TEMPERATURE REGULATION FOR HYDRODISTILLATION OF ESSENTIAL OIL EXTRACTION PROCESS FROM GARCINIA MANGOSTANA LINN (GML) PERICARP

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ABSTRACT

Garcinia Mangostana Linn (GML), commonly known as mangosteen is an emerging category of novel functional foods sometimes called “the queen of fruit”. It is presumed to have a combination of appealing subjective characteristics such as taste, visual qualities and fragrance, nutrient richness, antioxidant streangth and potential impact for lowering risk of human diseases. GML contains natural antioxidant constituents such as phenolic compounds, which have attracted a great deal of public and scientific interest due to their health-promoting effects as antioxidants. Eight hundreds (800) grams of GML pericarps were used as the raw material to produce essential oil through hydrodistillation. Temperature of distilled water was measured to study the relation between the temperature and the composition in the essential oil. HPLC analysis report shows that the significant amount component contained in GML pericarp is Ferulic Acid. The relation between the temperature and concentration of Ferulic Acid cannot be determined since the mercury thermometer cannot measure a slightly elevation of temperature precisely. Boiling-point elevation occurs due to solute dissolved in the water.

ABSTRAK

Garcinia Mangostana Linn (GML), biasanya dikenali sebagai manggis adalah kategori baru muncul makanan berfungsi novel kadang-kadang dipanggil "*the queen of fruits*". *GML* dianggap mempunyai gabungan ciri-ciri menarik subjektif seperti rasa, kualiti visual dan aroma, kekayaan nutrien, antioksidan streangth dan kesan potensi untuk merendahkan risiko penyakit manusia. *GML* mengandungi juzuk antioksidan semula jadi seperti sebatian fenolik, yang telah menarik banyak kepentingan awam dan saintifik disebabkan oleh kesan kesihatan - mempromosikan mereka sebagai antioksidan. Lapan ratus (800) grams kulit *GML* telah digunakan sebagai bahan mentah untuk menghasilkan minyak pati melalui *hydrodistillation*. Suhu air suling diukur untuk mengkaji hubungan antara suhu dan komposisi dalam minyak pati. Laporan analisis *HPLC* menunjukkan bahawa komponen yang paling banyak terkandung dalam kulit manggis adalah Asid Ferulic . Hubungan antara suhu dan kepekatan asid Ferulic tidak dapat ditentukan kerana termometer merkuri tidak boleh diukur ketinggian sedikit suhu dengan tepat. *Boiling- point elevation* berlaku disebabkan bahan larut terlarut dalam pelarut.

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LIST OF ABBREVIATIONS

g	gram
GML	Garcinia Mangostana Linn
L	litre
t	distillation time (min)
T_1	temperature of distilled water mixed with GML pericarps (°C)
T_{in}	inlet temperature of condenser (°C)
T_{out}	outlet temperature of condenser (°C)

Greek

α	alpha
β	beta
γ	gamma
μ	micro
m	milli

CHAPTER 1

INTRODUCTION

1.1 Research Background

Garcinia mangostana Linn (GML), a Clusiaceas, commonly known as "mangsoteen", is a tropical evergreen tree. It is an emerging category of novel functional foods sometimes called "the queen of fruits" presumed to have a combination of appealing subjective characteristics, for example taste, visual qualities and fragrance, nutrient richness, antioxidant strength and potential impact for lowering risk of human diseases (Moongkarndi *et al.*, 2004). GML pericarp has remarkable biological activities such as antioxidant, anti-inflammatory, antitumoral, antiallergy, antibacterial, antifungal, and antiviral activities (Kitti *et al.*, 2007). Several studies have shown that obtained xanthones from pericarp of GML have been widely used as a phytomedicine for the treatment of trauma, diahorrea and skin infections and chronic wounds in South Asia for many years (Mahabusarakam and Wiriyachitra, 1987).

Essential oils are complex mixtures of monoterpenes, monoterpenoids, sesquiterpenes, sesquiterpenoids, diterpenes, and diterpenoids (David, 2002).They contain highly volatile substances which are isolated by a physical method or process from plants of a single botanical species. The essential oils normally bear the name of the plant species from which they are derived such as Lavender oil is the essential oil extract from Lavender plant. Essential oils are so termed as they are believed to represent the very essence of odour and flavour. Furthermore, phenolic compounds contained in the essential oil are synthesized in plants partly as a response to ecological and physiological pressures such as pathogen and insect attack, UV radiation and wounding.

