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GRADUATE REVIEWS

# Recent Development on the Extraction Process of Plants Essential Oil and its Effect on Chemical Composition: A Review

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ABSTRACT

This study presents a thorough review on different innovative extraction techniques of different plant essential oil derived from its peel, leaves, seeds and shrubs. The review also entails the different pre-treatment processes that affects the quality and recovery of the plant essential oil. Also, discussed the recently developed green extraction method such as Microwave Assisted Hydrodistillation (MAHD), Solvent Free Microwave Extraction (SFME), Ultrasound Assisted Extraction (UAE), Supercritical Fluid Extraction (SFE) and Ohmic Heated Assisted Hydrodistillation (OHAD). The impact of these extraction process on the important chemical composition of essential oil is further analyzed in this review. The important parameters in extraction is also studied such as the water to material ratio, extraction temperature, power input and extraction time. Based on the different articles reviewed, it signifies that the innovative extraction method improves the quality and quantity of the essential oil yield. It also improved the number of component that can be extracted in the plant essential oil and its biological activities such as antioxidant and antimicrobial activities. Thus this review aims to emphasize the potential of the newly developed essential oil extraction techniques that would help to boon the pharmaceuticals, food and agriculture industry.

**Keywords:** Essential oil, Extraction process, Chemical composition

## 1 Introduction

Essential oil draws great attention in research for its chemical compounds and antimicrobial activities. It is usually, located in different parts of the plant such as roots, stems, leaves, flowers, fruits, and even in seeds depending on the plant species. Essential oil has a primary composition of various volatile compound including hydrocarbons, alcohols, esters and aldehydes [1].

Relatively, about 3000 essential oils are known, of which 300 are commercially important, being added to food, cosmetics, perfumes, pharmaceuticals, sanitizers and agricultural products. In those products, they act as flavoring, fragrances, fragrance fixatives, antioxidant, antimicrobial, antiparasitic, virucidal, insecticide, and adjuvant in pharmaceutical and oral compositions marketed in their raw or processed form [2].

There are lot of existing technologies and techniques that has been investigated for the intensification and improvement of essential oil extraction from citrus however, it constitutes of intensive yet uneconomical process. Extraction method is one of prime factors that determine the quality of essential oil. Inappropriate extraction procedure can lead to the damage or alter action of chemical signature of essential oil. This results in the loss in bioactivity and natural characteristics. For severe case, discoloration, off-odor/flavor as well as physical change such as the increased viscosity can occur. Those changes in extracted essential oil must be avoided [3].

Many natural products are thermally unstable and can easily be damaged during thermal extraction. The method of extraction used depends on the kind of compounds present in the oil and the location of the oils within the vegetative structure of the plant species [4]. Therefore, this review investigates the recent developments in the different extraction process of plant essential oil and analyzed the effect of these methods to the chemical composition and quality of the essential oil.

## 2 Pre-Treatments On Fresh Material Before Extraction

Pretreatment is a significant process that offers great advantage in the improvement of the yield, bioactive compound extraction with effects in the antioxidant and antimicrobial activities, reduction in the thermal degradation of compounds, and reduction in time to extract the products.

### 2.1 Drying

Drying pretreatment was used in the study of Kamal [5] to determine its effect to the yield and composition of citrus essential oil after it was isolated from fresh, ambient and oven dried peels of the sample. The result shows that the maximum amount of the oil was obtained from oven dried sample with average percentage of 1.07% while minimum from fresh sample with only 0.2%. While for the chemical composition of essential oil including its major component such as limonene it was observed that the result is varied significantly with respect to the drying pretreatments employed. Similarly, Asekun *et al.* [6] also determine the effect of drying on the yield and composition of extracted essential oil in *Helichrysum odoratissimum*. The result shows that the oils isolated from fresh, air-dried, sun-dried and oven-dried aerial parts of the plant yielded 0.28, 0.46, 0.33 and 0.36%, respectively. The study also emphasize that drying has a significant impact on the chemical alterations in the major component of the plant essential oil.

Relatively, Wang *et al.* [6], presented the effect of the drying temperature on the yield and composition of black cardamom. The samples were dried at 20 °C, 40 °C, 55 °C, 70 °C, 85 °C and 100 °C. The result shows that the samples dried under 55 °C presented highest concentration in oil, with an average of 3.71%. Meanwhile, the difference between oil yield of relatively high and low drying temperature groups was significant. Drying temperatures of 25 °C, 40 °C, 55 °C and 70 °C accumulated more oil, whereas relatively high drying temperature (85 °C and 100 °C) resulted in lower oil yield. These results were proved and describe in the study of Guenther *et al.* [7], that the leaves tend to emit more isoprene and terpenes as temperature increase, while the emission rate begins to decrease above 40 °C.

Consequently, the drying has significant effect in the essential oil compositions and proportion of various components, as when the temperature increased, the monoterpene content decreased and vice versa for sesquiterpenes [8]. Drying above 40 °C leads to the damage of leaf trichomes where the essential oils are stored contributing to volatilization of oil constituents.

### 2.2 Ultrasound Pretreatment

The utilization of advanced technology like ultrasound as pretreatment provides many beneficial advantages in the improvement in the yield of essential oil, bioactive compounds extraction with effects in the antioxidant and antimicrobial activities, reduction in thermal degradation of compounds, reduction in time to extract the products, making the extraction cheaper and environment friendly. However, this method demands higher initial investment and technicality [9].

Yu *et al.* [10], compared the ultrasound pre-treatment and microwave power pre-treatment on the traditional hydrodistillation extraction of essential oil and the results shows that the ultrasound pretreatment decreased the extraction time and increased the yield but did not noticeably affect the chemical composition of the essential oil. The highest essential oil was obtained when the ultrasonic power and extraction duration was 210W, and 30 minutes respectively.

Moreover, ultrasound has been considered as "green" extraction technology for the destruction of cell wall structure and the release of intracellular components, based on the several mechanisms including fragmentation, erosion, cavitation and detexturation [11]. Furthermore, ultrasound pre-treatment can accelerate the mass transmission of target analytes from the inside of materials to the outside of the solvent thereby improving the separation efficiency. The extraction of essential oil was tested in different ultrasonic power from 80W to 200W. The result shows that from 80W to 160W the extraction yield significantly increases while above 200W the extraction yield is drastically decreases. The ultrasound power can cause notably forceful impact on drastic cell disruption that leads to high extraction yield.

