appropriate volume of 50% methanol and similarly can be evaluated by HPLC.

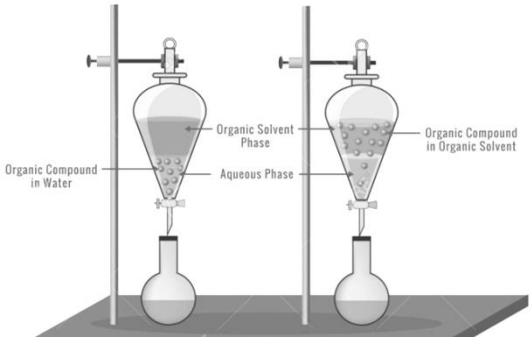

Figure 2. Liquid-liquid extraction

2.3.2 Solid-phase extraction (SPE)

SPE is a fast, selective procedure commonly used in analytical labs for the analyte extraction. Schematic diagram for SPE extraction in fig 3. A reversed-phase solid-phase extraction was used for SPE extraction. A plant sample (ca. 50 mg) was extracted with 5 ml of solvent (5% acetic acid, 0.1 M sodium citrate buffer of pH 6.0, water) and allowed to sonicate for 30 min. After mixing in vortex mixer (1 min) and centrifugation (18000g, 10 min), 3 ml of the supernatant was purified by SPE extraction cartridge according to the protocols (Waters, 2001). In

the detailed, SPE extraction cartridges were procured in methanol (3 ml) and then equilibrated in water (3 ml). In solid-phase extraction cartridge, 3 ml of crude extract was loaded and then cartridge washed with washing solvent (3 ml). The alkaloids were eluted with elution solvent twice (E1, 2 ml; E2, 1 ml) and each elute was concentrated to dry in nitrogen stream, dissolved in volume of 50% methanol and estimated by HPLC (Yoshimatsu, 2005).

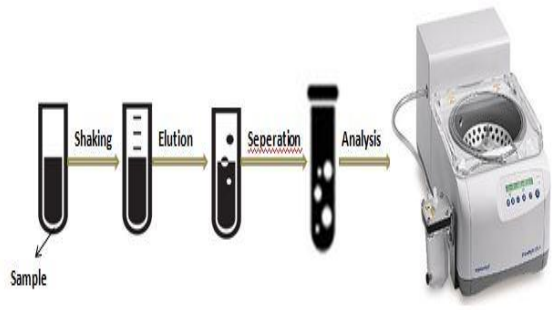

Figure 3. SPE extraction process

2.3.3 Maceration, infusion, decoction, percolation & soxhlet extraction

In maceration, coarse powdered plant sample is kept with the desired solvent in a stopper container for a definite time period and frequent stirring till the soluble component is dissolved. This is the best method to heat sensitive components present in plants (Anonymus, 1966). Infusion and decoction method follows the theory similar to maceration; both are allowed to immerse in the cold or boiled water. Boiling process might be damage heat sensitive component present in the extract. However, the sample is boiled in a certain amount of water for a specific amount of time for decoction, while the maceration process for infusion process is shorter [16]. In percolation method, a unique instrument percolator is used. Dry powder sample added with boiling water is enclosed in percolator and allow to the macerate up to 2 hours. In order to get concentrated extract, the percolation method is often carried out at a moderate rate (e.g. 6 drops/min) till the extraction is complete (Rathi et al., 2006). In soxhlet extraction, powdered sample is taken in thimble and solvent used for extraction is heated in the bottom flask, vaporizes into sample thimble, condenser to condense and drip back. When the liquid content reaches to siphon arm, it evacuated into bottom flask again and process continued. This extraction method required a small amount of solvent (Handa, 2008).

2.3.4 Microwave assisted extraction (MAE)

This method of extraction used electromagnetic radiations that carry plenty of energy presented in Fig 4. Plant sample in microwaves system are heated themselves through conventional heating method as opposed to heating from outside. Microwave heating may damage the plant cell wall and liberate active components for effective extraction. Previous studies reported that MAE method provides better yields of extracts and significantly higher than the conventional method for the extraction of active components (Citadin et al., 2016; Li et al., 2011; Patil and Akamanchi, 2017). The active compounds from *Eucalyptus globulus* have been extracted using MAE, UAE and EAE methods and it was observed that similar components obtained from the extracts. After testing the above-mentioned extraction methods the researchers suggested MAE methods because it has significant lower specific energy consumption (Gullon et al., 2019). MAE is the fastest method and consumes less solvent compared to UAE, SFE and maceration methods of extraction for active compounds. MAE extraction method gives a satisfactory extraction yield (Odabas and Koca, 2016).Aqueous alcohol used as a solvent in MAE extraction, provide an appropriate solvent polarity to extract the bioactive components from lime peel (Rodsamran and Sothornvit, 2019). Triterpene from *Centella asiatica* extracted using MAE demonstrated an increasing yield twice of soxhlet extraction and absolute alcohol is used as a solvent at 75˚C and