The GML pericarp oil is processed through various extraction methods such as hydrodistillation, steam distillation, supercritical solvent extraction, ultrasonic extraction, conventional method and so on. A dedicated extraction technique implemented in this study is hydrodistillation process. This method is the simplest and cheapest method for ease of use. In addition, hydrodistillation process is chosen in order to maximize the profit and lower the cost, while in the same time can produce a high quality of essential oil.

1.2 Motivation

GML pericarp is thrown away after the fruit has been eaten. It produces waste to the environment. Recently, more attention has been focused on the utilization of food processing by-products and waste, as well as underutilized agricultural products. Significantly, such utilization would contribute to maximize available resources and cause the production of various new products and thereby avoid waste disposal problems. In recent years, essential oil of GML pericarp is highly needed due to the usage for medical field.

1.3 Problem Statement

The quality of essential oil is a vital matter in many industries or applications. Fragile aromatic molecules contained in essential oil from plant material can be easily annihilated or modified by any changes during extraction process. It can give significant effect on the oil quality even a subtle difference in extraction process conditions. In many studies, there are several parameters such as temperature, distillation time, pressure, chemical composition and particle size are connected that have effect to extraction yield (Ozel, 2003). This paper is concentrating on the temperature variation as a controlled parameter since it is one of the most significant parameter in distillation process (Li *et al.*, 2009).

1.4 Objective of Research

The aim of this research

- To determine the effect of temperature on the composition of essential oil.
- To develop empirical model that describes the relation between the temperature and composition of essential oil.

1.5 Scope of Research

This research is an experimental study of hydrodistillation method using Garcinia Mangostana Linn pericarp as raw material. In order to realize the objective, four scopes have been identified. The scopes are:

i. GML pericarp are prepared for the experiment
ii. Hydrodistillation unit is set up and used to extract the essential oil from GML pericarps. The operating pressure is at 1 atm.
iii. The temperature will be recorded throughout the hydrodistillation experiment until equilibrium condition.
iv. The essential oil from raw material will be analyzed by using HPLC.

1.6 Main Contribution of This Work

The hydrodistillation equipment is expected to produce the best quality of essential oil from Garcinia Mangostana Linn (GML). There are some expected results from this research:

i) The equipment for hydrodistillation will be one of the most efficient and effective to produce essential oil.
ii) Potential savings in the operational cost.
iii) The environmental friendly experiment will be conducted.

1.7 Organisation of This Thesis

The structure of the reminder of the thesis is outlined as follow:

Chapter 2 provides a description of the introduction, application and benefits of GML essential oil. There are different types of technologies employed to extract GML essential oil. Furthermore, there are also variety parameters that would affect the yield and composition of essential oil. Components in the essential oil will be analyzed by various of methods.

Chapter 3 gives a review of the process of extraction of GML pericarp essential oil. Researh design flowchart will be clearly showed the flow of the process.

Chapter 4 is devoted to the results obtained from the experiment. Tables and figures will be provided to show the data obtained. Explanation about the results obtained is necessary.

Chapter 5 draws together a summary of the thesis and outlines the future work which might be derived from the model developed in this work.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This report presents the background and history of Garcinia Mangostana Linn (GML). Applications and benefits of GML will also be discussed. Essential oil obtained from different parts of GML will be compared to determine which parts of GML contained more benefits components. Furthermore, there are various technology employed to extract essential oil from GML. The extracted essential oil will be analysed by different types of technologies, thus suitable method will be chosen after understood the fundamental of each technology.

2.2 Garcinia Mangostana Linn. (GML)

Garcinia Mangostana Linn. (GML), commonly known as mangosteen grows on a tropical evergreen and is only found growing in a few places predominantly in South East Asia due to it being very climate sensitive. It is a tropical tree from India, Myanmar, Malaysia, Philippinies, Sri Lanka, and Thailand. This tree can reach 6-25 m and it has leathery, glabrous leaves and is slow to grow (Morton, 1987). GML fruit is dark purple or reddish in colour. The edible pulp is white, soft and juicy with a slightly acid and sweet flavour and a pleasant aroma (Jung *et al.*, 2006). In the ripening stage, GML pericarp can be easily torn open manually at the equator revealing the edible aril segments (Palapol *et al.*, 2009). In addition, it is affectionately referred to as “food for the Gods” in the French Caribbean and “the queen of fruits” in Asia.

