CHAPTER

2 Extraction techniques

Saqib Farooq[1], Shabir Ahmad Mir[2], Manzoor Ahmad Shah[3] and Annamalai Manickavasagan[4]

[1]Department of Food Technology, Islamic University of Science and Technology, Awantipora, India [2]Department of Food Science & Technology, Govt. College for Women, Srinagar, India [3]Department of Food Science & Technology, Govt. Degree College for Women, Anantnag, India [4]School of Engineering, College of Engineering and Physical Sciences, University of Guelph, Guelph, ON, Canada

2.1 Introduction

Extraction is one of the important operations for obtaining the target compounds from different types of plant materials. This is the first step for separating the compounds from the plant matrix. The extraction from plant materials can be achieved by different methods based on the nature and quantity of compounds to be extracted, and each approach has its own merits and demerits (Table 2.1). The main aim of selecting the method is to maximize the extraction yield of plant compounds without modifying or contaminating its original form. The efficiency and yield of the extraction procedure depend on various factors such as diversification of bioactive compounds, type of extraction procedure, concentration of solvent, time, and temperature. Different protocols and standards have been developed by the researchers and industries as per the type of plant material to enhance its yield and functional properties.

There are three approaches of extraction depending on the phase of the mixture and the extraction agent. In solid—liquid extraction, solvent extracts as solute from the solid phase. In liquid—liquid extraction, the solvent extracts solute from the liquid phase. Third approach is the supercritical extraction, where a fluid under supercritical conditions is used as the solvent. The conventional methods like maceration and soxhlet extraction have been used since ancient times and are still most commonly used for the extraction of different compounds from plant materials mainly based on their simplicity and moderate operating cost. The majority of conventional methods is based on the extraction efficiency of different solvents, homogenization and thermal factors. However, conventional methods have certain disadvantages such as low extraction yield and selectivity, long extraction procedure, and degradation of heat liable plant compounds. New techniques or assisting procedures are continuously being developed to overcome the limitations of traditional methods for the extraction of plant compounds. The assisting methods such as microwaves, ultrasound, pressurized liquid, pulsed electric field, supercritical fluid and enzymes have gained popularity for the extraction of plant extracts due to less use of chemicals, good yield and eco-friendly nature. Furthermore, new techniques minimize the degradation of plant compounds and also eliminate the undesirable components from the extract.

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Table 2.1 Advantage and disadvantages of various extraction methods.

Extraction method	Advantages	Disadvantages
Soxhlet	• Simple operation procedure • Low cost technique • Efficient recovery of extract	• Time consuming • Requires large quantity of solvent
Maceration	• Simple extraction method • Inexpensive technique	• Time consuming process • Low extraction yield • Usage of large amount of solvent
Supercritical fluid	• Short extraction time • Suitable for heat sensitive compounds • Low viscosity and higher diffusion coefficient • Eco-friendly	• Not suitable for extraction of polar molecules
Pressurized liquid	• Reduces solvent consumption and extraction time • Eco-friendly	•Decreased selectivity
Pulsed electric field	• Suitable for large volume of samples • Short extraction time • High yield • Facilitation of purified extract	•Process parameter are required to be maintained critically
Ultrasound assisted	• Short processing time • Less chemical usage • Less power and energy consumption • Higher yield	• Extraction yield depends on optimized process parameters
Microwave assisted	• Less extraction time • Higher extraction yield • High selectivity of desired extracts	• Less eco-friendly due to use of organic solvents • Equipments are costly • Poor extraction yield for nonpolar compounds • Unsuitable for heat liable compounds
Enzyme assisted	• Eco-friendly • High extraction rate • Suitable for bound compounds • High selectivity of desired extracts	• High enzyme cost • Not suitable at industrial level • Difficult to maintain suitable conditions during extraction

2.2 Extraction methods

Several methods are applied for the preparation of extracts from various types of plant sources (Fig. 2.1). The selection of suitable procedure is very important for the maximum yield or extraction with high phytochemical quality. Solvent has primary importance for the extraction of compounds irrespective of the method of extraction. The chemical nature of solvent favor the compound solubility, selectivity and extraction yield. The solvent interacts with the compounds depends on its chemical properties and the knowledge of the chemical behavior of the solvent are the basis for selection of solvent for efficient results. Several studies have focused on the selectivity of different solvents for the extraction of targeted compounds. Numerous technologies have been implemented in food industry to enhance the extraction capacity of plant compounds (Farooq et al., 2020).

