PATCHOILI OIL EXTRACTION USING ULTRASONIC EXTRACTION METHOD

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I declare that this thesis entitled "*Patchouli Oil Extraction by Using Ultrasonic Extraction Method* " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....
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Date : 9 MAY 2008

In the Name of Allah, The Most Gracious and The Most Merciful

I humbly dedicate to .....

my beloved family members

my best friend

those who has influenced my life on the right path

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ABSTRACT

Essential oil is an aromatic liquid that is extracted from various parts of the plants. It contains the true essence of the plant. Patchouli essential oil is primarily used in the perfumery industry and has a very high commercial value due to its therapeutic properties. Recently, this essential oil has high demand all over the world due to its usages in the daily life. In this research, Patchouli oil is extracted from dried Patchouli (*Pogestemon Cablin*) leaves. The purpose of this research is to determine the best condition in order to get higher yield of patchouli oil using the ultrasonic wave. The method used in this research to extract this patchouli oil is ultrasonic extraction method. The ultrasound is used to penetrate into the leave cells to extract the patchouli essential oil from the leaves. Water is used as the extraction medium in this process. Basically, there are two parameters have been studied which are extraction temperature and extraction time. In the first experiment, the extraction time is varies into four different times which are 1.5, 2.0, 2.5 and 3.0 hours. For the second experiment, the extraction temperature is varies into four different temperatures which are 50°C, 65°C, 80°C and 95°C. Based on these parameters, the best condition to obtain the best oil yield is determined at three hours extraction time and 95°C extraction temperature.

ABSTRAK

Minyak pati adalah cecair aromatik yang diekstrak dari pelbagai bahagian dari tumbuhan. Minyak pati tersebut mengandungi minyak pati dari tumbuhan yang tulen. Pati minyak patchouli adalah bahan utama yang digunakan dalam industri minyak wangi dan mempunyai nilai yang tinggi kerana mempunyai unsur- unsur penyembuhan dan perawatan. Dalam kajian ini, minyak patchouli diekstrak dari daun patchouli kering. Permintaan tahunan bagi minyak ini adalah sangat tinggi bagi seluruh dunia kerana ia digunakan untuk pelbagai kegunaan dalam kehidupan seharian. Tujuan utama kajian ini adalah, untuk mendapatkan keadaan terbaik dari segi masa dan suhu untuk mendapat hasil minyak yang maksimum. Kaedah yang digunakan untuk mengekstrak minyak ini adalah menggunakan keaedah pengekstrakan gelombang ultrasonik. Gelombang ultrasonik digunakan untuk memecahkan dinding sel daun patchouli dan air digunakan sebagai medium untuk mengekstrak minyak patchouli. Terdapat dua parameter yang dikaji iaitu suhu dan masa. Kedua- dua parameter tersebut dikaji bagi menentukan keadaan dimana kuantiti optimum minyak dapat diekstrak. Dalam kajian yang pertama, factor masa adalah parameter yang dikaji. Masa untuk mengekstrak minyak ini telah dikaji pada masa 1.5, 2.0,2.5 dan 3.0 jam. Suhu adalah parameter yang dikaji dalam eksperimen yang kedua. Dalam eksperimen ini, kajian telah dijalankan pada suhu 50°C, 65°C, 80°C dan 95°C. Hasil daripada kajian ini, kuatiti minyak patchouli paling optimum dapat diekstrak pada masa tiga jam dan suhu 95°C.

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LIST OF SYMBOLS

%	-	Yield percentage
°C	-	Degree Celsius
T	-	Extraction temperature
t	-	Extraction time

LIST OF ABBREVIATIONS

g	-	Gram
ml	-	Mililiter
GC-MS-		Gas chromatography mass spectrometry
m	-	Mass

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays there are a lot of fragrant herb plants the can produce essential oil. One of these plants is patchouli (*Pogestemon Cablin*). Patchouli basically is a fragrant herb with opposite, egg-shaped leaves and square stems, famous for its oil. It has its origin in South East Asia and lives in tropical climes. It's botanical name is Pogostemon patchouli and it belongs to the lamiaceae family. The crop is cut two or three times a year, the leaves being dried and packed in bales and exported for distillation of the oil (available from http://en.wikipedia.org/wiki/Patchouli). This fragrant herb is a bush with furry leaves and purplish white flowers. It can grow up to three and half feet tall and it has large fragrant leaves. True patchouli has hairy stems, flowers only reluctantly, and is usually propagated by cuttings. Another species is Pogostemon heyneanus, known as Java patchouli, has smooth stems and flowers (Byers M. *et al*., 1961). Java patchouli has an inferior aroma and may show up as an adulterant in the whole leaf form or the distilled oil.

Patchouli oil is one of the important natural essential oils used to give a base and lasting character to a fragrance in perfumery industry. The dry leaves of patchouli on steam distillation yield an essential oil called the oil of patchouli. Indonesia is the major producer of patchouli oil in the world with an estimated 550 tons per year, which is more than 80% of the total (Robbins *et al.*, 1983). Currently, India is producing a large

quantity of patchouli oil and most of its domestic requirement is met by importing about 50 tons of pure oil and 100 tons of formulated oil. The crop normally responds to application of N fertilizer and plant under irrigated conditions.