GML show a limited shelf life with a beginning decay 14 days after picking. Furthermore, the ripe fruits are very sensitive towards impact damage (Kanchanapoom and Kanchanapoom, 1998). GML is not tolerated with cool temperature and low concentration of oxygen which are the common methods used to increase the storability and postharvest life of fruits. It will cause chilling injury under such conditions. Storage of GML at temperatures below 12 ℃ or a mechanical damage of the fruits induces lignin biosynthesis and lowered polyphenol content in the pericarp (Bunsiri *et al.*, 2003; Dangcham *et al.*, 2003). Consequently, GML pericarp hardens to a leather-like consistence, and the purple colour of the fruits turns into brown (Palapol *et al.*, 2009). Therefore, processing of GML is mostly realised in their cultivation areas to prevent hardening of the pericarp.

GML has compounds with antioxidant, anti-bacterial, anti-fungal, and anti-tumor activity. Laboratory testing thus far indicates that extracts of GML have activity against several cancer cell lines including breast, liver, and leukemia. GML also appears to have anti-histamine and anti-inflammatory properties. Most notably, the GML provides powerful anti-inflammatory benefits which play an important role in numerous health conditions.

Table 1 Traditional Medicinal Properties of Garcinia Mangostana Linn (GML)

Illness	References
Dysentery, Diarrhea and chronic diarrhea, Suppuration, Eczema, Thrush	Morton (1987)
Haemorrhoids, Food allergies, Arthritis, Skin infections	Pierce (2003)
Wounds	Mahabusarakam *et al.* (1987)
Tuberculosis	Suksamrarn *et al.* (2006)
Inflammation, Ulcers, Micosis	Harbone *et al.* (1999)
Affections of the genitor-urinary tracts, Mouth aphthae, Fever, Amoebic dysentery	Caius (2003)
Acne, Abdominal pain	Chomnawang (2005)
Leucorrhoea,	Moongkarndi *et al.* (2004)
Convulsants	Malawska (2005)

2.2.1 GML Pericarp

GML pericarp has been used in Thai indigenous medicine for the treatment of skin infections, wounds, and diarrhea for many years (Moongkarndi *et al.*, 2004). Since few years ago, the inner rind of the GML pericarp has been found to be effective against cancer and inflammation. The conventional understanding is that GML pericarp fight heart malfunctions, stroke, cancer and inflammation when actually it might very well be that a class of phyoto-components called Xanthones in GML pericarps are anti-fungal. Xanthones are naturally occurring biologically active group of molecule that contains a distinctive chemical structural component, namely a tricyclic aromatic ring system. This ring system makes the xanthone molecule very stable and allows it to be extremely versatile. Xanthones came from "Xanthus" in greek means yellow, thus the oil has a bright yellow colour. Several studies have shown that xanthones obtained from GML pericarps have remarkable biological activities (Suksamrarn *et al.*, 2002) Alpha-, beta-, gamma-mangostins, garcinone E, 8-deoxygartanin and gartanin are the most studied xanthones. There are fifty xanthones have been isolated from pericarp GML.

GML pericarp also contained phenolic acids, which is a secondary metabolites that create a large group of naturally occurring compounds and showing a broad spectrum of biological activities. The content of phenolics in GML pericarp is affected by the degree of maturity at harvest, genetic differences, preharvest environmental conditions, post-harvest storage conditions and processing (Naczk, 2004). Phenolic acids constitute about one-third of the dietary phenols and they are present in GML pericarp in the free and bound forms (Robbins, 2003). Clifford (1999) mentioned that daily consumption of phenolic acids ranged from 25 mg to 1 g. An increasing interest in determining the antioxidant activities exhibited by phenolic acids and their derivatives should be take note and further investigation (Haghi, 2010). Examples of phenolic class that contained in GML pericarp are:-

- Gallic acid
- Gentistic acid
- Protocatechuic acid
- 4-hydroxybenzoic acid
- Veratric acid