## 2.3 Microwave Pretreatment

Microwave pretreatment was used and described by the study of Navarrete *et al.* [12], to improve the yield of essential oil. Microwave extraction methods are based on the capability of the radiation to disrupt the oil containing glands to accelerate the extraction process. The fundamental mechanism of microwave extraction is the interaction of the electromagnetic field with the polysaccharide molecules and moisture present in the trichome walls which causes disruption. Therefore, the essential is rapidly draw outward from the trichome and will be evaporate by the surrounding steam.

Radzi & Kasim [13], describes the effect of microwave pretreatment on gaharu essential oil using hydro-distillation method. Results show that the pretreated gaharu with 3 min exposure to microwave produced a higher oil yield which was 0.0877 wt.% compared to the non-pretreated sample which only produced 0.0286 wt.%. The increase in the extracted oil yield was due to the modification of the cellular walls which resulted in greater porosity. The electromagnetic wave produced by microwave at high frequency can cause penetration to the plant and reach the inside of the materials and rupture the cell wall, thus causing damage to accelerate and simplify the cell wall and bring the oil out of the material. Rupture of cells is essential before the extraction of the desired compound of plant tissue. Pretreatment of material by blanching and microwave treatment can influence product quality. Thus, a higher quality of essential oil can be obtained with lower time and fuel consumption by performing microwave pretreatment.

## 2.4 Enzymolisis Pretreatment

Enzymolosis pretreatment followed by microwave method was used to extract essential oil from *Cinnamomum burmannii* leaves. The result shows that compared with the extraction yield of traditional hydrodistillation, higher essential oil yields were acquired using enzymolosis pre-treatment in a shorter extraction time. This was because the enzymolosis pretreatment and microwave assisted extraction gives same directions of heating energy and mass transfer behaviors, which all diffuse from the inner to the outside of the plant cells and hence the essential oil releases more quickly from its cells to the collector. As for traditional hydodistillation, the heat energy diffuses from water to the plant materials while the mass transfer occurs from the inner of plant materials to the outside. Enzymolosis pretreatment – (MAE) possessed the significant higher essential oil yield than traditional MAE and HD probably owing to that the destruction of plant materials cellular structures in EP-MAE from the synergistic effects of both enzyme hydrolysis and microwave irradiation [14].

Mishra *et al.* [15], describes that the use of enzymatic pretreatment in extraction of essential oil from mandarin peel increased the yield by 15%. The peels were pretreated by varying concentrations from 0.1% to 0.3%. The increase in recovery was determined due to rupture of oil and sacs/glands by enzymatic action resulting excess release of essential oil from oil sacs. Relatively Chávez-González *et al.* [16], also justified that enzymatic hydrolysis improved the recovery of essential in different varieties of citrus fruits. Additionally, enzymatic pretreatment allowed the release of a significant amount of sugar (22g/L) that could be used in fermentation processes.

### 2.5 Physical Size Alteration

Extraction can be enhanced by reducing the sample's physical size either by cutting or grinding. It can elevate the efficiency of extraction and reduce energy and time for distillation. As the particle size decreased, the final yield would increase irrespective of the extraction methods. This is due to an increase of area at the surface as leaves are cut into small pieces. With increasing surface area, the resistance of mass transfer decreases which leads to excellent transfer of heat. This phenomenon can slow down transporting oil from cells when using the solvent extraction process. Therefore, to achieve an excellent yield of essential oils, particle size reduction is crucial. This can be done by reducing the diameter of the sample [17].

## 3 Innovative Essential Oil Extraction Techniques

There are lot of existing technologies and techniques that has been investigated for the intensification and improvement of essential oil extraction however, there are some compounds require low temperature extraction while some can only be extracted on higher temperature. The method of extraction determines the quality of essential oil. Inappropriate extraction procedures can lead to damage or change of the chemical nature of the essential oil. Many natural products are thermally unstable and can easily be damaged during thermal extraction. The method of extraction used depends on the kind of compounds present in the oil and the location of the oils within the vegetative structure of the plant species [4].

### 3.1 Microwave Assisted Hydrodistillation Technique (MAHD)

Microwave assisted hydrodistillation method is one of the recent and most innovative method of extracting plant essential oil. The extraction was achieved by utilizing two mechanism of heat transfer, ion conduction and dipole rotation. Microwave energy heats the polar molecules inside plant cells and causes enormous pressure in the plant cell walls. This pressure breaks the cell wall to release broken cell component into the solvent and thus improve the extraction yield [18]. Therefore this method provides beneficial advantages including more efficient heat flow, reduce extraction time, lower solvent utilization, higher quality of extracted products and more environment-friendly method [19]. Figure 1, illustrates the sample schematic diagram of the microwave assisted hydrodistallation process which primarily consists of the following

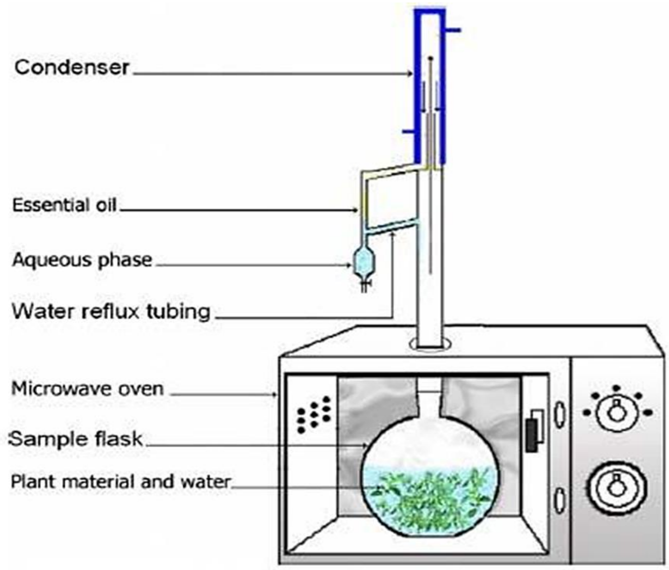


**Figure 1:** *Diagram of Microwave Assisted Hydrodistillation (MAHD) apparatus*

components; microwave oven, water reflux tubing and the condenser. It is a 2450 MHz multimode microwave with a maximum delivered power of 900W.