Patchouli is a plant which has good economic prospect. From the patchouli leaves, it can be taken its oil. Patchouli oil has many usages in our daily life such as in aromatherapy, perfumery, spiritual use and cosmetic. Patchouli oil is an essential ingredient and used as a 'base' material in perfumery industry. Patchouli oil is considered an excellent base note and fixative in perfumery, being a component in many famous perfumes. As a fixative, it slows the evaporation of other, more volatile oils so that their aroma may be released over a longer period of time (M. Saligovt *et al*., 1996). A little can be used in natural perfume blends, adding that special deep and earthy aroma. There is no synthetic substitute for patchouli oil until today, which increases its value and demand in the perfumery market. Currently, the consumption of patchouli oil in the world is about 2000 tonnes per annum (Amir H. Barati *et al*., 2007).

The patchouli oil is processed through various methods of patchouli's leafs and small branch. Basically, there are several methods to extract the oil. For example steam distillation, supercritical solvent extraction, ultrasonic extraction, conventional distillation method etc. The leaves of the patchouli bush are first dried in the sun, and then distilled to produce thick oil, amber to dark orange in colour (Fang Chen et *al*., 2007). The smell of the Patchouli oil is very powerful with an earthy sweet and somewhat musty fragrance. The wonderful fragrance of patchouli oil cannot be believed unless one actually smells it personally. It is difficult for us to properly describe this fragrance to you, as there is really nothing that compares to it. It is certainly the most unique of all aromas.

For this study, ultrasonic extraction method will be use to extract the oil from the dried leaves. In this method, ultrasonic wave will be used to extract the oil from the leaves by using water as the extraction medium. Basically, the ultrasonic wave will form

bubble and after that will produce great force to penetrate into the cells. Several concomitant physical effects, such as the mechanics, thermotics and cavitation effect, present themselves during the propagation of ultrasonic wave in various media, and these effects have been recognized to be beneficial to many physical and chemical processes (Jianyong Wu *et al*., 2001).

Chemical engineering may be among the most that the ultrasonic enhancement technique can be applied to. Ultrasonic enhancement on mass transfer has been realized in such unit operations as leaching, extraction, adsorption and desorption (Haizhou *et al.,* 2003). The ultrasonic power supply transforms line voltage to high frequency electrical energy. This electrical energy is transmitted to the probe where it is converted to mechanical energy. The probe vibrates in a longitudinal direction and transmits this motion and immersed in the solution. Cavitations results, in which microscopic vapor bubbles are formed momentarily and implode, causing powerful infinitesimal shock waves to radiate throughout the solution in proximity to the radiating face of the tip (Ivana T. Stanisavljevic *et al*., 2006).

There are a lot of researches that have been done previously on the production of patchouli oil. The researches are done through various methods such as Soxhlet extraction, hydrodistillation method, conventional steam distillation method, maceration method, percolation method etc. Moreover, there are also previous researches that use ultrasonic extraction method to extract others essential oils. Some of the oils extracted are Salvia officinalis oil, ginseng oil, soy bean oil, olive oil, vegetables oil etc.

Most of the researches and company that produce essential oil use conventional steam distillation method for obtaining the oil of patchouli. This method is widely use for patchouli oil production. The distillation equipment needed for distilling the oil consists of boiler, distillation still, condenser and receiver. This distillation method gives higher yield and better quality of oil. But if it is distilled for to long, the oil will have disagreeable odour (Z. Hromádková *et al*., 2003). This is not a suitable method to extract

the material (oil) since it induces thermal degradation of many compounds contained in the leaves. This is the disadvantages of this method.

Basically, there are a lot of essential oil have been produced by ultrasonic extraction method. For example the oil extraction from ginseng, soy bean, oleaginous seeds, and tobacco seeds etc. In oil extraction research from ginseng showed that the used of ultrasound in the extraction process increased the yield and quality of the oil better than other methods such as maceration and stirring (Hui *et el*., 1994). In the mean time, less extraction time is needed by using the ultrasonic extraction method to extract the oil. The composition of the oil is also not affected by the use of ultrasound. This shows that ultrasonic can be use to extract the essential oil without damaging the product quality (oil).

There is also a research of oil extraction from Hibiscus tiliaceus L. flowers by using ultrasonic extraction method. The output of this research is that ultrasound enhanced the extraction efficiency and shortening of extraction time (Maria Ine Soares Melecchi *et el*., 2005) A most likely mechanism for ultrasonic extraction is an enhanced mass transfer, the improved penetration of the solvent into the vegetal due to cell disruption, and capillary effects. So, the yield of the oil extracted will be increase due to the introduction of the ultrasound wave.

There are some factors that affect ultrasound cavitation such as ultrasonic intensity, ultrasonic frequency, mass to solvent ratio, liquid properties, extraction temperature and hydrostatic pressure (Thomas V. Magee *et al*., 1995). In general, this research will be focus more on the ultrasonication time (extraction time) and temperature factors. The manipulated variables in this research will be the extraction times and temperatures. The dependent variable is the oil yield while the independent variables are volume of the solvent, solvent polarity, solvent concentration, size and amount of patchouli leaves, ultrasonic intensity and frequency.