- Vanillic acid
- Caffeic acid
- Syringic acid
- P-coumaric acid
- Sinapic acid
- Ferulic acid
- t-cinnamic acid catechin
- Epicatechin

2.2.1.1 Antitumoral Properties

Several studies have been designed to examine the anticancer activities of xanthones isolated from GML pericarp. Ho *et al.* (2002) found that garcinone E has a potent cytotoxic effect on hepatocellular carcinoma cell lines. They found that garcinone E was the most toxic. It exhibited a very broad spectrum of dose- and time-dependent cytotoxic effects against various cancer cell lines; with the exception of lung carcinoma cell line CH27 LC-1, all cell lines tested were killed. In another study, Matsumoto *et al.* (2003) investigated the effect of 6 xanthones such as α, β and γ-mangotins, mangostinone, garcinone E and 2-isoprenyl-1,7-dihydroxy-3-methoxy xanthone are isolated from GML pericarp on the cell growth inhibition of human leukemia cell line HL60. Chiang *et al.* (2004) studied the antileukemic activity of hot water and juice extracts of 17 most used fruits in Taiwan in K562, P3HR1, Raji and U937 leukemia cells; however, only the hot water extract of GML pericarp exhibited a potent antileukemic activity. In another study performed by Moongkarndi *et al.* (2004), the antiproliferation, apoptosis and antioxidant activity of crude methanolic extract from GML pericarp was evaluated using SKBR3 human breast cancer cell line as a model. This methanolic extract had a significant antiproliferation activity by inducing apoptotic cell death.

2.2.1.2 Antioxidant Properties

Antioxidants play a key role in cleaning up the destruction caused by these free radicals. They clean house before free radicals get a chance to harm the body. Researchers have determined that antioxidants are beneficial use in the prevention of carcinogenic effects of oxidation. Mahabusarakam *et al.* (2000) found that α-mangostin and their synthetic derivatives prevent the decrease of the α-tocopherol consumption induced by LDL oxidation. They found that the structural modifications of α-mangostin modify the antioxidant activity. On the other hand, Weecharangsan *et al.* (2006) investigated the antioxidant and neuroprotective properties of four extracts obtained from GML pericarp (water, 50% ethanol, 95% ethanol and ethyl acetate). Water and ethanolic (50%) extract showed hight antioxidant capacity. However, the 50% ethanolic extract had higher neuroprotective activity than the water extract. Furthermore, Garcia *et al.* (2005) studied the antioxidant capacity of several fruits and vegetables from the Philippines by measurement of lipoperoxidation and hydroxyl radical (HO^-) scavenging. They found that the extract obtained from the GML pericarp had one of the highest antioxidant activities.

2.2.1.3 Anti-Inflammatory and Anti-Allergy Properties

Inflammation is a natural response to help heal wounds by surrounding and isolating the area of damage. It also induces a pain response to inform the brain of the damage and to attract immune cells to come to the defense. However, with people under more stress and living longer, chronic inflammatory conditions associated with arthritis, ulcers, dysentery, gum disease, neurodegenerative diseases such as Parkinsons and Alzheimers as well as heart disease suggest that the manage inflammation to reduce the damage it may cause. Chairungsrilerd *et al.* (1996) demonstrated that methanolic extract of GML pericarp inhibits the contractions of isolated thoracic rabbit aorta induced by histamine and serotonin. They suggested that α- and γ-mangostins are histaminergic and serotonergic receptor blocking agents respectively. Another study done by Nakatani *et al.* (2004) examined the effect of γ-mangostin isolated from GML pericarp on arachidonic acid cascade in C6 rat glioma cells. They found that γ-mangostin has a potent inhibitory activity on A23187-induced PGE_2 release. This inhibition was concentration-dependent, with an IC_{50} of about 5μM. The IgE receptor activates intracellular signal transductions resulting in the release of inflammatory signal mediators such as histamine and this is the primary event in several allergic responses. Based on this information, Itoh *et al.* (2008) demonstrated that xanthones isolated from GML suppresses the degranulation in Ag-mediated activation of IgE receptors in rat basophilic leukemia RBL-2H3 cells. They proposed that the inhibitory mechanism of degranulation by xanthones was mainly due to suppression of the SYK/PLCγs/PKC pathway.