Jeyaratnam *et al.* [20], compared the yield and quality of extracted essential of *Cinnamomum cassia* bark using hydrodistillation and microwave assisted hydrodistillation technique. The results displayed using Gas Chromatography – Mas Spectroscopy (GC-MS) that MAHD produced nine percent oxygenated compounds than HD. The longer extraction duration using HD results to decomposition and degradation of some active compounds. Additionally, the method is more energy saving and environment friendly by reducing the carbon emission by 59% compared to HD.

In similar method, [11], [18], compared the MAHD to HD. The results revealed that MAHD produced 3.85 higher essential oil yield compared to HD. Furthermore, the study shows that the MAHD essential oil had higher anti-oxidant activity compared to HD essential oil. It also proves that MAHD is an innovative, economical, and environment-friendly approach to efficiently and safely extract essential oil.

### 3.2 Solvent Free Microwave Extraction

Solvent free microwave extraction (SFME) is a combination of microwave heating and dry distillation, performed at atmospheric pressure without added any solvent or water. the principle of operation of this process is the internal heating of the in situ water within the material distends it and makes the glands and oleiferous receptacles burst. The vapor consisting of essential oils from the extraction will pass through a condenser outside the microwave cavity. the distillate is collected continuously in the collecting flask [21].

The process has been designed as green method for the extraction of essential from plants that extensively used in different pharmaceutical, food and agriculture industry [22]. Compared to steam distillation and hydrodistillation, the essential oil obtained using SFME in 30 minutes were quantitatively (yield) and qualitatively (aromatic profile) similar to 120 minutes obtained using the two conventional methods. The method also provides less waste, less solvent and less energy consumed. While there is no significant difference on the antioxidant and antimicrobial activities obtained in both methods [23].

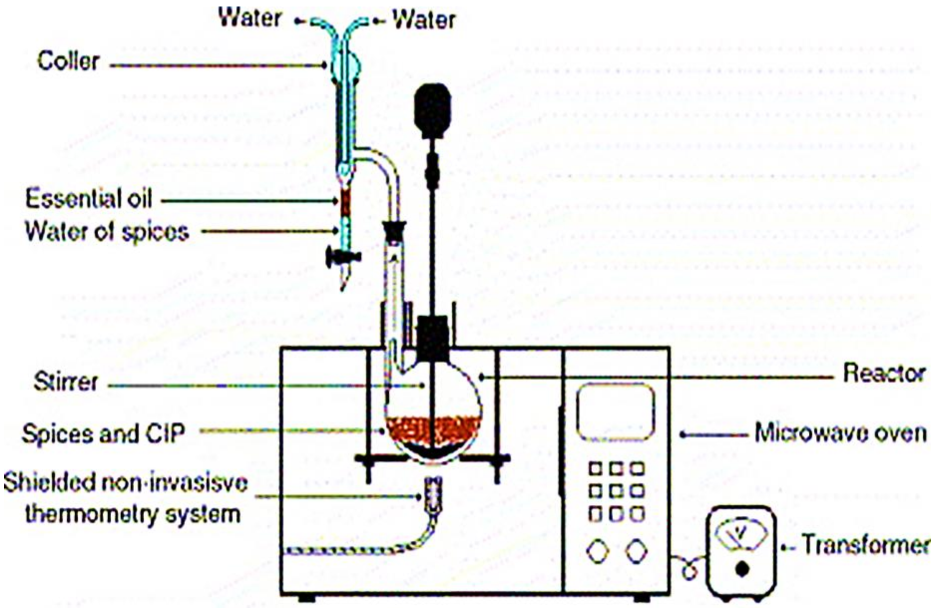


**Figure 2:** *Schematic Diagram of Improved Solvent Free Microwave Extraction by Adding Microwave Absorption Medium*

There are some modifications identified in improving the performance of solvent free microwave extraction. Wang *et al.* applied microwave absorption medium such as carbonyl iron powders (CIP) from the dried plants without any pretreatment. The study proved that the CIP has greater absorption capacity than water hence, the extraction time improves to less than 30 minutes using a microwave power of 85W. While some modification were by using graphite powder and activated carbon powder [24]. Figure 2, shows the modification of the improved solvent free microwave extraction process by providing additional mechanical stirrer, powdered CIP and ensuring that the water ($H_2O$) separated from the extracted essential oil will not returned to reflux.

### 3.3 Ultrasound Assisted Extraction

Ultrasound extraction considered as one of the most innovative essential oil extraction of plant essential oil. It has remarkable advantages in terms of duration of extraction, minimum energy consumption, higher extraction yield and more acceptable quality of essential oil. Ultrasound allows selective and intensification of essential oil extraction by from plant when used in combination with other techniques. Additionally, ultrasound effect improves the efficiency of extraction by increasing the penetration of solvent into the plant cells via cavitation and prevents the degradation of plant extract.

Moreover, it proves that by utilizing ultrasound assisted essential oil extraction minimize the use of solvent compared to mechanical and traditional extraction. Richa & Kumar [25], shows that the optimum values for extraction were at 40 ºC, 210W and 20mg/L of temperature, ultrasonic power and liquid to solvent ratio respectively. This method is a non-thermal extraction process that effectively enhances the surface area of the plant through size reduction, hence minimize the processing time and maintain its nutritional value.

Meanwhile, G. Chen *et al.* [26], used ultrasound assisted extraction in enhancing the extraction of essential oil of *Cinnamomum cassia* bark. Different parameters were considered such as the ultrasound time, ultrasound power, extraction time and liquid to solid ratio. The results show that the extraction yield increases on the first 10-30 minutes and decreases gradually with further lengthening the extraction time. The further increasing of duration of extraction the more oil compounds were degraded into small molecule specie. While in the ultrasonic power, less than 300Watts shows significant increase in the oil yield and decreases with further increasing the ultrasonic power. This was due to increase in ultrasonic power develops superheated localized temperatures and more free radicals generated as more cavitation bubble collapsed that leads to the degradation of target compounds, hence resulting to decrease in the oil yield. On the other hand, the solvent to liquid ratio is also considered as an important factor in increasing the yield of essential oil. A ratio of six (6) increases the yield and decreases as the moisture content rises. The higher solid to liquid ratios would lead to decrease of the ultrasound adsorption of the material resulting in the insufficient energy that will facilitate cell wall breakage for the release of essential oil compounds.