1.2 Problem statement

Currently, the price of patchouli oil is very high due to the demand of it. The demand is very high almost every year (2000 tonnes per annum) because it has wide range usages in daily life such as aromatherapy, spiritual use, cosmetic (Fang Chen et *al*., 2007). Even many aromatics chemicals has been produce, many people still prefer the true botanical aroma.

Choosing the suitable method is very important because better method is the method that can give large yield and high quality of patchouli oil. As mentioned before, due to high demand in patchouli oil market, yield of the oil extracted is the main aspect that should be concern. These mean that this research will concern more on the output (amount of the oil produced and the quality). In order to solve this problem, suitable extraction method must be use.

In this research, ultrasonic extraction method will be use to solve the problem and certain parameter such as extraction time and temperature will be manipulate in order to get better yield of patchouli oil. The ideal or suitable condition (T & t) for better oil yield production will be determined. The oil yield extracted will be the dependent variables in this research.

1.3 Objectives of the Research Work

The purpose of this research is to study the ultrasonic extraction method and to find the suitable condition in term of extraction time and temperatures to produce high yield and quality of patchouli oil.

1.4 Scopes of Research Work

The scopes in this research work are:

1. To study the effect of different extraction time on oil yield.
2. To observe the effect of different temperatures on oil yield.

CHAPTER 2

LITERATURE REVIEW

2.1 Patchouli

Patchouli (*Pogostemon cablin*) has been used throughout the centuries and in different cultures. Patchouli was first described by botanists in the Philippines in 1845. The plant originated in Southeast Asia, and is extensively cultivated in various Indonesian Islands, India, the Philippines, Malaysia, China, and South America. (W. Lauterborn *et al*., 2007). Patchouli is also known as patchouly, tamala pattra in Sanskrit and guang huo xiang in Chinese. Today growing interest in its fragrance has led to patchouli's widespread cultivation throughout tropical Asia. It is a member of the mint family. Patchouli is also recognized as pachouli or patchouli. It is a small shrub and oil is taken out from the leaves of this shrub. The fragrance of patchouli is strong. The plant that produces this remarkable aroma is a tropical member of the lamiaceae family. Patchouli essential oil has traditionally found its uses as a traditional medicine in the East. Patchouli has been used since ancient times by countries such as China, Japan and Malaysia. Patchouli was also used for scenting clothes and the scent of patchouli is so strong that it can last for up to two weeks. In the nineteenth century patchouli is known to have been used to perfume paisley shawls. Patchouli has also been used extensively in

modern perfumery. In the 1960's patchouli essential oil was worn by hippies as a symbol of peace (Rosaˆngela Assis Jacques *et al*., 2006).

This fragrant herb is a bush with furry leaves and purplish white flowers. It can grow up to three and half feet tall and it has large fragrant leaves. True patchouli has hairy stems, flowers only reluctantly, and is usually propagated by cuttings. Another species, *Pogostemon heyneanus*, known as Java patchouli, has smooth stems and flowers. Java patchouli has an inferior aroma and may show up as an adulterant in the whole leaf form or the distilled oil(L.F. Hu *et al*., 2005).

Patchouli oil is an essential ingredient and used as a 'base' material in perfumery industry. There is no synthetic substitute for patchouli oil, which increases its value and demand in the perfumery market. Consumption of patchouli oil in the world is about 2000 tonnes per annum. In India due to increase in chewing tobacco and pan masala industries, consumption has gone up to about 300 tons per annum while the production is below 50 MT. Hence, the country mostly depends on import mainly from Indonesia and on reconstituted oil (Thomas V. Magee *et al*., 1995).

Patchouli oil is one of volatile oils which have good prospect. It is used mostly as material of cosmetic especially perfume. The market world recently needs 1200-1400 tons patchouli oil per year. 80-90% demand is supplied from Indonesia. The biggest importer is United State of America which needs 210 tons per year (M. Singh *et al.*, 2002). The other importers are United Kingdom, French, Switzerland, Germany, and Dutch.

Figure 2.1: Patchouli (Pogostemon cablin)

Table 2.1: Scientific Classification of Patchouli

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Lamiales
Family	Lamiaceae
Genus	Pogestemon
Species	P.cablin

2.1.1 Physical Properties

Oil of patchouli is thick, viscous, sticky and very slow to volatilize. The colour is being brownish-yellow tinted green. It contains coerulein which is the vivid blue compound found in matricaria, wormwood and other oils (Adusumilli Srikrishna *et al.*, 2005). High-quality oils possess an elusive, wine-like, floral sweet topnote. This topnote commands more of a presence as the oil ages (approximately one year from distillation.) The bodynote is incredibly rich, intensely sweet, woody, balsamic and earthy. The aroma can cling to a perfume blotter for weeks. Patchouli alcohol (C15H26) will have long-lasting fragrant aroma when blended with other aroma chemicals. It has diuretic

properties, therefore helpful for water retention, cellulite, constipation and overweight. It has a deodorizing action, and helps when feeling hot and bothered(D.M. Kirpalani *et al*., 2005).