2.2.2 GML Pulp

GML pulp or botanically called aril, has a long history of medicinal use in Chinese and Ayurvedic medicine. The extract of GML pulp has been used to control fever (Mahabusarakam, 1987). GML pulp is a rich source of phenolic compounds such as xanthones, condensed tannins and anthocyanins (Fu *et al.*, 2007). The degree of maturity will affect the content of phenolics in fruits at harvest, genetic differences (cultivar), preharvest environmental conditions, post-harvest storage conditions and processing (Naczk, 2004). Basically, bound phenolic acids were the predominant phenolic acids in GML pulp.

2.2.3 GML Seed

The GML seed is neither eaten nor used for any industrial purposes. GML seeds could be utilized as sources of dietary fibre and for roughage in feed for livestock due to their high crude fibre and carbohydrate contents (Ajayi *et al.*, 2003). Table 2 shows the physical and chemical properties of oil that extracted from GML seeds.

Table 2 Physical and Chemical Properties of Oil Extracts from GML seeds

Component	GML seed
Acid value (mg NaOH/g oil)	4.58 ± 0.16
Saponification number (mgKOH/g oil)	134 ± 2.14
Iodine value (mg/100g)	53.64 ± 0.15
FFA (%) as oleic acid	2.31 ± 0.08
Peroxide value (mg/g oil)	3.27 ± 0.12
Ester value (mg/KOH)	130 ± 2.14
State at RT	Liquid
Colour	Golden-orange
Specific gravity	0.98 ± 0.01
Refractive index at RT	1.482

2.2.4 Comparision between GML Pericarp, Pulp and Seed

Most of the studies with GML have focused on the pericarp as opposed to the pulp. The pulp itself probably has some beneficial compounds but the compounds within the GML fruit have not been studied as well as the GML pericarp. According to the research about the composition of phenolic acids in various parts of GML done by Ryszard *et al.* (2008), they found that the phenolic acids are mainly located on the pericarp of GML. Total content of phenols contained in pericarp is 218.1 ± 18.0 g/kg.d.m, whereas total phenol contained in pulp is 6.4 ± 0.5 g/kg.d.m. Furthermore, several studies have showed that the antioxidant activity is strongly correlated with the total content of phenolic compounds (Lim *et al.*, 2007). Consequently, research about the pericarp of GML is necessary to raise the value of GML and subsequently reduce the waste disposal. On the other hand, GML seed does not contain any beneficial phenolic compounds.

2.3 Essential Oils Extraction Methods

Techniques commonly utilized for extracting essential oils are hydrodistillation, steam distillation, solvent extraction, expressed oils, as well as fractional distillation and percolation. The method employed is depends on the type of botanical material because the composition, biological activities, and extraction efficiency of the extracted essential oils may change with different extraction method (Wang *et al.*, 2010).

2.3.1 Steam Distillation

Steam distillation is a type of separation process for temperature sensitive materials like oils, resins, hydrocarbons, and so on, which are insoluble in water and may decompose at their boiling point. Basically, most of the oils' constituents are high boiling and will decompose under the high heat needed to bring them to a boil. Steam distillation is a much gentler method of achieving the same end and it is the most widely accepted process for the production of essential oils on large scale. The fundamental nature of steam distillation is that it enables a compound or mixture of compounds to be distilled at a temperature substantially below that of the boiling point(s) of the individual constituent(s) (Satish Kumar, 2010).

In steam distillation, the distilling pot is infused with steam, and fresh, or sometimes dried, botanical material is placed in the plant chamber of the still and the steam is allows to pass through the herb material under pressure which softens the cells and allows the essential oil to escape in vapor form. After that, the steam tiny droplets of essential oil travel through a tube into the still's condensation chamber. The essential oil vapors condense with the steam. The essential oil forms a film on the surface of the water. The film is then decanted or skimmed off the top to separate the essential oil from water. The by-product of distillation, which is the remaining water, is called floral water, distillate, or hydrosol (Boutekedjiret *et al.*, 2003).

The advantages of steam distillation are that it is a relatively cheap process to operate at a basic level, and the properties of oils produced are not changed. This method apart from being economical, it is also relatively faster than other methods (Hauser, 2008).