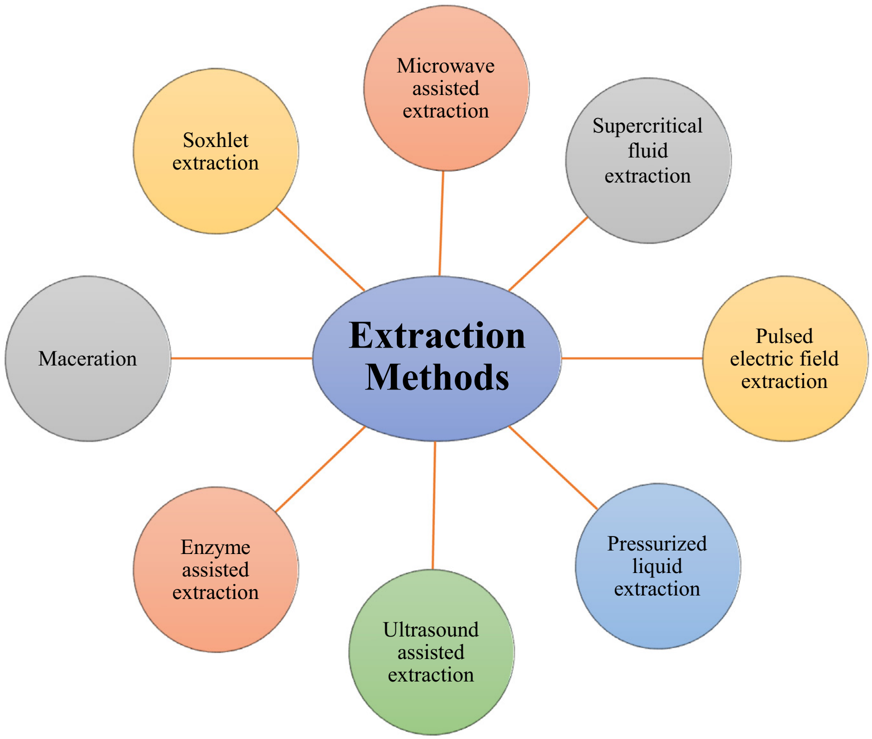

FIGURE 2.1

Extraction methods from plant material.

The development of new methods with considerable advantages over traditional methods for the extraction from the plant material plays an important role in ensuring the availability of high-quality extracts for different applications in food industry.

2.2.1 Maceration

Maceration is one of the simplest extraction techniques in which coarse and powdered plant material is soaked in solvents such as methanol, ethanol, ethyl acetate, acetone, hexane etc. It is one of the popular and inexpensive techniques used for the extraction of different bioactive compounds from plant material. However, maceration procedure has certain limitations such as low extraction yield, lower efficiency and use of large amount of solvents which have some health hazards. Furthermore, the selection of appropriate solvent is important along the methodology for the extraction of particular plant extract. Maceration process consists of grinding of plant material into smaller particles to increase the surface area for easy mixing with solvent and efficient extraction of compounds. Then this mixture of plant material and solvent is kept for longer time, agitated at different intervals and filtered through a filtration medium. The efficiency for the removal of bioactive compounds from the plant material depends on the type of solvent and type of plant material. The polarity of solvent is the important parameter affecting the extraction efficiency. In this method different solvents and time-temperature combinations are used for efficient extraction. Maceration raptures the cell structure and expose the chemical constituents to react with the solvent and helps in removal of different plant components. This method is extensively used for the exaction of different types of bioactive compounds at laboratory scale. Maceration as one of the simplest method was used for obtaining the *Papaver rhoeas* L. flower extracts (Marsoul, Ijjaali, Oumous, Bennani, & Boukir, 2020), *Morus* leaf extracts (Radojković et al., 2016), kinnow peel extract (Safdar et al., 2017) and chokeberry fruit extract (Ćujić et al., 2016). This technique can be operated at both small and large scale and finds application at an industrial scale.