2.1.2 Chemical Properties

Newly distilled patchouli oil has a fresh, green, slightly harsh aroma. As the oil ages it mellows considerably, becoming sweeter and more balsamic. Patchouli is one of very few oils that, like fine wine, improve with age. High quality patchouli oils emit a suave, fruity, wine-like top note when uncapped. The chemical components in the patchouli oil are b-patchoulene, a-guaiene, caryophyllene, a-patchoulene, seychellene, a-bulnesene, norpatchoulenol, patchouli alcohol and pogostol. The constituents of the oil include: Patchoulol (25-35%), Alpha-Bulnesene (12-20%), Alpha-Guaiene + Seychellene (15-25%), and Alpha-Patchoulene (5-9%)(Adusumilli Srikrishna *et al.*, 2005). Patchouli has a rich musky-sweet, strong spicy and herbaceous smell. It is very rich and long-lasting oil. The aroma can be rather crude when the oil is young and grows more refined with age, as it becomes valued “vintage oil”. It is non-toxic, non-irritant and non-sensitizing, but the smell of patchouli oil may be a little persistent for some people and large doses may cause loss of appetite in some individuals.

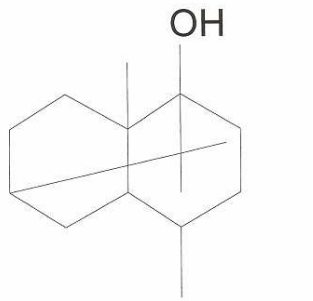

Figure 2.2: Patchoulol structure

2.2 Patchouli's Planting

Patchouli (Pogostemon cablin) is an herb native to Southeast Asia. Normally, it can be found in India, Philippines, China, Malaysia, Indonesia and Paraguay. It is growing wild in Sumatra and Java at elevations between 3,000 and 6,000 feet. For the cultivation it is more in lower tropical jungles. March – May followed by September – October is considered ideal for time of planting. Avoid planting during winter (Dec-Jan) and high rainfall period (July-August) (http://en.wikipedia.org/wiki/Patchouli). Planting in wet soil during July-August shows poor growth due to temporary anaerobic condition developed within the root zone. Planting of mother plants for propagation should preferably be done during September.-November (Rosaˆngela Assis Jacques *et al*., 2006).

A fertilizer dose of 100 kg N, 50 kg P2O5 and 60 kg K2O per hectare is recommended in planting the patchouli Basal application of 330 kg Single super phosphate (SSP) and 50 kg Muriate of potash (MOP) is done at least 2 days ahead of planting. Total quantity of 220 kg urea /hectare/ year in 4 equal splits should be applied. An extra dose of 30 kg K2O as top dressing along with 4th urea application may be done (M.Singh *et el*., 2002). It is better to avoid application of urea as basal initially. Because it will encourage weed growth and part of it will go waste as the newly planted seedlings remain unable to absorb the available N. The annual dose of NPK for subsequent years should be applied during March when there is irrigation and in May/ June without irrigation.

2.2.1 Patchouli's Harvesting

For essential oil production, the plant is cut two or three times per year, with the best quality oil derived from leaves harvested in the wet season. The leaves are hand picked, bundled or baled, and allowed to partially dry in the shade and ferment for a few days before the oil is extracted. The harvested material is spread out under shade in thin layers and is turned periodically to ensure proper drying. For higher recovery and good quality of oil, moisture content of herbage should be between 2.5 and 8.3% (M. Singh *et al* 2002). Drying normally requires 3-6 days. It, however, depends much on available sunshine and atmospheric humidity. Properly dried leaves develop characteristic patchouli aroma, which is less noticeable in fresh leaves. The fermentation process softens the plant's cell walls, easing the extraction of the oil.

The first harvest of the crop is taken about 6 months after transplanting. The stage at which crop has to be harvested is very important for good yield and better quality of oil. It has to be harvested when the foliage becomes pale green to light brownish and when the stand emits characteristic patchouli odour which could be easily smelt by a passer-by, especially in the morning hours. Subsequent harvest can be taken after every 3 months. The crop can be maintained for about 3 years. Harvesting is done with the help of small sharp shear. It is necessary to leave 4-6 juvenile sprouting buds at the basal region for fast regeneration, while harvesting. The crop should not be harvested prematurely as it results in less yield and oil of inferior quality (M. Singh *et al* 2002).

Harvesting of mature branches is otherwise encouraging the new shoots from lower sides of each branch. In selected harvesting (pruning) the plant is not getting enough stress and normal metabolic functions continue through out the growing period. Harvesting and other intercultural operations should be done from the side drains only without disturbing or compacting the root zones. This is necessary for quick regeneration by maintaining soil aeration. The selection of the branch for harvesting can be so planned a few branches attain this stage at an interval of 35-45 days (M. Singh *et al* 2002).

2.2.2 Factors Effect Patchouli Growth

Various natural or controllable factors could affect the yield, the exact character and the quality of the oil such as growth under sun and shade conditions, soil heterogeneity, quality of planting material and cultivation practices (M. Singh *et al.*, 2002). This diversity has induced some variation in the chemical composition and physical properties of the oil. As a result, the composition of patchouli oil has been the subject of a large number of studies.

