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Review Article

COMPARISON OF MICROWAVE ASSISTED HYDRO DISTILLATION WITH STEAM DSITILLATION FOR THE EXTRACTION OF ROSEMARY ESSENTIAL OIL

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Abstract: This project majorly focuses on the comparison of the two methods namely Microwave Assisted Hydro Distillation (MAHD) and Steam Distillation (SD). The study of the extraction of rosemary essential oil and its components is characterized by the Gas Chromatography coupled with mass spectroscopy (GC-MS). The comparison of the two methods has been done on the basis of cost, energy, time and cleanliness or the environmental safety. The results according to the literature reviewed suggest that the yield of the essential oil from rosemary plant is much likely the same in both the methods quantitatively (yield) and qualitatively (aroma). But the Microwave Assisted Hydro Distillation is proven to be more efficient than Steam Distillation in terms of the cost, time, energy, and environment safety based on the research. The total time of the extraction of essential oil for 100 gm of plant was calculated to be *30 mins* for MAHD and *90 mins* for SD. In the conclusion MAHD has more advantages over the traditional SD method and therefore it can successfully replace the SD method on a pilot and industrial scale for extracting essential oil from different plants.

INTRODUCTION: Plants synthesize mainly two kinds of oils: volatile oil (essential oil) and fixed oil. The volatile compounds are so called "essential oils" because of their property of solubilizing in fats and fatty oil. This volatile compound is denoted by the term oil because it shows the viscous (not soluble in water) and hydrophobic characteristic whereas the word essential is used to designate the typical fragrance and local essence of the plant. Essential oils in aromatic plants are generally present in different proportions and different concentration. The goodness of aroma and medicine of these plants can be extracted in the form of essential oils (EO). Which can be further characterized and treated for commercial use in industries like perfume, food, medicines, cosmetics etc. Parts of the plants, such as leaves, barks, roots, buds, flowers, stems, twigs, and fruits, they all contain EOs. For example, the rose secretes etheric oil predominantly from the flowers, while the rhizome contains more aromatic oil in ginger. Volatile oil is as varied as nature itself, each type of essential oil is unique, even if they are from same plants but from different parts. There are several different methods by which essential oils can be isolated from different plants and different parts of plants. Among all the methods Steam distillation (SD) or Hydro-distillation (HD) were some of the traditional methods which has been used for the extracting essential oils from the plants. However, by hydrolysis or thermal conditions some useful components of the oils are lost or some unsaturated compounds are degraded by these conventional extraction techniques. In order to overcome these limitations Microwave-assisted Hydro-distillation (MAHD) technique which is a combination of the rapid heating of microwave field and the solvent extraction technique of the traditional method which also saves time has proven to be one of the best replacement for the conventional Steam Distillation technique.

CHEMICAL CONSTITUENTS OF THE ESSENTIAL OILS

Essential Oil consists over 200 chemical constituents, some of which are very complex than others. Oxygen, carbon and hydrogen are the major building blocks of an essential oil.

Alcohols: Alcohols are considered usually as secure and contains a very less or totally negligible toxic reactions in human body or when applied on the outer skin and therefore is safe for children. Alcohols are very useful because of their antibacterial, antiseptic and antiviral properties. They are either combined with ester or terpene or is present as a free compound and are availabe in lavender as linalool, as a compound geranium as geraniol and citronellol and as palmarosa in lemon, eucalyptus and rose. Some of the other alcohols are nerol, benzyl alcohol and menthol.

Aldehydes: Aldehydes are majorly established in oils which are lemon-scented such as limon, citronella, verbena, Melissa, etc. and comprise citronellal, neral and citral. Aldehydes normally have antiseptic properties with some specific sedative qualities. Moreover, other familiar aldehydes are cinnamic aldehyde, peril aldehyde and benzaldehyde. Plant Essential oils that contains aldehydes helps in treating viral infections, Candida and inflammation.

Terpenes: These compounds usually have names that ends with "**ene**". For example, pinene, limonene, camphene, piperene etc. Terpene compounds has antiviral, antibacterial, anti-inflammatory, antiviral, bactericidal and antiseptic. This can further be divided into sesquiterpene, diterpenes and monoterpene. When two isoprene units are combined head to tail, then it results in a mono terpene. Similarly, when 3 units are combined, it is known as sesqui-terpene and when 4 units are joined together it is called diterpenes.