In the experimental set up of ultrasonic assisted extraction of N.A Md Salehan *et al.* [27], shown in Figure 3, illustrates that the ultrasonic probe was immersed in the extraction medium and the energy is transmitted via the sonotrode directly into the sample. The ultrasound power level was fixed by setting the amplitude of the sonotrode and the cumulative average ultrasound dose by adjusting the duty cycle.

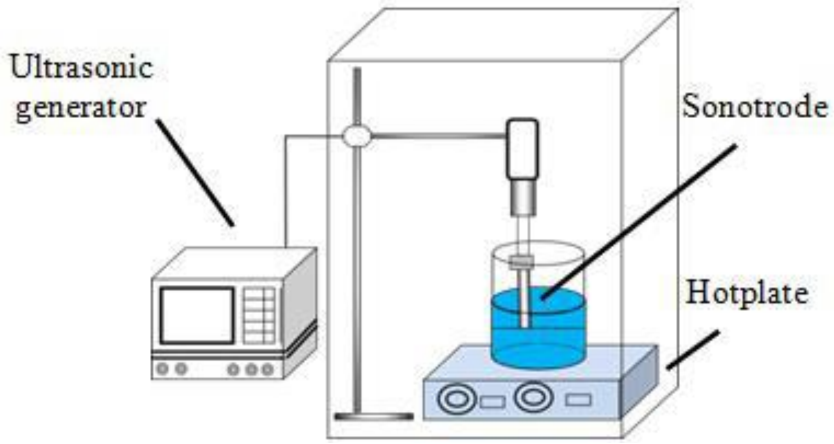


**Figure 3:** *Schematic Diagram of Ultrasound Assisted Extraction*

### 3.4 Supercritical Fluid Extraction

Supercritical Fluid Extraction (SFE) is a "green alternative" for traditional extraction process, it provides effective quick extraction that requires low to moderate temperature and preventing the use of harmful solvents. The most common solvent use in isolating essential oil from plants is carbon dioxide since it is non-explosive, non-toxic, readily available, and easily eliminated from the extracted product [28]. Figure 4 illustrates the process flow diagram of supercritical fluid extraction which is mainly composed of extraction kettle, separation kettle, rectification column, $CO_2$ high-pressure pump, auxiliary pump, refrigeration system, $CO_2$ storage tank, heat exchange system, purification system, flow meter, temperature, and pressure control (protection) system. This system provides low critical temperature which gives suitable process for extraction and purification of heat-sensitive compounds.

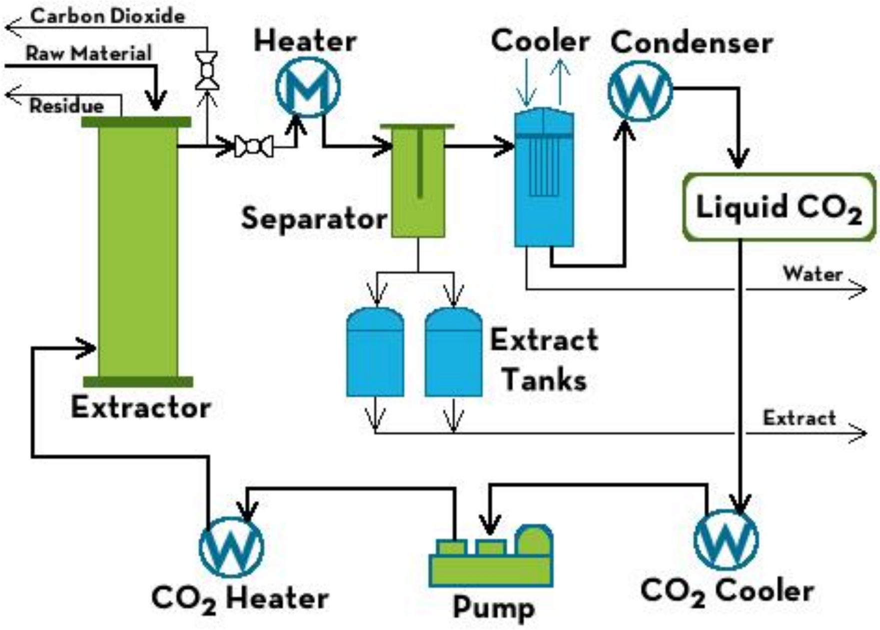


**Figure 4:** *Schematic Diagram of Flow of Supercritical Fluid Extraction*

Relatively, the method was used in the study of Salinas *et al.* [29], in extracting almond oil and evaluate the effect of temperature and pressure on the extraction yield and essential oil composition. The highest yield was obtained at 60 °C and 40 MPa and lowest at 60 °C and 20MPa this was due to the solubility of essential oils increases with the pressure increment due to the increase of solvation power of $CO_2$, allowing higher permeability of the solvent into plant matrix.

Moreover, Sodeifian *et al.* [30], also investigate the effects of different operating parameters including pressure, extraction time, particle size and temperature. The maximum yield was obtained at the optimum conditions of 300 bar, 308K, 0.75mm and 130 minutes. A pressure more than 300 bar could increase the density, decreasing the distance between the molecules, increasing solvent power and solubility of the extract. While the increment on temperature had negative effect in the essential oil yield. The effect of reducing density and solubility induced in the increase of vapor pressure; hence, extraction yields decreased by the increased in extraction temperature. On the other hand, particle size directly affects the yield of essential oil by increasing the surface area for the supercritical fluid across which to contact with the samples. Furthermore, higher amount of extraction process at initial extraction time was caused by the higher extractible compounds contained in the surface of the plant.

### 3.5 Ohmic Heated Assisted Hydrodistillation

Ohmic assisted hydrodistillation is a promising green techniques in extracting essential oil from plants because it does not necessitate the use of organic solvents and requires substantially less energy to operate.