Patchouli adapts itself to a wide range of soil and climatic conditions. However, it best growth in partially shaded, well - drained, fertile soil with evenly distributed rainfall or under assured periodic irrigation. Water logged soils are found to be detrimental to the crop. A moderate temperature and high average humidity have been found to be ideal for its growth. The crop grows well as an intercrop in partial shade, however complete shade has to be avoided (L.F. Hu *et al*., 2005)

The land selected for patchouli should be well-drained, loamy fertile soils, rich in organic matter. The land should not be subjected to water stagnation even for a shorter period. Heavy clay and sandy soils with poor water holding capacity are not suitable for its commercial cultivation. Best medium is riverbed sand or silt. An ideal rooting medium can be prepared by mixing 50 part sand + 50 part soil. Quickest rooting is obtained in riverbed sand. Acidic soil with pH value from 5.5- 6.2 is reported to be the ideal (Adusumilli Srikrishna *et al.*, 2005). It is advisable to avoid nematode infested areas. Patchouli prefers warm and humid climate. The crop can be grown successfully on a fairly heavy and evenly distributed rainfall ranging from 1500 – 3000 mm per annum. A temperature of 24 ºC – 28ºC is ideal. It grows successfully up to an altitude of 500 m above the mean sea level.

2.2.3 Problems During Planting

Basically there are two major problems encountered in the cultivation of patchouli which are viz. root-knot and leaf blight. Of the two, root knot has been found to be the most destructive. Treatment with suitable nematicides and proper management practices greatly reduce the root knot incidence and provide better scope for commercial cultivation of patchouli. Leaf blight can be well controlled with two sprays of Dithane z-78, 0.5% at one month interval. This, however, depends upon the severity of the disease.

During July-August in some areas leaf and stem gall disease caused by a fungus Synchytrium pogostemonis f.sp. Patchouli appears in a considerable extent. Soil application with PCNB (Penta chloronitre benzene) or Brassicol @ 5 kg/ha or 1 % Bordeaux mixture (100 g copper sulphate + 100 g lime in 10 litre water) should be done 10-15 days ahead of planting. On appearance of symptoms 2-3 foliar sprays should be given at a 7-10 days interval with copper oxychloride like Blitox 0.25 % or Bordeaux mixture @ 0.5 or Bavistin (0.25-0.30%) as control measure. This should be done after removing of affected branches. As a precautionary measure especially during monsoon one spray of Bavistin (1g/litre of water) should be given after each harvest (Ivana T. Stanisavljevic *et al*., 2006). In heavy soils of plain land impeded drainage causes root rot and wilting followed by death of plants. In plain planting in raised beds or in ridges minimizes incidence. Proper drainage should be ensured. Trichoderma viride a beneficial soil fungus when used as soil drenching helps in minimizing root rot. Application of “Redomil” (a systemic fungicide) with irrigation water or drenching the root zone found to be effective (L.F. Hu *et al*., 2005).

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Another problem is Leaf Roller (Pachyzacia stultalis). Larvae of patchouli leaf roller characteristically roll a few leaves and feed inside causing browning and drying of infested parts. Infestation is high when the crop is raised under plantation having more than 30 % shade and causes considerable damage to the crop. Sometimes the entire leaves are infested particularly during October to December. Collection and destruction

of rolled leaves followed by spraying of 2-3 rounds of methyl parathion @ 1 ml or fenvalerrate 0.5 ml/lit water will control the pest (M. Singh *et al.*, 2002).

Myriad bug (Pachipeltis spp) is another problem in planting patchouli. This bug makes small holes all over the leaf surface. The insect can be controlled by spraying Dimethoate 30 EC (Rogor, Tara 909 etc) or Monocrotophos (like Nuvacron) at 1 ml/litre of water or Malathion 30 EC once or twice (Amir H. Barati *et al*., 2007)

2.3 Usages of Patchouli Oil

The oil of patchouli is used so extensively that it is very difficult to specify its field of application. It blends well with sandalwood, geranium, vetiver, cedarwood derivatives, clove oil, lavender, bergamot and many others. The oil is almost a perfume by itself. It is widely used in soaps, cosmetics, tobacco and in scents (M. Singh *et al.*, 2002).The oil possesses antibacterial activity and it is used as an ingredient in insect repellant preparations. The dried leaves are used for scenting wardrobes.

2.3.1 Tonic

The main traditional uses for patchouli were as a tonic. Patchouli has also been used as a stimulant and as an antiseptic. Patchouli is also known to have been used for treating snake bites, for treating the stings of other poisonous insects and has also been used as an insecticide. Patchouli essential oil can also be used to help with tiredness, tension and has also been used as a treatment for obesity. Patchouli essential oil has several actions which are good for treating the causes of obesity, patchouli is reported to induce the loss of appetite and also reduces fluid retention. Patchouli can also act as an anti-depressant and can work well on all stress related conditions and anxiety (W. Lauterborn *et al*., 2007)

2.3.2 Perfumery

Patchouli oil is considered as an excellent base note in perfumery and being a component in many famous perfumes. As a fixative, it slows the evaporation of other, more volatile oils so that their aroma may be released over a longer period of time (M. Saligov/t *et al.,* 1996). A little patchouli can be used in natural perfume blends, adding that special deep and earthy aroma. It mixes well with many essential oils, with almost all common oils being mentioned across a variety of sources. These include vetiver, rosemary, sandalwood, frankincense, bergamot, cedarwood, myrrh, jasmine, rose, citrus oils, clary sage, lemongrass, geranium and ginger. Patchouli oil is used in many famous perfumes such as ‘Tabu’ and ‘Shocking’ (L.F. Hu *et al*., 2005).

