Solvent Extraction of Essential Oils from Cinnamon

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Abstract

In this project, solvent extraction of essential oils from cinnamon. The essential oil from cinnamon was cinnamaldehyde with antioxidant and inhibit the growth of infection. In this study, Factor of solvent extraction affecting to yield of essential oils that extraction including to type of solvent that hexane and ethanol, time (1 hour and 3 hours) and solid to solvent ratio (1:20, 1:30, 1:40 g/ml). This experiment, 5 g cinnamon in 75 ml hexane at 75 ◦C and different time. It was found that the essential oil yield for 1-hour extraction was 0.78 % and the yield for the 3 hours extraction was 0.8% concluded extraction oil yield increase with increases time until constant. In part of solid to solvent ratio, solvent extraction by hexane condition at 60 ◦C and 350 min it was found that 1:30 of ratio had 11.50 % that higher essential oil yield. when ratio of extraction increased affects to higher yield of extraction.

Keyword: solvent extraction, essential oils, cinnamon, extraction time

เรื่อง	การสกัดน้ำมันหอมระเหยจากอบเชยโดยใช้ตัวทำละลาย
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บทคัดย่อ

งานวิจัยนี้ศึกษาการสกัดน้ำมันหอมระเหยจากอบเชยด้วยการสกัดโดยตัวทำละลาย น้ำมันหอมระเหยของอบเชยมีสารที่สำคัญ คือ ชินามัลดีไฮด์ มีคุณสมบัติต้านอนุมูลอิสระ ยับยั้งการเจริญเติบโตของเชื้อแบบคทีเรีย ศึกษาปัจจัยต่างๆที่มีผลต่อปริมาณน้ำมันหอมระเหยของอบเชยที่สกัดได้ ได้แก่ ชนิดของตัวทำละลาย 2 ชนิด คือ เฮกเซนกับเอทานอล เวลาที่ใช้ในการสกัด 1 ชั่วโมง และ 3 ชั่วโมง อัตราส่วนของแข็งกับของเหลวที่ใช้ในการสกัดมี 1:20 1:30 1:40 กรัม/มิลลิลิตร จากการทดลองสกัดอบเชย 5 กรัมในตัวทำละลายเฮกเซน 75 มิลลิลิตที่อุณหภูมิ 60 องศาเซลเซียสในเวลา 1 ชั่วโมงและ 3 ชั่วโมง พบว่าเวลาที่ใช้ในการสกัด 1 ชั่วโมงผลได้ของน้ำมันหอยระเหย 0.78 % และการสกัดในเวลา 3 ชั่วโมงผลได้ของน้ำมันหอมระเหย 0.8 % จะเห็นได้ว่าผลที่ได้ของน้ำมันหอมระเหยเพิ่มขึ้นเมื่อเวลาเพิ่มขึ้น สำหรับอัตราส่วนพบว่าการทดลองการสกัดด้วยเฮกเซนที่เวลา 50 นาที อุณหภูมิ 60 องศาเซลเซียส จากการทดลองพบว่าที่อัตราส่วน 1:30 กรัมต่อมิลลิลิตรผลได้ของน้ำมันหอมระเหยมากที่สุดคือ 11.50 % จึงสรุปได้ว่าผลได้ของน้ำมันหอมระเหยจะยิ่งมากขึ้นเมื่ออัตราส่วนมากขึ้น

คำสำคัญ: การสกัดด้วยตัวทำละลาย, น้ำมันหอมระเหย, อบเชย

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Artiteya Dachponsamrit

Table of Contents

List of Figures

List of tables

Nomenclature

J	Rate of transfer of solute per unit area or diffusion flux
D	Diffusivity or diffusion constant
C	Concentration
x	Coordinate axis in the direction of solute flow
t	Diffusion time
GC-Ms	Gas Chromatography- Mass spectrometry
HPLC	High Performance Liquid Chromatography
MIC	Minimum Inhibition Concentration

CHAPTER I

INTRODUCTION

1.1. Background and significant of the study

Essential oils (EOs) are defined as volatile secondary metabolites of plants that give the plant a distinctive smell, taste, or both. Essential oils are produced by more than 17,500 species of plants. Compounds included in the essential oils are synthesized in the cytoplasm and plastids of plant cells. The essential oils present of liquid in the leaves, stems, flowers and fruits, bark, and roots of plants. Essential oils are formed by different organic compounds that contain conjugated carbon double bonds, as well as hydroxyl groups, which can donate hydrogen, thus inhibiting free radicals and minimizing oxidative stress. Essential oils extract from different herbs work differently to antioxidant activity because each type of composition has different compounds of essential oils such as cinnamon (cinnamaldehyde), clove (eugenol), cardamom (eucalyptol). So chemical properties of herbal substances in interest is the antioxidant ability, since free radical is another risk factor that to the development of human diseases such as atherosclerosis, cancer, etc.