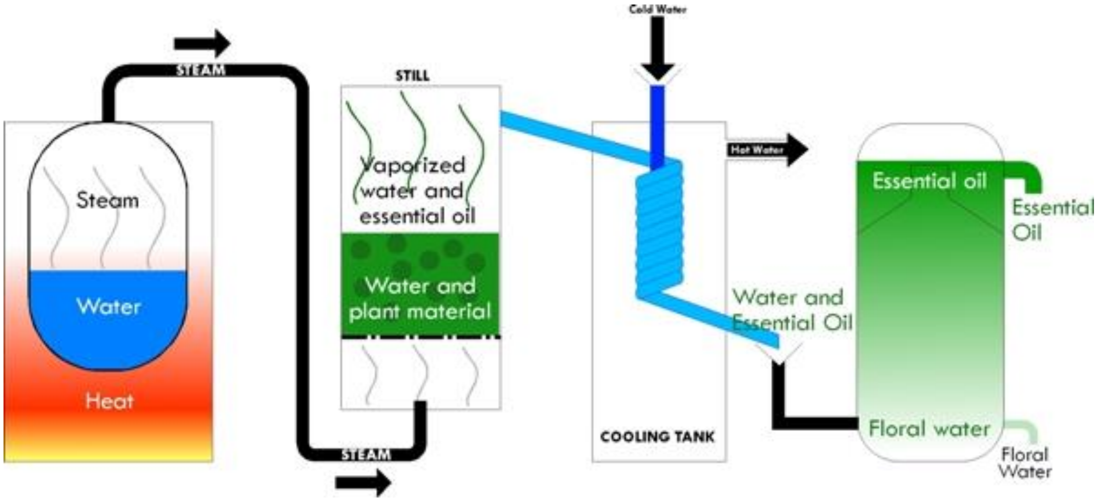

Figure 2-1 Process of Steam Distillation

2.3.2 Hydrodistillation

In the manufacture of essential oils using hydrodistillation, the botanic material is completely immersed in water and the still is brought to the boil by applying heat by direct fire, steam jacket, closed steam coil or open steam coil. The main characteristic of hydrodistillation is that there is direct contact between boiling water and botanical material. Furthermore, this method can protects the oils so extracted to a certain degree since the surrounding water acts as a barrier to prevent it from overheating. Similar to the steam distillation, the essential oil vapour condensed with steam through the condenser. The water and essential oil is then separated and the oil decanted to be used as essential oil (Boutekedjiret *et al.*, 2003). Hydro distillation can be done at reduced pressure, i.e. under vacuum, to reduce the temperature to less than 100 ℃, which is beneficial in protecting the composition of essential oils as well as botanical material. However, botanical material that contains high amounts of esters such as lavender do not employ this method because the extended exposure to hot water will start to break down the esters to the resultant alcohols and carboxylic acids.