Patchouli oil is a perfumery raw material, it blends well in all types of perfumes contributing a rich spicy aroma and has been used in its own right as the perfume of the 'hippies' of the 1960's and by aroma therapists. As a perfume component it contributes odour but the constituents also give the oil good fixative properties, particularly in soap perfumes. Some 'Patchouli' synthetics exist, but they are expensive and do not give the odour profile of the oil. The perfume industry has used patchouli in a number of the world’s finest perfumes, using the oil for its warm soul feeling and sensual, woody, voluptuous notes. Patchouli is found in Arpege, Tabu, Miss Dior, Opium, Paloma Picasso, Ysatis and Angel (M. Singh *et al.,* 2002).

Patchouli is used in the composition of chypre, woody and oriental perfumes. Patchouli essence has been widely used as an aromatic agent in breath-freshener sweets. Its slightly soapy scent is no longer in vogue in Europe and the United States, but is still popular in Asia and Latin America.A little patchouli oil, used as a fixative can be used in many natural perfume formulations. Patchouli oil mixes well with many essential oils including vetiver, sandalwood, frankincense, bergamot, cedarwood, myrrh, jasmine, rose and the citrus oils (M. Saligov/t *et al.,* 1996).

2.3.3 Aromatherapy

Patchouli is most often used especially in aromatherapy. In aromatherapy, it is used to help reduce tension, insomnia and anxiety, as well as just in general uplift the spirits. So far up, in fact, that it is also considered by many cultures to be an aphrodisiac. The emotional effects of patchouli are numerous. It can ease and diminish anxiety and depression. In high doses it can stimulate, and in lower doses it acts as a sedative. Patchouli helps to sharpen intelligence, improve concentration, and provide insight. Spiritually it is used in incense sticks as it helps to create a calming atmosphere.

Previously, dried leaves and stems are employed in traditional Chinese medicine to normalize the flow and balance of the life force known as qi (or chi). An aromatherapy blend inspired by the traditional Chinese use can evoke a feeling of gentle clarity and inspire the harmonious flow of emotional energy. It uses oils with balancing and mildly energizing aromas. In aromatherapy patchouli is often used as a relaxant too. The warmth and depth of its aroma make it comforting and relaxing. Patchouli's relaxing attributes, coupled with its rich and exotic nature, have led to its inclusion in sensual and amorous blends like massage oil. For these applications patchouli combines well with ylang ylang, jasmine, sandalwood, vetiver and rose. Patchouli's distinctive scent can always be relied upon to evoke (Jime´nez *et al*., 2007).

Oil of patchouli has had a long history of medicinal use in India, China and Japan. Patchouli has a sweet spicy aroma, with a hint of musk, used to stimulate the nervous system, lift depressed moods, relieve stress and give a feeling of elation and wellbeing. Patchouli is believed to help balance the endocrine system, which in turn balances the hormones of the body. The aroma assists the body to relax and promotes a feeling of peace (Fang Chen et *al*., 2007). It also stimulates the pituitary gland, which secretes endorphins, which are known for their ability to relieve pain and induce euphoria as well as sexual feelings. Just sniffing the fresh leaves can give a feeling of rejuvenation when feeling worn out. Perhaps, we need to appreciate the sense of smell

and what it can do for us, by giving ourselves just a few seconds to enjoy the perfumes growing in our garden; a natural way to relieve stress or pain and simply enhance our joy of life (L.F. Hu *et al*., 2005).

Patchouli oil may also relieve the strain of those with excessive mental activity who may feel 'out of touch' with their body and sensuality. It has been considered a relaxing aphrodisiac, and can be helpful for those with impotence, frigidity, and sexual anxiety that are products of mental anguish (I. Jerković *et al.*, 2007). Patchouli combines this aphrodisiac effect with an antidepressant one, uplifting the mind with its sweet, warm, spicy scent.

2.3.4 Topical Remedy for Skin Problems

Patchouli has traditionally been put to a great many uses, medicinally. It's probably best known for its antiseptic qualities and its use to treat skin and scalp problems such as athlete's foot, dandruff, acne, dermatitis and to help heal wounds and scars. Patchouli essential oil is also used as a topical remedy for skin problems such as acne, eczema, inflamed, cracked, chapped and irritated skin. It is known as a cell rejuvenator and helpful in healing wounds and scars. As an antifungal, patchouli oil has been used to treat athlete's foot. For the hair, patchouli oil has been used for dandruff and to aid oily hair a marked aromatherapeutic response. For the nervous system, patchouli essential oil helps to reduce tension, insomnia and anxiety. It is also know as uplifting fragrance that helps to soothe away everyday cares, and to bring about a sense of nourishment (Adusumilli Srikrishna et *al.*, 2005). In this way, and due to its wine-like intoxicating aroma, patchouli oil is also known as an aphrodisiac. Patchouli also has cell-regeneration properties and also has fungicidal properties. From these properties a large variety of skincare problems can be treated such as acne, cracked skin, burns, athlete’s foot, dandruff and eczema amongst others.