Acids: Commonly Organic acids are present in small traces in their free state in Essential Plant Oils. Acids in plants act as buffer system or components to manage acidity. Acids also exhibit anti-inflammatory property. For Examples are benzoic acid and cinnamic in benzoin, lactic and Citric acid.

Ketones: Ketones that are present in plants are commonly used for upper respiratory problems. They are responsible for easing congestion and for the flow of mucus. Essential oils containing ketones are beneficial for healing wounds and is known for forming ruptured tissue. Ketones are generally non toxic**.** The toxic ketone are sage, thuja and wormwood oils, tansy, Thujone found in mugwort. Other ketones that are toxic is found in essential oils are pinocamphone in hyssops and pulegone in pennyroyal. Therefore, there are also some non-toxic ketones, they are fenchone in fennel oil, menthone and dill oil in peppermint oil, carvone in spearmint and jasmone in jasmine oil

METHODS

There are several methods by which essential oil can be extracted from the plants namely, **Maceration, Cold Pressing, Supercritical Extraction by CO_2.** But this review is based on the comparison of the conventional Steam Distillation Method and the novel Microwave-assisted Hydro Distillation.

STEAM DISTILLATION: The basic character of conventional steam distillation is that it allows a component or different mixtures of components to get distilled at a slightly lower temperature than that of their boiling point(s) of each constituent(s). Essential oils consists compounds which have boiling points upto 200°C or higher. With the existence of boiling water or steam, these compounds are volatilized at a temperature of 100°C or close, at atmospheric pressure.

Dried, or fresh, botanical plant substance is kept in the chamber of the distillation column and the vapor is allowed to pass through the plant matrix under the pressure which soothes the cells and permits the Essential plant Oil to vaporize in the atmosphere in the form of vapor. The steam temperature should be enough high to volatilize the oil present in it, but it shouldn't be very high that it ruptures the plants or burns the Plant Oils. The droplets of steam of the Oil vaporize and flows through the tube into the condensation chamber of distillation column condensation chamber. Here the vapors of Essential Plant Oil condenses with the vapors. The formation of film of essential oil occurs over the surface of the water. To isolate the Oil and water, the thin film is then skimmed or decanted from the top of the water droplets. The water left behind, is called the floral water, hydrosol or distillate which is a byproduct of the distillation. It consist the wide range of the therapeutic properties which makes it valuable for skin for the purpose of using in toners and facial mists. In some cases, the floral water is to be preferred to be pure essential oil, especially when a child is to be treated or when treating a sensitive individual, or when a very dilute oil for the treatment is required. For example rose hydrosol, is usually used for its mild soothing and antiseptic properties, and it has pleasing flowery scent.

Microwave-Assisted Hydro Distillation: The process was proposed by sir Stashenko in 2004, which works totally on the principle of conventional hydro distillation method, a part of the hydro distillation assembly line is situated in the microwave oven. The plant material is loaded with water in the reactor container that has already been kept inside the microwave oven. The cooling system and the recovery of essences part are placed outside the oven.

An improvement version of microwave assisted hydro distillation method was coined by Flamini in the year of 2006 by intstigating an insulated coaxial microwave antenna in the flask made of glass containing water and plant matrix. Therefore, the heating of the microwave appears to be very versatile & safe. It has the advantage of energy & time savings and can be used

for industrial use. Another version of this process is microwave steam distillation (MSD), which was evolved by Chemat in 2008. The process is based on the principle of traditional steam distillation process in which microwave radiation is applied only on the reactor of extraction. The cooling & the recovery part system are placed outside the microwave oven.