2.2.2 Soxhlet extraction method

Soxhlet extraction is a widely used method for the extraction of different compounds from plant material. The popularity of soxhlet method is due to its simple operation procedure, low processing cost, efficient recovery of extracts, suitable for bulk extraction, and consumes less time as compared to other conventional methods. In this method, powdered sample is placed in a thimble that is positioned in a soxhlet extractor (Fig. 2.2). The solvent of particular interest such as petroleum ether, hexane etc. is placed in distillation flask which is heated by heating mantle and its vapors are condensed by the reflux condenser. The condensed solvent drips into the thimble containing the sample and extracts the bioactive compounds by contact. When the level of the solvent reached to an overflow level, the solvent of the thimble holder (extractor) is aspirated by a siphon and unloads the solvent back into the distillation flask. This method is still used as a reference method to compare the success of new extraction method. Alara, Abdurahman, and Ukaegbu (2018) reported that efficiency of soxhlet extraction depends on various factors including extraction time, solvent

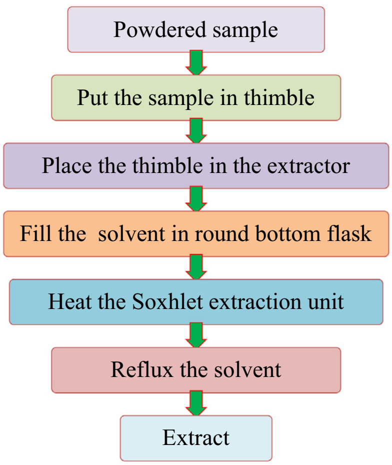

FIGURE 2.2

Flow diagram of Soxhlet extraction method.

concentration and feed to solvent ratio. The soxhlet extraction has been reported as an excellent method for extraction of polyphenols, antioxidants and antimicrobials from *P. rhoeas* flower (Marsoul et al., 2020). Karabegović et al. (2014) reported that soxhlet extraction facilitates the highest extractive yield from cherry laurel leaf and fruit. Soxhlet extraction also showed better performance for the extraction of phenolic compounds from olive leaves (Lama-Muñoz et al., 2020).

2.2.3 Supercritical carbon dioxide extraction

Supercritical carbon dioxide is a state of carbon dioxide at a temperature and pressure above its critical point where distinct liquid and gas phases do not exist (Fig. 2.3). The critical point of carbon dioxide is easily accessible and allowing the fluid to be used at low temperature without leaving the harmful organic residues. The fundamental concept behind the supercritical CO_2 extraction strategy is to replace the conventional organic solvents with a supercritical fluid solvent (Fig. 2.4). Compared to other extraction techniques, supercritical fluid extraction prevents sample oxidation, requires less extraction time, uses nontoxic solvents and is also safe. Supercritical fluid extraction is very effective and efficient technique for extraction of different bioactive compounds from plant material. This technique extracts the compounds near to ambient temperature, thus preventing the degradation of heat liable plant material. There are several solvents such as CO_2, benzene, hexane, pentene, butane, toluene, ethanol, ammonia and nitrous oxide, which can be used as supercritical fluid. However, carbon dioxide is commonly used fluid in supercritical fluid extraction technology. Carbon dioxide is nontoxic, cheap, and chemically stable and absorb a wide variety of organic compounds under supercritical conditions. Being a "green" process, supercritical fluid extraction presents an alternative technology to replace the organic solvents.

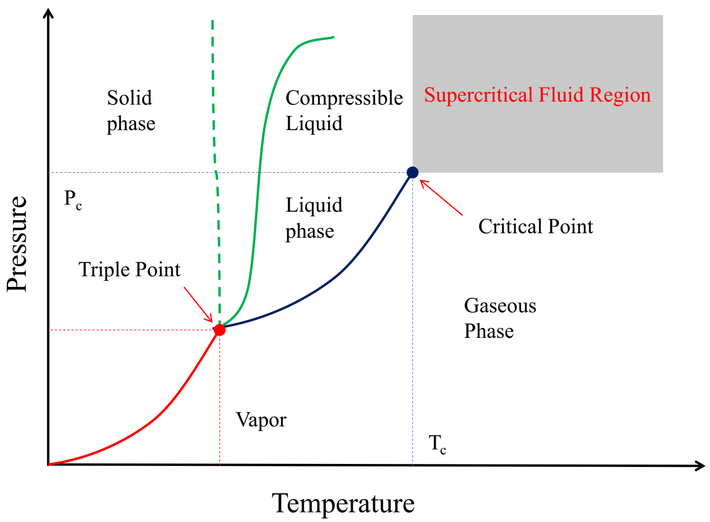

FIGURE 2.3

Phase diagram of a supercritical fluid.