In skin care the uses of patchouli are manifold. It helps to regenerate skin cells and also helps in reducing cellulite. It is used to treat skin disorders like acne, cracked skin, some eczemas, fungal infections, sores, scars and dandruff. Patchouli also tones and tightens the skin and smoothes rough, dry and cracked skin. It acts as an anti-wrinkle agent and even as a deodorant (W. Lauterborn *et al*., 2007). Patchouli is a known curative and is used for headaches, muscle spasms, colic and angina. It is also used as a mild sedative and pain-reliever and also for fighting insomnia, anxiety, agitation and depression. It is a venous and lymphatic decongestant, making it useful for varicose veins, hemorrhoids and congestive pelvic conditions.

It is very effective with inflamed or cracked skin due to its regenerative properties. Acne, skin allergies and eczema may also respond well. It is a gentle oil and helpful with mature or aged skin. It aids in the resolution of problems associated with wrinkles and aging. It can be helpful with the re-growth of skin cells and scar tissue. Patchouli oil can assist with stress related conditions and anxiety; and is also helpful in cases of substance addictions. Energetically, this oil is considered warm in nature. It may help ground and stabilize the overanxious mind, bringing one back to one's body. Long considered an aphrodisiac, it may work through this relaxing, re-establishing connection to one's sensuality. The aroma may also uplift and work as an antidepressant for some, and has been considered to bring about a sense of spiritual nourishment (Amir H. Barati *et al*., 2007). .

2.3.5 Others

Furthermore, patchouli oil is also needed in spiritual use. Patchouli is used in temples as incense. It is said to assist in grounding and centering the mind prior to meditation. It is also produces a strong connection to the earth as such is an aid to connecting with the natural beauty of our planet.

Alternative medicine like Ayurveda has always recognized the medicinal and curative features of Patchouli. It served as anti-venom for snakebites and stings of creatures like scorpions and even mosquitoes. Victims of poisonous snakes like cobra are administered pure patchouli oil as a first aid. After that patchouli oil is mixed with any base oil such as cold pressed sesame, coconut, sweet almond, grape seed, wheat germ or sandalwood oil in a 1:1 ratio and applied twice daily until the wound gets completely healed. Stings of other creatures like bugs and mosquitoes are treated with a mixture of patchouli oil and any base oil in a ratio of 1:3 (M. Saligov/t *et al.*, 1996).

2.4 Ultrasonic Wave Extraction

2.4.1 Introduction

Ultrasonic extraction is one of the methods used to extract patchouli oil. Basically, the ultrasonic wave will form bubble and after that will produce great force to penetrate into the cells. Ultrasonic wave is referred to the acoustic wave with the frequency between 20 kHz and 10 MHz. Several concomitant physical effects, such as the mechanics, thermotics and cavatition effect, present themselves during the propagation of ultrasonic wave in various media, and these effects have been recognized to be beneficial to many physical and chemical processes (Ivana T. Stanisavljević et al., 2007).

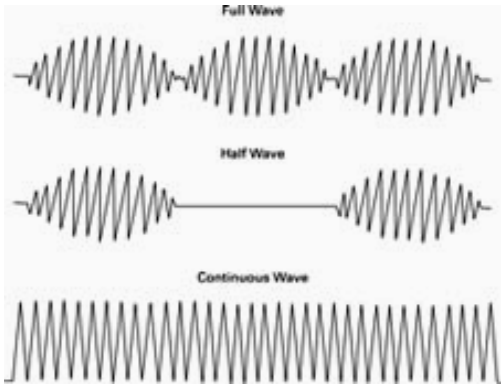

Figure 2.3: Types of Ultrasonic Waves (Full wave, half wave and continuous wave).

Ultrasound produces a series of effects when it travels across a medium that can affect mass transfer. The high intensity of the waves can generate the growth and collapse of bubbles inside liquids, a phenomenon known as cavitation (L.F. Hu *et al*., 2005). The asymmetric implosions of the cavitation bubbles close to a solid surface generate microjets in the direction of the surface that can affect mass transfer. Some other effects of ultrasound are the heating of the medium, the microstirring at interfaces and several structural effects such as the ‘‘sponge effect’’ or the generation of micro channels. Acoustic energy has been applied in order to improve mass transfer in solid–gas systems to dry products such as onions, carrots, potatoes or apples. In liquid–solid systems, ultrasounds have been applied in the osmotic dehydration of apple, in cheese brining and in meat brining (Ca´rcel *et al.*, 1998).