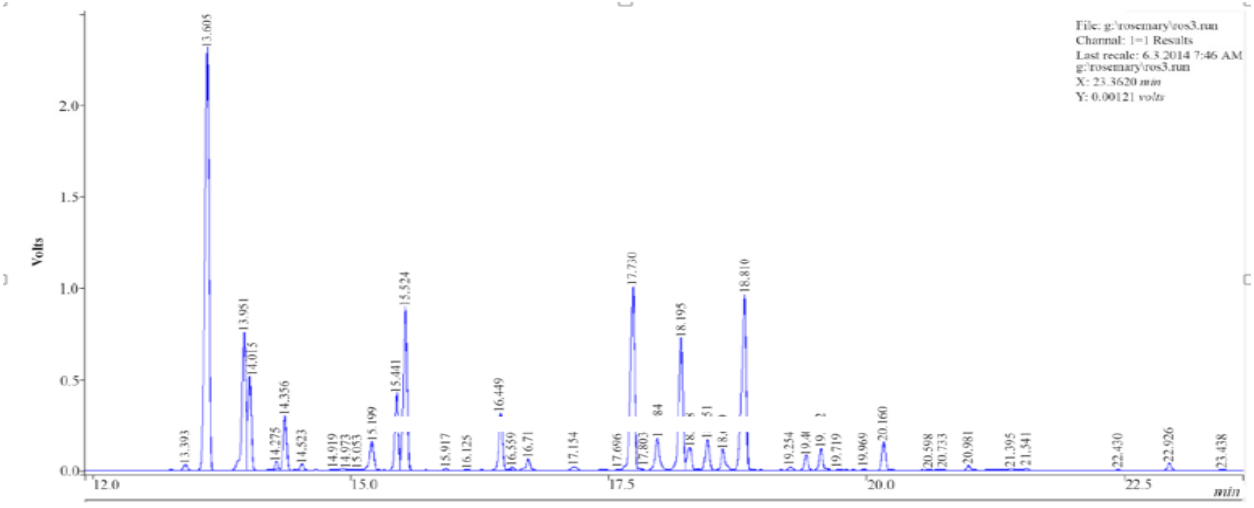
PLANT MATERIAL

Rosemary: Rosemary, is a small plant that belongs to family of the Lamiaceae and is local to the basins of Mediterranean, commonly known rosemary is known as *Rosmarinus officinalis L.* scientifically, is a perennial, woody herb with evergreen, fragrant needle-like leaves home-grown in the Mediterranean region. Rosemary is known for its antioxidant properties which are still used for extending the shelf life of the foods which are prepared. Rosemary also exhibits the powerful antibacterial activity which helps medicinally as a chemo preventive agent. Today, rosemary essential oils is broadly used in the cosmetic industry to produce various hair lotions, shampoos and bathing essences. 100g of rosemary plant matrix soaked in 2 liters of distilled water is then processed by both the methods (SD and MAHD) to extract the rosemary essential oil has been studied and reviewed in this project.