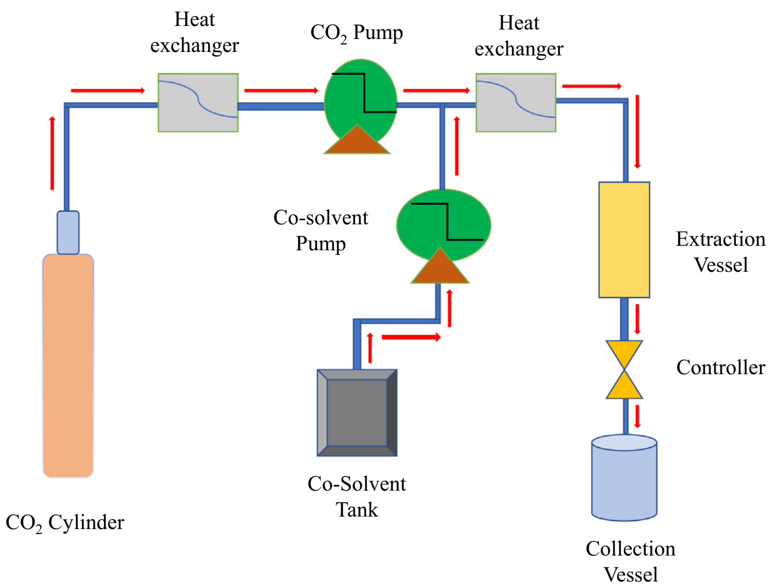

FIGURE 2.4

Schematic representation of supercritical CO_2 equipment.

Supercritical fluid extraction is one of the effective techniques for maximizing the extraction of phenolic compounds and flavonoids with high quality and efficiency. Different process parameters such as temperature, pressure, and solvent or co-solvent flow rate are involved in supercritical fluid extraction. Researchers have optimized the process parameters according to the type of plant material to improve the extraction percentage and selectivity of the recovered compound. Extraction of bioactive compounds from radish leaves were obtained by using supercritical CO_2 (Goyeneche, Fanovich, Rodrigues, Nicolao, & Di Scala, 2018). This technique efficiently extracted the bioactive compounds especially phenolic compounds and flavonoids. The maximum yield was observed at 400 bar and temperature of 40°C. Zhang et al. (2020) reported that supercritical CO_2 extraction was efficient and produced higher yield as compared to the methanol extraction method for extraction of plant compounds form cherry leaf.

Supercritical CO_2 has a high solvent strength because of its high density, which in turn increases its dielectric constant. As a result, this thick gas has the ability to dissolve a wide range of organic solutes, primarily nonpolar ones. The strong diffusivity of supercritical CO_2 together with its conveniently configurable solvent power is it's another advantage. At room temperature and pressure, CO_2 is gaseous in nature which makes the extraction of analytes easy and allowing for solvent-free analytes (Herrero, Mendiola, Cifuentes, & Ibáñez, 2010). Supercritical CO_2 is a special kind of extraction solvent. By changing the pressure and temperature, the solvent properties can be modified according to the protocol. It is sensitive to pressure and temperature changes owing to its compressibility. Density varies with pressure and temperature. It increases with increasing pressure and decreases with increasing temperature. The relationships with the compounds, and therefore their extraction can be altered as a result of density changes. A co-solvent, also known as a modifier, may be applied to increase the potential and selectivity of extraction by attenuating the polarity of supercritical CO_2. The polarity of the extracting solvent can be increased by applying an alcoholic modifier like ethanol to CO_2. Co-solvent can be safely extracted after processing. Modifying the characteristics of supercritical CO_2 using temperature, pressure, and co-solvents is a crucial step in achieving extraction selectivity (Lefebvre, Destandau, & Lesellier, 2020).

2.3 Microwave-assisted extraction

Conventional extraction methods such as organic solvent extraction and soxhlet extraction uses significant energy, time consuming, and pollutes the environment with toxic solvents. Microwave-assisted extraction employs an ecologically sound solvent and takes less energy while lowering the time of extraction. The extraction time and solvent volume are also reduced by using this extraction technique. Nonionizing electromagnetic waves are used in microwave-assisted extraction to extract bioactive chemicals from plant matrixes. Furthermore, microwave-assisted extraction allows for more efficient and selective transfer heating (without heat transfers), reducing temperature gradients, and may take use of different types of solvents to expand the extractions polarity range, boosting the variety and volume of extracted compounds (Esquivel-Hernández et al., 2016).