Humans have used essential oil for many years, not only as ingredients of perfumes or as seasonings for the aromatization of food, but also in folk medicine, because of their many different biological properties, including antimicrobial properties. In 2020, approximately 1.08 million people died and 38 million people infected all the world due to COVID-19 infection which infections of the upper respiratory tract, tuberculosis. Essential oil from herb are one of the most popular options.

In food production, using essential oil of herb instead inhibiting the growth of microorganisms by preservatives since chemical preservatives cannot eliminate several pathogenic bacteria. In addition, natural products are inherently better tolerated in the human body, usually with fewer side effects[1]. Essential oils are usually obtained as a result of hydro distillation, steam distillation, dry distillation, extraction and scarification & expression of plants.

Solvent extraction is the process of removal of a solute component from the solid by using a liquid solvent. The factors extraction of particle size (Interfacial area between the solid and solvent), solvent type (Solubility and extractability), temperature (The solubility and mass transfer), time of extraction (oil contained), ratio of solid and liquid (extractability) are the most important during the extraction process. To extract the essential oil is Soxhlet extraction method. Soxhlet extraction is one of the traditional methods used for the isolation of metabolites from plant material. The correct choice of solvent is important in order to obtain a good yield from the extraction as well as to prevent the loss of volatiles. The solvent used in this method is indicative of the polarity of the compounds extracted. The disadvantage of this technique is that, due to the long heating period, the analytes are exposed to high temperatures, which may lead to thermal degradation of some compounds. The solvent extraction is economically feasible in large scale of industries as it finds it application popular in chemical industry. This technique was found to be very effective because of high oil yield and consistent performance. In addition, this method has a negative environmental because of the wastewater generation and higher specific energy consumption.

In study, the yield extraction of the essential oils and effect of factors of extraction was carried out by solvent extraction method. The essential oils were analyzed using gas chromatography-mass spectrometry (GC-MS) to determine the chemical compound especially the essential oils.

1.2 Objectives

1.2.1 To extract essential oils from cinnamon barks by solvent extraction method.

1.2.2 To study the main parameter influencing the essential oils extraction condition from cinnamon bark with solvent extraction.

1.3 Study scopes

1.3.1 Extraction of essential oils from herbal plants example cinnamon by solvent extraction method.

1.3.2 Study variables

1.3.2.1 Type of solvent

- Hexane

1.3.2.2 Extraction time 50, 100, 150 min

1.3.2.3 Ratios of solid to liquid (g/ml)

- 1:20, 1:30, 1:40

1.4 Expected outputs

1.4.1 Understand the effect of parameters to condition for essential oil extraction by solvent extraction.

1.4.2 Understand the principle and mechanism of solvent extraction method.

1.4.3 Essential oils from solvent extraction have biological activities such as antibacterial, antifungal, insecticidal and antioxidant properties.

CHAPTER II

LITERATURE REVIEW

2.1 Essential oils

Essential oil is a secondary natural product. Most of which have Biological processes from 2-3 isoprene units formed as a monoterpene, sesquiterpene. And synthesized from shikimic acid formed as phenyl propane. It is the fact that plants make chemicals of essential oils and different odors each species depends on the various chemical component. They different in types and quantities cause different odors. The analysis of volatile oils can be classified according to the nature of qualitative analysis and quantitative analysis[2]. The results of the analysis can determine the chemical composition, concentration. There are many methods of chemical analysis techniques but the suitable method for essential oil analysis that Gas chromatography, High-performance liquid chromatography (HPLC).

Sources of essential oils

Essential oils are oil extracted from various of plant such as flowers, fruit peels, seeds, leaves, root, under the soil, bark. There plants have a special area that is responsible for storing essential oils.

1. Oil cell or Resin cells can be found cinnamon (Lauraceae), ginger (Zingiberaceae), and peper (Piperaceae).

2. Oil cavities or Oil sacs can be found Rutaceae, Mytaceae

3. Oil canals or Resin canals can be found Apiaceae/Umbelliferae, Pinaceae

4. Oil ducts can be found Asteraceae such as Chamomile

5. Glandular hairs can be found Lamiaceae

6. Internal hairs can be found Orchidaceae

7. Parenchyma or Idioblast can be found Magnoliaceae

Essential oil can be found in various parts of plants such as seed, leaves, flower, fruit peels, root, bark as detailed in Table 2.1.