2.4.2 Benefits of Ultrasonic

Ultrasonic enhancement on mass transfer has been realized in such unit operations as leaching, extraction, adsorption and desorption (J.A. Carcel *et al*., 2005). In addition, in the fields of heat transfer, chemical reaction, fine particles preparation, waste water treatment and the concerning processes also benefit from ultrasonic

irradiation. The ultrasonic power supply transforms line voltage to high frequency 20 kHz electrical energy. This electrical energy is transmitted to the probe or water bath where it is converted to mechanical energy. The vibrations from the probe are coupled to and intensified by the titanium tip. The probe vibrates in a longitudinal direction and transmits this motion to the titanium tip immersed in the solution. Cavitation results, in which microscopic vapor bubbles are formed momentarily and implode, causing powerful infinitesimal shock waves to radiate throughout the solution in proximity to the radiating face of the tip (Maria Ine Soares Melecchi *et al*., 2005)

Ultrasound is an efficient non-thermal alternative. Ultrasonic cavitation creates shear forces that break cell walls mechanically and improve material transfer. This effect is being used in the extraction of liquid compounds from solid cells (solid-liquid extraction). In this case, the compound to be dissolved into a solvent is enclosed in an insoluble structure. In order to extract it, the cell membrane must be destructed. For this, ultrasound is faster and more complete than maceration or stirring. The particle size reduction by the ultrasonic cavitation increases the surface area in contact between the solid and the liquid phase significantly (Julius K. Tangka *et al.*, 2003). The mechanical activity of the ultrasound enhances the diffusion of the solvent into the tissue. As ultrasound breaks the cell wall mechanically by the cavitation shear forces, it facilitates the transfer from the cell into the solvent (M. Singh *et al.*, 2002).

2.4.3 Cavitations

Cavitation is usually considered playing the most important role in ultrasonic enhancement of membrane process for liquid–liquid and liquid–solid system. Cavitations phenomenon is referred to the formation, growth, compression, and sudden collapse of micro bubbles (cavitation bubbles) in liquids. The collapses of the micro bubbles bring significant mechanical and thermal effects, generating temperature and pressure that is above 5000 K and 500 atm (50 MPa) in the bubbles and associated with

which powerful shock wave and microstreaming with the speed of about 110 m/s are created. The implosions occur within very short lifetime, less than 0.1 μs. These effects are considered beneficial to the mass transfer of membrane process (J.A Carcel *et al*., 2005).

The macroflow of liquid resulted from the mechanical effect can promote turbulence, reduce the boundary layer, and intensify eddy diffusion. Secondly, microstreaming, shock wave and acoustic streaming can continuously stimulate the interfaces between liquid–liquid and liquid–solid, therefore refresh the interfaces. Finally, microstreaming and shock wave also lead to the disturbance of fluid in microporous medium and accelerate the fluid diffusion through the pores(Thomas V. Magee *et al*., 1995).

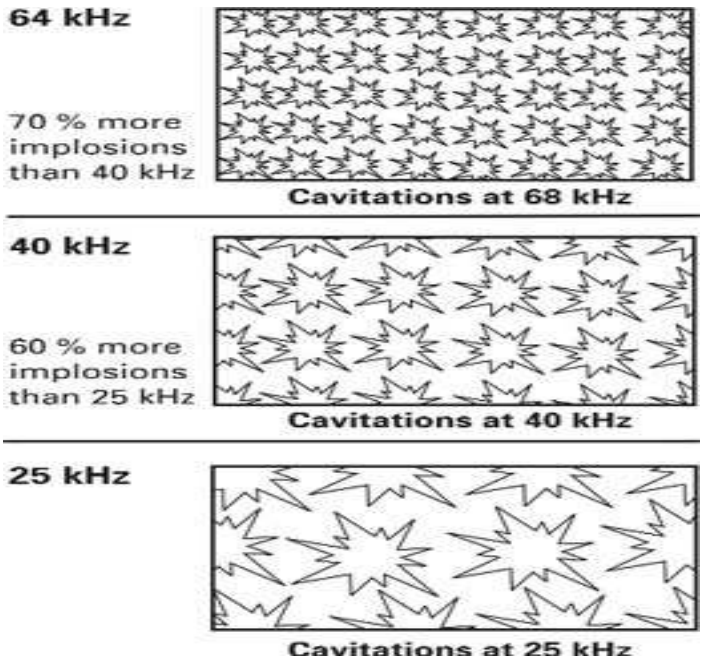

Figure 2.4: Cavitations at different frequencies

2.4.4 Factors That Influent Ultrasonic Effect

Factors such as ultrasonic intensity, ultrasonic frequency, liquid properties, temperature and hydrostatic pressure usually affect ultrasound cavitation, and ultrasonic intensity, which is defined as ultrasonic power per unit area, is the most important one (T.J. Mason *et al.*, 1996). In general, an increase in ultrasonic intensity leads to an increase in cavitation effects. Ultrasonic frequency is another important factor, under the same ultrasonic intensity, an increase of ultrasonic frequency reduces the production and intensity of cavitation in liquid. In addition, the cavitation threshold, the lowest energy required to achieve cavatition, increases with the increase of surface tension, the viscosity of liquid or the hydrostatic pressure, and with the decrease of temperature(D.M. Kirpalani *et al*., 2005).

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