Microwaves heat molecules by a combination of ionic conduction and dipole rotation. The heating of substances is caused by both ionic conduction and dipole rotation. The minute microscopic residues of moisture that exist in plant cells are the focus for heating in plant material. The microwave action heats up the moisture inside the plant cell, causing evaporation and creating immense pressure on the cell wall. Because of pressure, the cell wall is forced from within and ruptures. As a result, bioactive components are expelled from the burst cells, facilitates the production of phytochemical compounds. Most microwave-assisted extraction techniques use solvents with a high dielectric constant and the ability to absorb a large amount of microwave energy. However, solvent combinations may be used to alter extraction selectivity and the medium's propensity to interact with microwaves. Polar molecules with a high dielectric constant such as water and ethanol may absorb and re-emit this energy, causing the system to heat up, but solvents with a low dielectric constant, such as hexane are insensitive to microwaves (Lefebvre et al., 2020). The addition of water to the solvent results in higher extraction yields. For the extraction of phenolic compounds, microwave transparent solvents such as acetone found to be the most effective (Proestos & Komaitis, 2008). Temperature is the most important parameter in microwave-assisted extraction. The temperature may be adjusted by varying the duration and power of the irradiation (Lefebvre et al., 2020).

Microwave-assisted extraction is a fine choice to get extracts under moderate circumstances. When applied to plant materials, microwaves produce little or no quality degradation, whereas moist heat causes quality degradation (Gupta, Naraniwal, & Kothari, 2012). Plant extracts with potential antibacterial and antioxidant properties have been prepared by microwave-assisted extraction. Microwave assisted extraction showed the most efficient technology for obtaining higher yields of polar and nonpolar bioactive compounds from elder bark and annatto seeds (Bachtler & Bart, 2021).

Microwave assisted extraction technique has been proven efficient and fast extraction method for the extraction of phytochemical compounds from *Ficus racemosa* (Sharma, Kumar, Kumar, & Panesar, 2020). Microwave extraction was an effective technology for obtaining the extracts with high antioxidant potential from avocado peels (Araujo et al., 2021).

Phenolic compounds in peanut skins were extracted using a microwave extraction technique. Under optimal conditions (90% microwave power, 30 s of irradiation duration, and 1.5 g skins), the maximum estimated total phenolic content was 143.6 mg gallic acid equivalent/g skins (Ballard, Mallikarjunan, Zhou, & O'Keefe, 2010). Microwave extraction of phenols such as chlorogenic acids from beans of green coffee was shown to be a viable alternative to standard procedures, and the extracted extracts had excellent radical scavenging activity (Upadhyay, Ramalakshmi, & Rao, 2012).

The extraction of antioxidants from potato peels at the methanol concentration of 67%, extraction period of 15 min, and a microwave power level of 14.67% leads to the production of maximum total phenolics content. The highest levels of caffeic acid, and ferulic acid were achieved at a methanol concentration of 100%, an extraction duration of 15 min, and a microwave power level of 10%. The optimal antioxidant activity was reached at a methanol concentration of 100%, an extraction period of 5 min, and a microwave power level of 10% (Singh et al., 2011). Several studies have been published comparing microwave-assisted extraction to traditional extraction procedures. The extraction of capsaicinoids from peppers, using traditional stirring extraction took 15 min to achieve the extractions of 95% of the capsaicinoids, while as microwave extraction achieved this percentage in 5 min (Barbero, Palma, & Barroso, 2006). Microwave extraction of antioxidants from the exotic *Gordonia axillaris* fruit was studied by Li et al. (2017). The best results were obtained with an ethanol concentration of 36.89%, a solvent/material ratio of 29.56 mL/g, extraction duration of 71.04 min, a temperature of 40°C, and a microwave power of 400 W. Furthermore, the microwave-assisted extraction approach was compared with traditional extraction techniques including soxhlet extraction and maceration. The antioxidant capacity of the microwave-assisted extract was higher than that produced by maceration and soxhlet techniques.