The principle of operation of this technique is by providing alternating electric current through plant sample for heating where heat is internally generated into the material due to electrical resistance when electric current passes through it. It is an innovative process in providing fast and constant heating resulting in less thermal decomposition of important composition of the sample [2].

Sample that undergone in ohmic heated hydrodistillation process shows micro fractures but less cell wall degradation. Additionally, it also exhibits less rigid cell wall of the sample compared to steam distillation. The secretory cavities scattered throughout the surface of the sample this were the essential oil were stored [31].

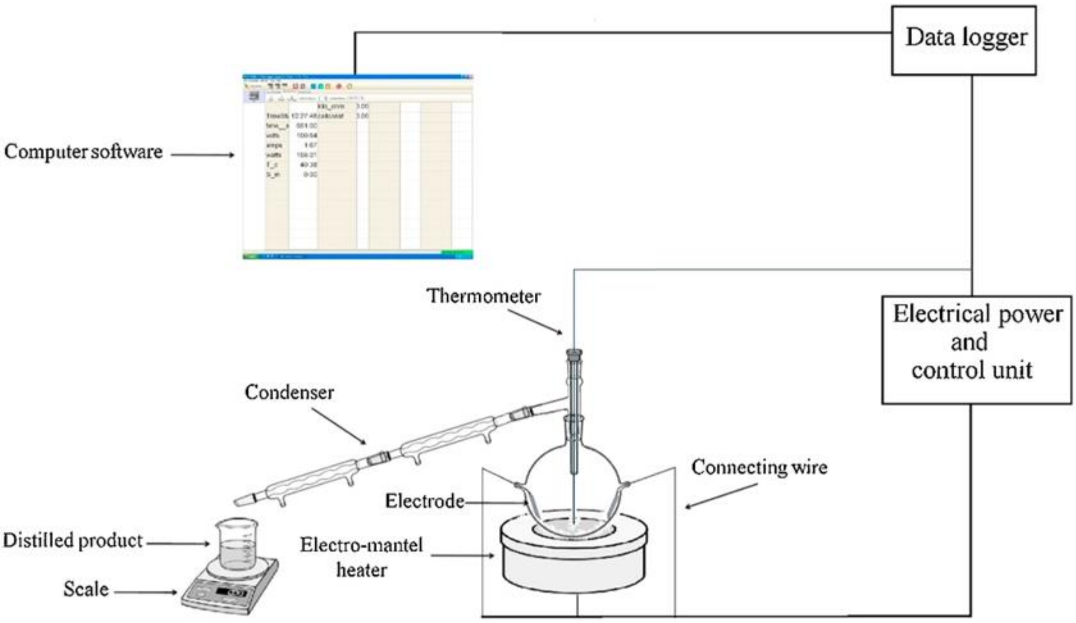


**Figure 5:** *Schematic Diagram of Flow Ohmic Heated Hydrodistillation Process*

In the same principle, [32], [33], design an ohmic heated hydrodistillation for the essential extraction of eucalyptus leaves. The study claims that ohmic heating provides more effective penetration of heat into the plant material. Result shows that OHHD provides faster extraction time and less energy consumption compared to conventional hydrodistillation process. Another advantage of ohmic heating is the rate of temperature increase and by directly generating heat inside the plant material compared to traditional hydrodistillation that requires temperature gradient to transfer heat to the process liquid shown in Figure 5. Experimental set-up illustrates the OHAD essential oil extraction device equipped with stainless electrodes (coated by titanium) [34]. However, the process requires further economic and upscaling studies for the industrial application.

Table 1 shows the different innovative extraction methods of different plants and its extraction parameters, solvent used, and its respective yields. The UAE generates the highest oil yield with 55.44 ± 0.53%, follorwed by SFE and UBAE, with oil yield of 39.5±.4% and 22.43% respectively.

**Table 1:** *Extraction of plant essential using the innovative method of extraction.*

| Extraction Method | Plant Extracted | Extraction Parameters | Solvent | Extraction Yield | References |
|---|---|---|---|---|---|
| Microwave Assisted Hydrodistillation (MAHD) | Vietnamese Basil *(Ocimum basilicum L.)* | Water to material ratio: 3.2:1<br>Extraction time: 97 mins.<br>Microwave power: 430W | $H_2O$ | 0.6% | [35] |
| Microwave Assisted | Lemon *(Citrus aurantifolia)* leaves | Water to material ratio: 3.27mL/g<br>Extraction time: 84.47 mins.<br>Microwave power: 523.89 W | $H_2O$ | 0.76% | [36] |

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| | | | | | |
|---|---|---|---|---|---|
| Hydrodistillation (MAHD) | | | | | |
| Microwave Assisted Hydrodistillation (MAHD) | Orange Leaves | Water to material ratio: 3.46mL/g<br>Extraction time: 100.47 mins.<br>Microwave power: 471.58 W | $H_2O$ | 0.43% | [37] |
| Microwave Assisted Hydrodistillation (MAHD) | Lavender | Water to material ratio: 17mL/g<br>Extraction time: 40 mins.<br>Microwave power: 500 W | $H_2O$ | 3.20% | [11] |
| Solvent Free Microwave Extraction (SFME) | Aromatic Herbs | Microwave Power: 150 W<br>Extraction Temperature: 100 °C | none | 0.54% | [22] |
| Solvent Free Microwave Extraction (SFME) | Dried patchouli leaves | Microwave power: 450 W<br>Ratio of mass of material / volume of distiller: 0.06g/mL<br>Raw material size: 4.66±1.41cm<br>Extraction time: 90 mins | none | 4.60% | [38] |
| Super Critical Fluid Extraction (SFE) | *Pistacia lentiscus* | Particle diameter: 220 µm to 650 µm<br>Pressure: 80 – 220 bar<br>Temperature: 40 °C<br>Flowrate: 0.6 – 1.2 kg/h | $CO_2$ | 0.093% - 0.285% | [39] |
| Super Critical Fluid Extraction (SFE) | *Eryngium billardieri* | Particle size: 0.75 mm<br>Pressure: 300 bar<br>Temperature: 308 K<br>Extraction duration: 130 min | $CO_2$ | 0.8522% | [30] |
| Super Critical Fluid Extraction (SFE) | *Geoffroea decorticans* | Pressure: 40 MPa<br>Temperature: 60 °C | $CO_2$ | 39.5±.4% | [29] |
| Super Critical Fluid Extraction (SFE) | *Myrtus communis L.* | Particle diameter: 0.315mm<br>Pressure: 30 MPa<br>Temperature: 313 K | $CO_2$ | 4.89 wt% | [40] |
| Ultrasonic Assisted Extraction (UAE) | *C. inophyllum* seed | Ultrasonic power: 210 W<br>Extraction time: 20 mins<br>Temperature: 40 °C<br>Liquid to Solid (L/S) ratio: 20mg/L | $H_2O$ | 55.44 ± 0.53 % | [25] |
| Ultrasound Bath-Assisted Extraction (UBAE) | Clove | Particle size: <0.5mm<br>Temperature: 60 °C<br>Extraction time: 45 mins.<br>Plant concentration (weight of material/volume of solvent): 5%<br>Frequency: 57 kHz | Ethanol | 22.43% | [41] |
| Ultrasound Assisted Hydrodistillation (UAE) | *Cinnamomum cassia* bark | Ultrasound power: 300W<br>Extraction time: 60 mins.<br>Liquid to solid ration (mL/g): 7 | $H_2O$ | 2.47% | [26] |
| Ohmic Heating Hydrodistillation (OHHD) | Eucalyptus leaves | Input power energy: 80V<br>Extraction duration: 90 mins. | $H_2O$ | 2.19% | [33] |