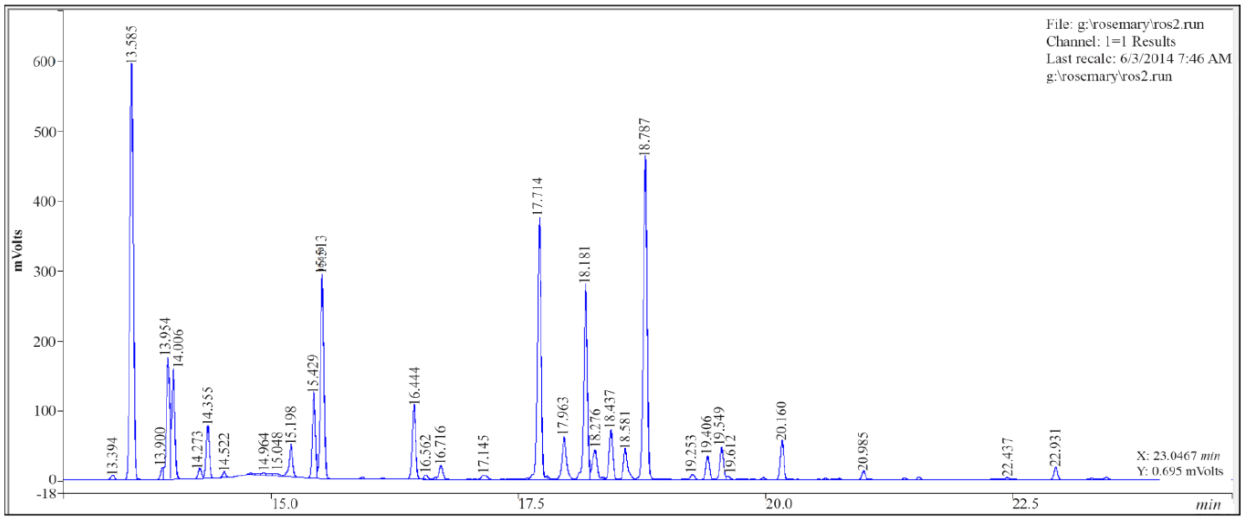
RESULTS

Effects of Extraction methods for the yield of essential oils

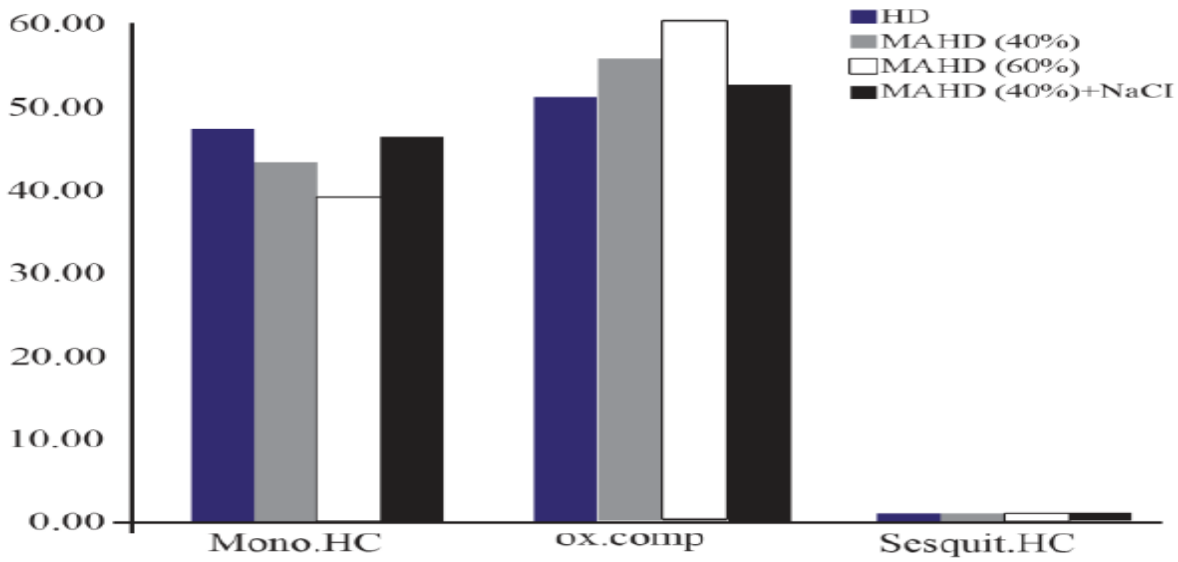
Both the extraction processes extracted the essential plant oils from the substantial parts of the rosemary produced a yellow, clear liquid essential oil. Efficiency of extraction of essential oil versus extraction time for both methods is shown in figure below. Extraction of the oil started much earlier with MAHD than with HD 10 *min for HD and* 30 *min for MAHD*, respectively. Different irradiation power of the microwaves was examined for the isolation of essential plant oil like, 180, 360 & 540 *W* (20, 40 and 60% of maximum oven power respectively). 360 *W* of power for 100 *g* of plant material was adapted as the best combination power density. 1.5 ml was the total extracted amount of the essential oil from this combination. This is because of the much effective flow of heat in microwaves. In microwave the entire sample gets heated simultaneously and even at a much high rate. Within 30 mins of the experiment yield of essential oil was achieved with MAHD. When compared to HD, process of HD requires a time period of at least 90 *min* to extract essential oil. For both the processes MAHD & HD, the extraction occurs at the boiling point of water i.e. 100^{o} *C*, at atmospheric pressure). These results are confirmed from the literature that indicates that the essential oil extracted from microwaves allows accelerated yields. Figure below shows the chromatography results obtained by both the methods. Qualitatively both the methods reflects the oil of same compositions, whereas difference was noticed quantitatively. The major compounds of the obtained essential oil from rosemary were Borneol, Camphene, Camphor, Linalool, 1,8-Cineole and a-Pinene. It was observed too that the essential plant oil was comprised of mainly compounds of oxygen 51.35-59.74% whereas, sesquiterpenes and monoterpene hydrocarbons consists 0.36-0.6% and 38.86-47.43% of it, respectively.