2.4 Pressurized liquid extraction

Pressurized liquid extraction method, also referred as accelerated solvent extraction, is regarded as an environmentally friendly extraction process for the extraction of bioactive compounds from plant sources (Alvarez-Rivera, Bueno, Ballesteros-Vivas, Mendiola, & Ibañez, 2020). This technique reduces the solvent consumption and extraction time, with increased efficiency and analyte recovery precision compared to other methods. Pressurized liquid extraction can be viewed as an extension of supercritical fluid extraction, utilizing organic solvents instead of CO_2. This technique holds solvents near their supercritical region where solvents have elevated extraction properties, while remaining in a liquid state. Pressurized liquid extraction parameters include extraction temperatures (25°C−200°C), pressure (500−3000 psi), solvents (organic to weak acids), number of extraction cycles, duration of static cycles and rinse volume.

This method uses pressure to raise the temperature of the extraction solvent beyond its boiling point. As this method achieves higher temperatures than traditional extraction methods, it leads to higher extraction performance. Higher temperatures result in increased solvent solubility potential, decreased viscosity, improved solvent penetration into plant cells and decreased solute matrix interactions. These effects increases the extraction yield, however results in a decrease in selectivity. Temperature is the primary optimizing parameter during the pressurized liquid extraction as it critically affects the extraction capacity. Depending on the chemical structure of the compounds, temperature may affect their selective extraction in a positive or negative way. Furthermore, even when pressure allows for temperatures higher than the boiling point of the solvent, it is not necessary to use excessive heat for the extraction (Lefebvre et al., 2020). Pressurized liquid extraction promoted the largest recovery of valuable compounds from beetroot leaves and stem (Lasta et al., 2019). The technique provided the higher extraction yield, phenolic content and antioxidant activity than soxhlet and ultrasound assisted extraction.

An optimization analysis was carried out with ethanol as the solvent and independent variables of extraction pressure (5−10 MPa), temperature (313K−393K), and static extraction time (3−15 min) for the extraction of anthocyanins and other phenolic compounds from jabuticaba skins (Santos, Veggi, & Meireles, 2012). Under optimal conditions, traditional low-pressure solvent extraction and pressurized liquid extraction yielded similar extraction yields; however, pressurized liquid extraction extracted 2.15 and 1.66 times more anthocyanins and total phenolic compounds, respectively. Pressurized liquid extraction has been shown to be a successful approach for recovering bioactive compounds from blackberry residues and other food by-products. Machado, Pasquel-Reátegui, Barbero, and Martínez (2015) used pressurized liquid extraction to remove antioxidant compounds from blackberry residues. Temperature has a beneficial effect on yield, overall phenolics, and antioxidant capacity. Authors reported that pressurized liquid extract method is superior for obtaining the extracts from plant as compared to other traditional methods.

2.5 Ultrasound-assisted extraction

The development of effective extraction techniques to minimize extraction time and increase yield is in highly demand. Ultrasound is a term used to describe sonic waves that have frequencies greater than those heard by the human ear. Ultrasound-assisted extraction has the benefit of being easy, taking lesser time and using little amount of solvent in comparison to other processes, and it can be conveniently combined with several other extraction methods. This procedure can resist oxidation and decomposition of target natural substances since it can be done at room temperature. The use of ultrasound-assisted extraction in the extraction of various natural ingredients has become increasingly common. This extraction methodology doesn't require any complex instrumentation and is relatively low cost technique (Fig. 2.5).

The utilization of ultrasound improves the extraction process. At specific frequencies and amplitudes, these waves produce cavitation bubbles, which implode as they reach a nonstable stage, releasing high temperature and pressure. This occurrence has the potential to break down cell walls, allowing metabolites to escape. Ultrasonic waves can be influenced by several factors, the major ones being frequency and amplitude. Power is the amplitude over time, while intensity is the power over surface area. These variables alter ultrasonic waves, causing plant samples to interact accordingly. Ramić et al. (2015) investigated the effect of various factors on the extraction of