## 4 Effect of Different Extraction Methods in the Chemical Composition in the Plant Essential Oil

Extraction process is one of the most critical points that will greatly influence the chemical profile of the plant essential oil. Inappropriate extraction method may cause destruction of phytochemicals present in aromatic oils. The resulting effects can be the loss of pharmacological constituents, stain effect, off-flavor/odor, and physical change of essential oils. Essential oil are complex mixtures of volatile compounds has more than 200 components mainly mixtures of terpenes, and phenylpropanoid derivatives. These chemical compositions commonly contain numerous biological activities such as antioxidant, anti-inflammatory, and antimicrobial which is beneficial in pharmaceutical, food and agriculture industry [42].

In the comparative analysis made by Salman *et al.* [43], on the effect of SFME, MAHD and HD extraction method in the chemical composition of *Mentha piperita* L. it was appeared that the qualitative composition of each oil were the same. The oil consists of monoterpene and sesquiterpenes. It was found out that SFME increase the extraction of sesquiterpenes compounds. It was also appeared that the SFME increase the extraction of carvone than HD and MAHD methods. While Djouahri *et al.* [44], also analyzed the effect of extraction method to the chemical profile and biological activities of essential oil. The study shows that the oil from MAHD was characterized by higher amount of oxygenated compounds. It also exhibited higher antioxidant and anti-inflammatory activities which will be consider as good source of bioactive compounds and would be more advantageous in health and food industry.

Some of the composition of essential oil can be abundant using specific extraction method. Rassem *et al.* [45], states that the extracts prepared using supercritical fluid extraction (SFE) yielded higher antioxidant activity than extract prepared by other methods. It also produces higher diffusion coefficient and lower viscosity. Many essential oil that cannot be extracted by the traditional distillation can be obtained using carbon dioxide extraction. In recent studies [9], [26], uses ultrasound assisted extraction method to enable the growth in the extraction of bioactive compounds and improve the antioxidant and antimicrobial properties of the essential oil. It also shows that more component of essential oil was extracted compared to the traditional extraction method. While for ohmic heating the number of composition of essential oil affected in the changes of voltage applied.

## 5 Conclusion

Plant essential oil provides numerous beneficial advantage in food, cosmetics pharmaceutical and agriculture industry. Its composition possesses many biological activities that are responsible for products fragrance fixatives, flavoring, antimicrobial, insecticide and antioxidant that being marketed in processed or raw form. Hence, essential oil extraction method is a crucial process in ensuring to that the important chemical composition will not be decomposed during the extraction process. This study analyzes and presents different innovative extraction method and technologies, observes its applicability and adaptability of the process, economic viability, advantages and its drawbacks especially in enhancing the quality of the essential oil. The study discussed the significance of the pretreatment process in improving the yield and its bioactive compounds. These pretreatments are drying, microwave, ultrasound, enzymolosis and physical alteration. The common advantage of these pretreatments is to disrupt or rupture the plant cell wall where the essential oils are stored and draw it outward from the cell trichomes. The innovative extraction techniques discussed in this study such as MAHD, SFME, SFE, UAE, and OHHD considered as “green chemistry approach”. It drastically reduced operation time in the sample preparation step under conditions that offer the same level of essential oil quality and yield. It also reduced energy consumption, allows use of alternative solvents and renewable natural products, and ensure a safe and high quality extract product. Hence, these studies are beneficial for further improvement in processing of raw materials into fine and marketable product economically. Furthermore, processing of peel waste and other by products of plant processing industry is a great advantage in addressing the problem in biodegradable wastes that causes soil acidity, infertility and pollution.

# 6 Declarations

## 6.1 Competing Interests

The authors declared that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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## References

[1] T. P. Dao *et al.*, "Optimization of Operating Conditions of Essential Oil Extraction of Vietnamese Pomelo (Citrus grandis L.) Peels by Hydrodistillation Process," *Asian J. Chem.*, vol. 32, no. 2, pp. 237–243, 2020, doi: 10.14233/ajchem.2020.22179.

[2] C. N. Joshi, "Basics of Ohmic Heating-A Novel Food Preservation Technique Review Paper," *Int. J. Eng. Dev. Res.*, vol. 6, no. 1, pp. 2321–9939, 2018.

[3] P. Tongnuanchan and S. Benjakul, "Essential Oils: Extraction, Bioactivities, and Their Uses for Food Preservation," *J. Food Sci.*, vol. 79, no. 7, 2014, doi: 10.1111/1750-3841.12492.

[4] L. G. Mugao, B. M. Gichimu, P. W. Muturi, and S. T. Mukono, "Characterization of the Volatile Components of Essential Oils of Selected Plants in Kenya," *Biochem. Res. Int.*, vol. 2020, 2020, doi: 10.1155/2020/8861798.