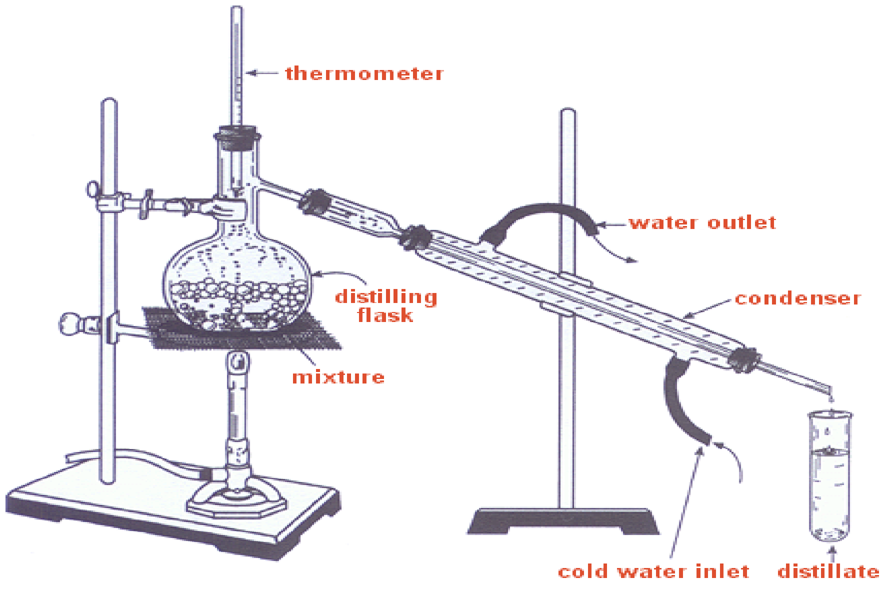

Figure 2-2 Process of Hydrodistillation

2.3.3 Solvent Extraction

Solvent extraction involves separating the constituents of the mixture based on their chemical differences instead of differences in physical properties. It depends on the selective dissolution of one or more liquid constituents of the mixture into a suitable immiscible liquid solvent. Essential oils can be extracted by using solvents such as petroleum ether, methanol, ethanol or hexane. Furthermore, it is often used on fragile material like jasmine, hyacinth, narcissus and tuberose, which would not be able to handle the heat of steam distillation. A solvent extracted essential oil is very concentrated and is very close to the natural fragrance of the material used.

The fundamental behind the extraction involved contacting of a solution with another solvent that is immiscible with it. The solvent is also soluble with a specific solute contained in the solution. After the addition of the solvent, two phases are formed due to the differences in densities. The solvent is chosen so that the solute in the solution has move affinity towards the solvent (Felder and Rousseau, 1978). This is based on the concept of an equilibrium or ideal stage which is the stage from which the resultant solution is of the same composition as the solution adhering to the solids leaving the stage. The two phases may be solid and liquid, immiscible liquid phases, or solid and gas.

2.3.4 Expression

Expression or cold pressing, just as its name implies, does not requires heat in the extraction process. In Switzerland, ‘cold-pressed’ is defined to mean that oils have reached temperatures not exceeding 50 ℃ during the entire process from seed to bottle. It is only used in the production of citrus oil which is less volatile fixed oils. The acids in the fruit juice break down and diminish the citral content of the fresh oil when heat is applied. The mechanical system used does exert great mechanical force on the plant material, which results in the raising of temperature.

2.4 Factors Affecting the Compositions of Essential Oils in Hydrodistillation

There are some parameters affect essential oil yield and chemical composition of aromatic plants. It is necessary to know the proper way of distillation in order to obtain the highest quantity and quality of essential oil since the value of essential oil is related to the quality of the oil.

A. Distillation Time

Distillation time has been shown to have an effect on essential oil yield and composition of some aromatic plants, for instance, peppermint, lemongrass, and palmarosa, orengano and pine (Cannon, 2013). The yield of the essential oil is increasing with the distillation time; however, it will come to equilibrium when optimal yield of essential oil obtained (Valtcho *et al.*, 2013). On the other words, the distillation must be stopped at the point when it is no longer economically viable to proceed.

B. Temperature

The highest quality of essential oils takes time to distill because they are extracted with low temperature. Higher temperature during the steam distillation process may alter the properties of the oil and diminishes its therapeutic properties. According to Ozel and Kaymaz (2004), applying high temperature to botanical plant that being extract may cause the extruded oil yield to experience thermal degradation. Consequently, quality of oil's chemical composition properties will reduce as it affects the oil's aromatic profiles and its physical color.

C. Pressure

Similar to the temperature, the low pressure throughout the distillation process will produce better quality of essential oil. Higher pressures will result in a 'harsh' aroma; which will produce more chemical than floral and lessen the oil's therapeutic effects.

2.5 Analysis of Essential Oils

Gas chromatography (GC) has been the method of choice for the analysis of essential oil for many years (Garnero, 1987). It dominates the analytical endeavours in fields as diverse as food, flavours and fragrance, petrochemicals, pharmaceutical and environmental studies. Capillary GC has strongly contributed to the development of the essential oils science from both the academic research and the industrial point of view such as quality control and new sources for odoriferous compounds. In addition, it is also the best method due to its simplicity, rapidity and efficiency, for both the identification and quantification of essential oils composition variations (Ester *et al.*, 2011). The compositions of essential oils can be identified using a combination of different GC techniques such as GC with flame ionization detection (FID) and determination of retention indices, GC with olfactometric detection (sniffing), GC in combination with mass spectrometry (GC/MS) and GC with element-selective detection, atomic emission detection and so on. However, the most common detection techniques applied to analyze the components in the essential oil is GC-MS and GC-FID.