CHROMATOGRAPHY OF ROSEMARY ESSENTIAL OIL BY HYDRODISTILLATION



CHROMATOGRAPHY OF ROSEMARY ESSENTIAL OIL BY MIROWAVE ASSISTED HYDRODISTILLATION



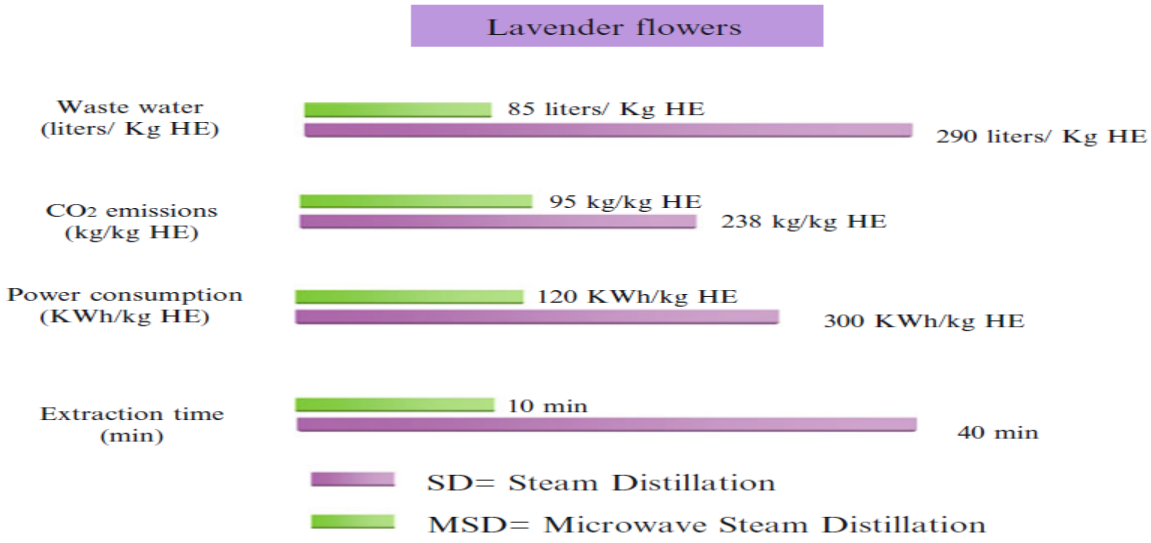
COMPARISON OF CHEMICAL COMPOSITION OF ROSEMARY BY DIFFERENT PROCESSES

Compounds of oxygen and monoterpene hydrocarbons concentrations deviated by 17% increment and decreased by 17.7% with the increase of 50% of microwave irradiation when compared to hydro distillation method. Besides, this the concentrations of these compounds decreased by 5.8% and increased by 8.3% in the presence of salt in microwave assisted hydro distillation method, respectively.

Due of therapeutic properties, flavor and aroma, oxygenated compounds is used as a quality measurement of essential oil. Essential oils having oxygenated compounds are more valuable than essential oils having monoterpene hydrocarbons in terms of their aromatic property. Therefore, higher the oxygenated compounds in microwave process higher the quality of of the oil.

Cost, cleanliness & safety considerations

Reduction in extraction cost of oil is undoubtedly the advantage for microwave assisted process in terms of energy & time. The energy needed to extract the oil, based on maximum power consumption considering the full recovery period, were 1500 *W* for HD and 180 *W* for MAHD. This indicates a substantial saving in the extraction cost when using MAHD rather than HD. The quantity calculated as per the literature the injection of carbon dioxide into the atmosphere is higher in the case of HD (1200 *g* CO2) than for MAHD (144 *g* CO2). Therefore, microwave assisted hydro distillation process is proposed to be an "environment friendly" or "green technology" extraction method suitable for extracting essential oil.



Comparison of MSD and SD for lavender essential oil for the identical extraction yield of oil.

CONCLUSION

The essential oils which is extracted by 'MICROWAVE ASSISTED HYDRODISTILLATION' are qualitatively (aromatic) and quantitatively (yield) is homogenous to that obtained by conventional method of Steam distillation. A very similar products was achieved at comparatively shorter extraction time when extracted by microwave assisted hydro distillation rather than conventional hydro distillation. Moreover, microwave assisted hydro distillation method offers more important advantages over traditional methods, for example, substantial savings of energy and relevant shorter extraction times, reduced environmental hazard i.e. less ejection of CO_2 in the atmosphere. The results of graph chromatography showed that the amount of monoterpene hydrocarbons and oxygenated components decreased and increased, respectively by microwave assisted hydro distillation method. Therefore, microwave assisted hydro distillation can be considered as a "green technology". Microwave method can be considered as a better replacement for the isolation of rosemary plant oils since it produces essential oils of comparable quality compared to traditional hydro distillation method.

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