[5] G. M. Kamal, F. Anwar, A. I. Hussain, N. Sarri, and M. Y. Ashraf, "Yield and chemical composition of Citrus essential oils as affected by drying pretreatment of peels," *Int. Food Res. J.*, vol. 18, no. 4, pp. 1275–1282, 2011.

[6] M. C. M. Fonseca *et al.*, "Effect of Drying Temperature on the Yield and Phytochemical Quality of the Essential Oil of Pepper Rosemary (Lippia Origanoides Kunth) and of Clove Basil (Ocimum Gratissimum L.)," *Brazilian J. Dev.*, vol. 6, no. 8, pp. 57107–57120, 2020, doi: 10.34117/bjdv6n8-208.

[7] J. Wang *et al.*, "Drying temperature affects essential oil yield and composition of black cardamom (Amomum tsao-ko)," *Ind. Crops Prod.*, vol. 168, p. 113580, 2021, doi: 10.1016/j.indcrop.2021.113580.

[8] S. Khangholi, "PSILOTUM NUDUM ( L .) P . BEAUV . ( PSILOTACEAE ), A NEW RECORD FOR THE," no. February, 2017.

[9] F. M. Dalla Nora and C. D. Borges, "Pré-tratamento por ultrassom como alternativa para melhoria da extração de óleos essenciais," *Cienc. Rural*, vol. 47, no. 9, pp. 1–9, 2017, doi: 10.1590/0103-8478cr20170173.

[10] F. Chen *et al.*, "Ultrasound pre-treatment combined with microwave-assisted hydrodistillation of essential oils from Perilla frutescens (L.) Britt. leaves and its chemical composition and biological activity," *Ind. Crops Prod.*, vol. 143, no. October 2019, p. 111908, 2020, doi: 10.1016/j.indcrop.2019.111908.

[11] S. Mollaei, F. Sedighi, B. Habibi, S. Hazrati, and P. Asgharian, "Extraction of essential oils of Ferulago angulata with microwave-assisted hydrodistillation," *Ind. Crops Prod.*, vol. 137, no. December 2018, pp. 43–51, 2019, doi: 10.1016/j.indcrop.2019.05.015.

[12] A. Navarrete, S. Wallraf, R. B. Mato, and M. J. Cocero, "Improvement of essential oil steam distillation by microwave pretreatment," *Ind. Eng. Chem. Res.*, vol. 50, no. 8, pp. 4667–4671, 2011, doi: 10.1021/ie102218g.

[13] N. C. Radzi and F. A. Kasim, "Effect of microwave pretreatment on gaharu essential oil using hydrodistillation method," *Indones. J. Chem.*, vol. 20, no. 4, pp. 960–966, 2020, doi: 10.22146/ijc.43191.

[14] "ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF CHEMICAL AND BIOENGINEERING Extraction , Characterization and Optimization of the Sweet Basil ( Ocimum Basilicum ) Essential Oil," 2021.

[15] "Enzyme-assisted extraction of citrus essential oil in_ Chemical Papers Volume 70 Issue 4 (2016)." .

[16] M. Chávez-González, L. López-López, R. Rodríguez-Herrera, and C. Aguilar, "Extraction of Essential Oils of Different Citrus By Enzymatic Hydrolysis," p. 2009, 2009.

[17] M. Mohideen, M. Iqbal, H. Idris, Z. Abidin, and N. A. Kamaruzaman, "Review On Extraction Methods Of Essential Oil From Kaffir Lime (Citrus hystrix) LEAVES," *J. Acad.*, vol. 9, no. 1, pp. 173–184, 2021.

[18] H. Boudraa, N. Kadri, L. Mouni, and K. Madani, "Microwave-assisted hydrodistillation of essential oil from fennel seeds: Optimization using Plackett–Burman design and response surface methodology," *J. Appl. Res. Med. Aromat. Plants*, vol. 23, no. July 2020, p. 100307, 2021, doi: 10.1016/j.jarmap.2021.100307.

[19] N. Ghazanfari, S. A. Mortazavi, F. T. Yazdi, and M. Mohammadi, "Microwave-assisted hydrodistillation extraction of essential oil from coriander seeds and evaluation of their composition, antioxidant and antimicrobial activity," *Heliyon*, vol. 6, no. 9, p. e04893, 2020, doi: 10.1016/j.heliyon.2020.e04893.

[20] N. Jeyaratnam, A. H. Nour, R. Kanthasamy, A. H. Nour, A. R. Yuvaraj, and J. O. Akindoyo, "Essential oil from Cinnamomum cassia bark through hydrodistillation and advanced microwave assisted hydrodistillation," *Ind. Crops Prod.*, vol. 92, pp. 57–66, 2016, doi: 10.1016/j.indcrop.2016.07.049.

[21] N. A. A. Aziz, J. Hassan, N. H. Osman, and Z. Abbas, "Extraction of essential oils from Zingiberaceace family by using solvent-free microwave extraction (SFME), microwave-assisted extraction (MAE) and hydrodistillation (HD)," *Asian J. Appl. Sci.*, vol. 5, no. 1, pp. 97–100, 2017.

[22] A. Filly, X. Fernandez, M. Minuti, F. Visinoni, G. Cravotto, and F. Chemat, "Solvent-free microwave extraction of essential oil from aromatic herbs: From laboratory to pilot and industrial scale," *Food Chem.*, vol. 150, pp. 193–198, 2014, doi: 10.1016/j.foodchem.2013.10.139.

[23] A. R. T. S. Araujo *et al.*, "Solvent-free microwave extraction of thymus mastichina essential oil: Influence on their chemical composition and on the antioxidant and antimicrobial activities," *Pharmaceuticals*, vol. 14, no. 8, pp. 1–13, 2021, doi: 10.3390/ph14080709.

[24] Y. Arafat, A. Altemimi, S. A. Ibrahim, and L. S. Badwaik, "Valorization of Sweet Lime Peel for the Extraction of Essential Oil by Solvent Free Microwave Extraction Enhanced with Ultrasound Pretreatment," *Molecules*, vol. 25, no. 18, 2020, doi: 10.3390/molecules25184072.

[25] R. Richa and R. Kumar, "Ultrasound assisted essential oil extraction technology : New boon in food industry Ultrasound assisted essential oil extraction technology : New boon in food industry," no. May 2021, 2020.