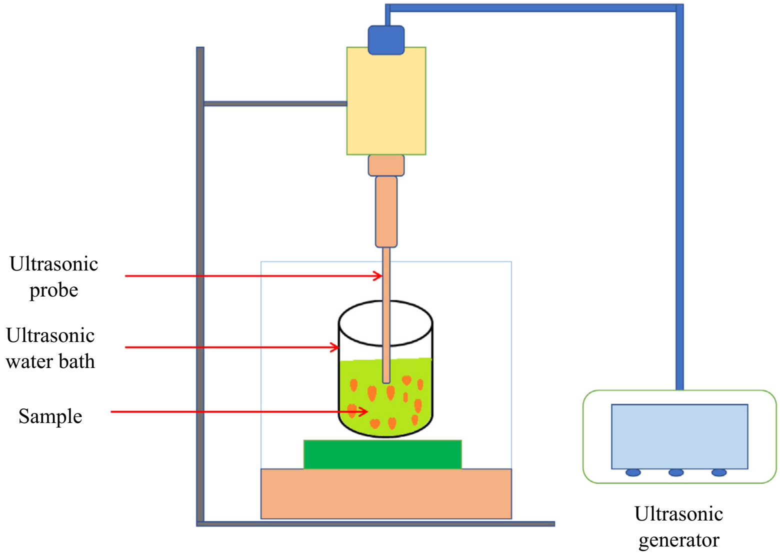

FIGURE 2.5

Schematic representation of basic ultrasound equipment.

polyphenolic compounds from *Aronia melanocarpa* by-products, including temperature (30°C−70°C) and ultrasonic strength (72−216 W). The optimized extraction temperature was 70°C and ultrasonic power of about 200 W. Bimakr, Ganjloo, Zarringhalami, and Ansarian (2017) investigated the impact of ultrasound-assisted extraction variables on the extractive value of bioactive phenolics from *Malva sylvestris* leaves. The concentration of bioactive phenolics showed a significant increase under the optimum ultrasound-assisted extraction conditions. Under the optimal ultrasound extraction conditions (48°C, 110.00 W, and 48.77 min), the experimental extractive value was 279.89 mg/g with 71.12% inhibition of scavenged DPPH, 73.35% inhibition of scavenged ABTS, and a total phenolic content of 152.25 mg GAE/g.

Pan, Qu, Ma, Atungulu, and McHugh (2012) used ultrasound extraction in continuous and pulsed modes for the extraction of antioxidants from the dry peel of pomegranate marc. Pulsed ultrasound-assisted extraction at an intensity level of 59.2 W/cm^2, a pulse duration of 5 s, and a resting interval of 5 s improved antioxidant yield by 22% and minimized time of extraction by 87% as compared to traditional extraction. Similarly, at the same intensity level, continuous ultrasound-assisted extraction enhanced antioxidant yield by 24%, while decreasing extraction time by 90%. As pulsed ultrasound-assisted extraction saved 50% more energy than continuous ultrasound-assisted extraction, the study suggests using pulsed ultrasound-assisted technique for the extraction with 14.5% antioxidant yield and 5.8 g/g DPPH scavenging activity. Vinatoru (2001) compared ultrasonic extraction to traditional methods for extracting bioactive substances from fennel, marigold and mint. The findings showed that the extraction yield (34%) was significantly higher than that of the traditional processes. Chukwumah, Walker, Verghese, and Ogutu (2009) investigated the impacts of ultrasound conditions (frequency and duration of ultrasound) on the extraction efficiency of peanut isoflavones and trans-resveratrol. The findings demonstrate that ultrasound treatment at frequency 80 kHz increased resveratrol, while ultrasound treatment at 25 kHz improved the extraction yields of daidzein and genistein.

2.6 Enzyme-assisted extraction

Enzyme-assisted extraction is one of the promising methods to conventional methods for the preparation of plant extracts. Enzymes have are beneficial to recover the phytochemical compounds from the plant material and their by-products. The main advantage of this method is the decrease of solvent quantity, environmental friendliness, selectivity and ability to catalyze the reaction under mild conditions. Enzyme based extraction method depends on the reaction time, types and concentration of enzyme. Furthermore, this method reduces the extraction time and increases the quality and quality of plant extracts. The enzymes used for the extraction hydrolyzing the plant matrix and the enzymatic reactions disintegrate the cell wall and increases the intracellular release.