irradiation power consumption of 600 W (Puttarak and Panichayupakaranant, 2013). In MAE, *Dioscorea hisptida* yields were highest using 85% ethanol at sample solvent ratios (1:12.5) (Kumoro and Hartati, 2015).

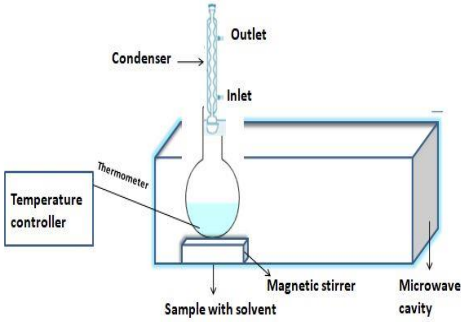

Figure 4. MAE extraction method

2.3.5 Ultrasound- assisted extraction (UAE)

UAE method use cavitations caused by ultrasound range 20 kHz to 2000 kHz and solvents to increase the extraction of active compounds (Handa, 2008). Schematic diagram for UAE extraction process presented in Fig. 5. The mechanic effect of ultrasound increases the surface contact between sample and solvent. The active phytochemicals may affect through formation of free radicals in more than 20 kHz of ultrasound. UAE is the best extraction method than other conventional methods to extract the *Elsholtzia ciliate* (Pudziuvelyte et al., 2018).

In order to shorten the extraction time and restrict exposure to high temperatures, UAE method was used in the extraction of thermolabile components, such as anthocyanin, from flower parts (Dhanani et al., 2017). *Withania somnifera* possess maximum extract yield in aqueous solvent (11.85%), compare to ethanol and aqueous ethanol solvent using UAE extraction method. It is reported that UAE extraction provide prominent extract yield as compared to MAE and SFE (Odabas and Koca, 2016; Kozioł et al., 2019; Rodsamran and Sothornvit, 2019).

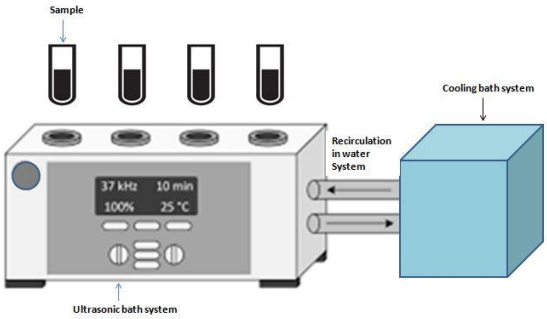

Figure 5. UAE extraction process

2.3.6 Accelerated solvent extraction

Accelerated solvent extraction process is an alternative of traditional method of extraction shown in Fig. 6. ASE takes advantages of magnified solubility that arise with increase in temperature of liquid solvent. On increasing temperature, viscosity of solvent decreased which allows easiest pass out of solvent matrix. Furthermore, analyte diffusion from sample matrix into solvent has been increased. In this way ASE method, gives similar yield of extract as obtained by solvent based extraction technique. Small consumption of solvent and short extraction time made this technique more efficient to use (Luthria et al., 2019). ASE method was observed the best for extraction of polycyclic aromatic hydrocarbons (PAH) (Wang et al., 2007).

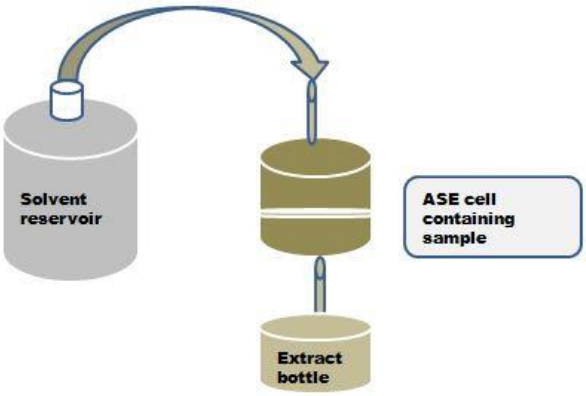

Figure 6. ASE extraction process

3. Discussion

Study on medicinal plants is the traditional approach to researchers and scientists via extraction of plants to analyze the chemical

components and further used in medication and ailment purpose. Nowadays various extraction techniques are in use than the conventional methods due to lack of time and solvent consumption in the extraction. Some extraction process of plant material is presented in Table 1.