[26] G. Chen, F. Sun, S. Wang, W. Wang, J. Dong, and F. Gao, "Enhanced extraction of essential oil from Cinnamomum cassia bark by ultrasound assisted hydrodistillation," *Chinese J. Chem. Eng.*, vol. 36, pp. 38–46, 2021, doi: 10.1016/j.cjche.2020.08.007.

[27] N. A. Md Salehan, A. Z. Sulaiman, and A. Ajit, "Effect of temperature and sonication on the extraction of gallic acid from Labisia Pumila (Kacip Fatimah)," *ARPN J. Eng. Appl. Sci.*, vol. 11, no. 4, pp. 2193–2198, 2016.

[28] M. Yousefi *et al.*, "Supercritical fluid extraction of essential oils," *TrAC - Trends Anal. Chem.*, vol. 118, pp. 182–193, 2019, doi: 10.1016/j.trac.2019.05.038.

[29] F. Salinas *et al.*, "Supercritical fluid extraction of chañar (Geoffroea decorticans) almond oil: Global yield, kinetics and oil characterization," *J. Supercrit. Fluids*, vol. 161, 2020, doi: 10.1016/j.supflu.2020.104824.

[30] G. Sodeifian, S. A. Sajadian, and N. Saadati Ardestani, "Experimental optimization and mathematical modeling of the supercritical fluid extraction of essential oil from Eryngium billardieri: Application of simulated annealing (SA) algorithm," *J. Supercrit. Fluids*, vol. 127, no. January, pp. 146–157, 2017, doi: 10.1016/j.supflu.2017.04.007.

[31] M. H. Hamzah, H. Che Man, Z. Z. Abidin, and H. Jamaludin, "Comparison of citronella oil extraction methods from Cymbopogon nardus grass by ohmic-heated hydro-distillation, hydro-distillation, and steam distillation," *BioResources*, vol. 9, no. 1, pp. 256–272, 2014, doi: 10.15376/biores.9.1.256-272.

[32] Iswahyono, A. S. Saleh, S. Djamila, A. Bahariawan, and L. Komariah, "The design and build of ohmic heated hydro distillation for the essential oil extraction of eucalyptus leaves," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 672, no. 1, pp. 1–9, 2021, doi: 10.1088/1755-1315/672/1/012017.

[33] A. Rehman and S. Al-Hilphy, "A practical study for new design of essential oils extraction apparatus using ohmic heating," *Int. J. Agric. Sci.*, vol. 4, no. 12, pp. 351–366, 2014.

[34] M. Gavahian, A. Farahnaky, and S. Sastry, "Ohmic-assisted hydrodistillation: A novel method for ethanol distillation," *Food Bioprod. Process.*, vol. 98, pp. 44–49, 2016, doi: 10.1016/j.fbp.2015.11.003.

[35] T. H. Tran *et al.*, "Optimization of microwave-assisted extraction of essential oil from Vietnamese basil (Ocimum basilicum L.) using response surface methodology," *Processes*, vol. 6, no. 11, pp. 1327–1337, 2018, doi: 10.3390/pr6110206.

[36] T. P. Dao *et al.*, "Optimization of microwave assisted hydrodistillation of essential oil from lemon (Citrus aurantifolia) leaves: Response surface methodology studies," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 736, no. 2, pp. 0–8, 2020, doi: 10.1088/1757-899X/736/2/022038.

[37] T. P. Dao *et al.*, "Modeling and optimization of the orange leaves oil extraction process by microwave-assisted hydro-distillation: The response surface method based on the central composite approach (RSM-CCD Model)," *Rasayan J. Chem.*, vol. 12, no. 2, pp. 666–676, 2019, doi: 10.31788/RJC.2019.1225107.

[38] H. S. Kusuma, A. Altway, and M. Mahfud, "Solvent-free microwave extraction of essential oil from dried patchouli (Pogostemon cablin Benth) leaves," *J. Ind. Eng. Chem.*, vol. 58, no. October, pp. 343–348, 2018, doi: 10.1016/j.jiec.2017.09.047.

[39] A. Aydi, A. W. Zibetti, A. Z. Al-Khazaal, A. Eladeb, M. Adberraba, and D. Barth, "Supercritical $CO_2$ extraction of extracted oil from Pistacia lentiscus L.: Mathematical modeling, economic evaluation and scale-up," *Molecules*, vol. 25, no. 1, 2020, doi: 10.3390/molecules25010199.

[40] A. Zermane, O. Larkeche, A. H. Meniai, C. Crampon, and E. Badens, "Optimization of essential oil supercritical extraction from Algerian Myrtus communis L. leaves using response surface methodology," *J. Supercrit. Fluids*, vol. 85, pp. 89–94, 2014, doi: 10.1016/j.supflu.2013.11.002.

[41] K. Tekin, M. K. Akalin, and M. G. Şeker, "Ultrasound bath-assisted extraction of essential oils from clove using central composite design," *Ind. Crops Prod.*, vol. 77, pp. 954–960, 2015, doi: 10.1016/j.indcrop.2015.09.071.

[42] W. Dhifi, S. Bellili, S. Jazi, N. Bahloul, and W. Mnif, "Essential Oils' Chemical Characterization and Investigation of Some Biological Activities: A Critical Review," *Medicines*, vol. 3, no. 4, p. 25, 2016, doi: 10.3390/medicines3040025.

[43] F. Chemat *et al.*, "A review of sustainable and intensified techniques for extraction of food and natural products," *Green Chem.*, vol. 22, no. 8, pp. 2325–2353, 2020, doi: 10.1039/c9gc03878g.

[44] A. Djouahri, L. Boudarene, and B. Youcef, "Effect of extraction method on chemical composition , antioxidant and anti-inflammatory activities of essential oil from the leaves of Algerian Tetraclinis articulata ( Vahl ) Masters," *Ind. Crop. Prod.*, vol. 44, pp. 32–36, 2013, doi: 10.1016/j.indcrop.2012.10.021.

[45] R. M. Y. Rassem, Hesham H. A., Abdurahman H. Nour, "AUSTRALIAN JOURNAL OF BASIC AND Techniques For Extraction of Essential Oils From Plants : A Review," vol. 10, no. November, pp. 117–127, 2016.