The commonly used enzymes evaluated for the extraction of plant extracts are cellulose, pectinase, tannase etc. The enzymes with specific properties rupture the matrix of the plant material in order to gain the access to the bioactive compounds found within the cell matrix and bound to the cell walls. Enzyme assisted extraction resulted in the enhanced phytochemical compounds from bay leaves (Boulila et al., 2015), ginger (Manasa, Srinivas, & Sowbhagya, 2013), red capsicum (Nath, Kaur, Rudra, & Varghese, 2016), sweet cherry pomace (Domínguez-Rodríguez, Marina, & Plaza, 2021). To ensure the complete fragmentation of cellular matrix, it is important to select the appropriate enzyme for the extraction.

2.7 Pulsed electric field extraction

Pulsed electric field process uses the high voltage pulses for different applications in food industry. Pulsed electric field method is one of the promising techniques used for the extraction of various valuable compounds from the plant material. The exposure of plant material to pulsed electric disrupts the cell membrane via electroporation by the high voltage short pulses and promotes the release of intracellular components (Fig. 2.6). The pulsed electric field method obtained extracts from plant material with high yield and purity. This method also helps to shortening the extraction time, decrease the solvent amount and also facilitate the selective extraction of intracellular compounds. The extraction efficiency by pulsed electric field depends on the factors such as properties of plant material, number and duration of electric pulses. The critical factors which effect the processing during this technique are treatment time, electric field intensity, pulse wave form, conductivity and ionic strength of the medium.

The applicability of pulsed electric field for the extraction of bioactive compounds is reported in literature. Pulsed electric field method is a potential alternative for the conventional extraction methods. Pulsed electric field (2 kV/cm, 30 pulses) treatment significantly enhances the extraction of the naringin bioactive from the pomelo peel (Niu, Ren, Li, Zeng, & Li, 2021). The pulsed electric field extraction efficiency increased with increase of intensity from custard apple leaf extraction (Shiekh, Olatunde, Zhang, Huda, & Benjakul, 2021). The increased extraction yield is due to the

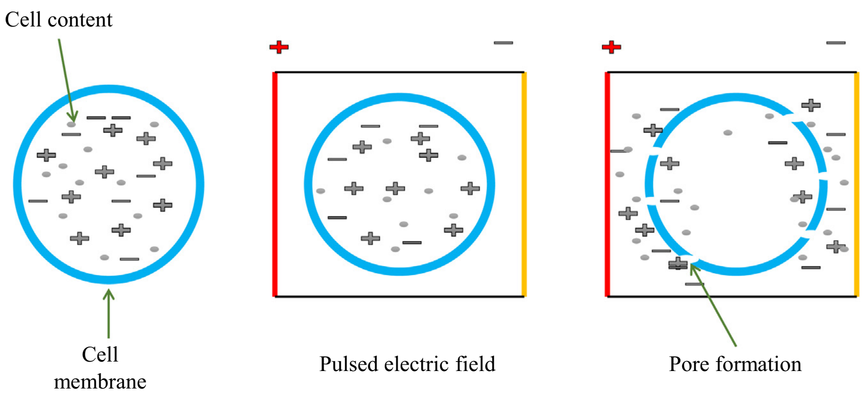

FIGURE 2.6

Schematic representation of electroporation in the cell membrane due to pulsed electric field.

electroporation which facilitates the disintegration of cell. Pashazadeh, Elhamirad, Hajnajari, Sharayei, and Armin (2020) also reported that pulsed electric field increased the extraction of bioactive substance from cinnamon by increasing the plant cell permeability. Pulsed electric field method has shown the enhanced phenolic and antioxidant recover from rosemary and thyme by-products as compared to the ultrasound method (Tzima, Brunton, Lyng, Frontuto, & Rai, 2021). The application of pulsed electric field enhanced the extraction of polyphenols form citrus fruits at 3 kV/cm (El Kantar et al., 2018).

2.8 Conclusion

The exploitation of bioactive compounds in the food industry has urged the researchers and industries to use different methodologies for the extraction of these compounds from plant materials. Many protocols and standards have been used, which affect the yield and composition of the extracted material. Many conventional methods have been used since long time in the industry. However, for some decades, nonconventional extraction methods also gained significant popularity and were commercialized at industrial scale. Emerging methods are environmental friendly extraction techniques due to the decreased use of synthetic chemicals, reduced process time, better yield, and quality of extract. The efficiency of the extraction methods depends on various factors including nature of plant matrix, chemistry of plant extract, and type of solvent used for extraction and methodology.

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