Table 1. Different methods of extraction from plant material

Plant material	Analyte	Extraction method	Reference
Centella asiatica	Triterpene extract	Absolute alcohol solvent used for MAE	[33]
Dioscorea hisptida	Extract	Ethanol used as solvent with MAE	[34]
Elsholtzia ciliate	Plant extract	UAE	[35]
Flower part	Thermolabile component	UAE	[36]
Withania somnifera	Plant extract	Aqueous solvent using UAE	[37]
Plant part	Sample matrix	ASE	[41]
Plant part	polycyclic aromatic hydrocarbons	ASE	[42]
Plant part	Extraction of alkanes and LCOHs	ASE	[46]

This article demonstrated the comparable study of conventional methods with advance techniques is presented in Table 2.

Table 2. A comparative study on extraction process and their yield

Plant material	Extract	Extraction Process	Extract yield	Ref.
Vernonia cinerea	Leaves extract	SE	10.01%	[44]
Sapindus mukkorosi	Oil extract	MAE SE	40.12% 40.63%	[45]
Vegetable (celery, lettuce)	Extraction –recovery	QuEChERS ASE	70.2-133.5% 70.1-118.6%	[46]
Oleuropein	Plant extract	SE SFE	3.78% 1.43%	[49]
Cannabis sativa	Plant extract	SPE SFE	91.1% 36.18-37.85%	[50]

Since ancient time, plants are best alternative for the ailment purpose has no adverse reaction in the health. Biological efficacy is widely depends on the phytochemicals observed in the plant extract. Extract yield can varies with primary process of extract preparation, solvent ratio and parts of plant used for the extraction. Soxhlet extraction method is one of the traditional procedure for the extraction. Soxhlet extraction of *Vernonia cinerea* leaves provide yield of (10.01±0.85% w/w) of extract (Alara et al. ,2018). The previous study depicts that essential oil yield in *Sapindus mukkorosi* was 40.12% and 40.63% via MAE and SE methods, respectively (Hu et al., 2021).

The extraction of pharmaceuticals from plants was done by QuEChERS method was comparable to ASE method. QuEChERS method performed in short time with less amount of solvent is used. This method is quite efficient to obtain pharmaceuticals in vegetables and safe for the agricultural produce used by humans (Chuang et al., 2015). A single step ASE method was efficient in extraction of alkanes and LCOH's from plants using less amount of solvent in significant time (Carnahan et al., 2013). The soxhlet method of extraction was effective to extract phenolic compounds from plants. MAE and UAE extraction techniques are found good to extract antibacterial components from plant material (Kothari et al., 2012).

Oleuropein yield was found in soxhlet extraction method was 37.8 mg/g dried leaf whereas, the better yield was observed in SFE method was 14.26 mg/g dried leaf (Sahin et al., 2011). By using a single SPE step, a final fraction with 91.1% of THC was obtained and in SFE, the highest content was 37.85% and 36.18% at 33 MPa and 15 MPa, respectively (Gallo-Molina et al., 2019). Literature survey revealed that tetrahydrocannabinol (THC) from *Cannabis sativa* L. using solid phase extraction process yields superior amount of extract. ASE method is the efficient way to extract vegetable (celery, lettuce) with prominent extract yield.

Conclusion

Extraction plays a key role to study the presence of phytochemicals in herbal plants. Pre-extraction process like drying and grinding eventually have an effect on the chemical constituent of sample and finally in the extract of plant sample. This study concluded that each method of extraction has their significant results either in terms of yield or the solvent required for the extraction. Soxhlet method is the traditional method having a good yield of extract consumes a lot of solvent and gives purity of extract. UAE, SPE, SFE and ASE methods are quite promising with respect to solvent consumption and yield of extract. Overall study depicts that ASE and SPE method could be better suggest for the extraction on the basis of efficiency, quality, purity, reproducibility, economically and yield efficacy of extract. The new bioactive components will come in force continually to explore ingenious extraction methods to get meritorious extract yield from the whole plant.

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Author contribution

Dr. Nisha Mehra involved in design, conceptualize, data curation, writing, review, editing and drafting the manuscript.

Conflicts of interest

The author declares no potential conflict of interest.

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