Table 2.1 The sources of essential oils from various parts of the plant[3]

Parts of plant	Sample plant	Essential oil	application
Fruit	Coriander	Linalool	Oriental, spicy
	Lime	d-limonene	Toiletries, perfumes
	Mandarin	d-limonene	French bouquet
	Star anise	Anethole	Floral, orientaltyper
Rind	Bergamot	Linalyl acetate	Top note
	Grapefruit	d-limonene	Foods
	Lemon	d-limonene	Toiletries, cosmetics
	Orange	d-limonene	Perfumes, soaps
	Tangerine	d-limonene	perfumes
Wood	Cedarwood	Cedrol	Perfumes, soaps
	Rosewood	Linalool	Soaps
	Sandalwood	Santalol	Fixative
Bark	Cassia	Cinnamaldehyde	Spicy note
	Cinnamon	Cinnamaldehyde	Antioxidant activity
Root/rhizome	Angelica	Phellandrene	Musk note
	Ginger	Zingiberene	Oriental type
	Orris	Myristic acid	Perfumes, soaps
	Sassafras	pinene	Soaps, dental product
	Vetiver	Vetivenol	Fixative, soaps
Flower	Boronia	β-ionone	Fruity note
	Calendula	Calendulin	Skin products
	Carnation	Eugenol	Floral, oriental types
	Clary sage	Linalyl acetate	Soaps
	Chamomile	Azulene	Hair products
	Jonquil	Lasmone	Perfume

Lavandin	Linalool	Soaps
Lavender	Linalool	Toiletries
Mimosa	Anisaldehyde	Floral, oriental type
Rose	i-citronellol	Perfumes
Sweet basil	Methyl chavical	Perfumes

Chemical composition of essential oils

Essential oils are complex compounds each type consists of many chemical component, most often they are terpenes $(C_5H_8)_n$ compounds divided 3 types of chemical composition as follows.

1. monoterpenes, this carbon atoms 10 atoms in structure and isoprene 2 to connect.

1.1 Hydrocarbon volatile oils such as limonene, pinene, myrcene, sabinene founds that lime, lemon, orange, neroli, pine. This essential oil group, has properties to activate of the nervous system, inhibit infection, stimulating effect, antiseptic.

1.2 Ketone volatile oils such as carvone, menthone, camphor, thujone founds that sage, spearmint, caraway, hyssop. This essential oil group, has properties to tissue regeneration, mucolytic, analgesic and digestive.

1.3 Aldehyde volatile oils such as citral, citronellal, geranial founds that lemon, lemongrass, citronella, cinnamon. This essential oil group, has properties to anti-inflammatory, antiviral, antipyretic and sedative.

1.4 Ester volatile oils such as linalyl acetate, methyl salicylate founds that chamomile, bergamot, lavender, rosemary. This essential oil group, has properties to antispasmodic, antifungal, balancing effect and relax.

1.5 Alcohol volatile oils such as linalool, citronellol, geraniol, terpineol founds that lavender, tea tree, geranium, juniper, sage. This essential oil group, has properties to anti-inflammatory and antiviral.

1.6 Phenolic volatile oils such as thymol, eugenol, carvacrol found that thyme, clove, cinnamon, pine. This essential oil group, has properties to anti-inflammatory and antiviral.

1.7 Oxide/Peroxide volatile oils such as cineol, linalool oxide found that eucalyptus, cajuput. This essential oil group, has properties to expectorant, anti-inflammatory and antiviral.

2. Sesquiterpenes, this carbon atoms 15 atoms in structure and isoprene 3 to connect.

2.1 Sesquiterpene alcohol volatile oils such as bisabolol, zingiberol, patchouli alcohol, santalol found that German chamomile, ginger, patchouli, sandalwood. This essential oil group, has properties to anti-inflammatory, antiviral and stimulating glandular secretion.

2.2 Sesquiterpene volatile oils such as chamazulene, caryophyllene founds that German chamomile. This essential oil group, has properties to anti-inflammatory and calming effect.

3. Phenylpropenes, aromatic compounds of structure.

3.1 Eugenol/Cinnamic aldehyde founds that clove, cinnamon, cassia. This essential oil group, has properties to anti-inflammatory, antiviral and local anesthetic.

3.2 Anethol/Estragole found that nutmeg, basil, anise. This essential oil group, has properties to relieve muscle pain

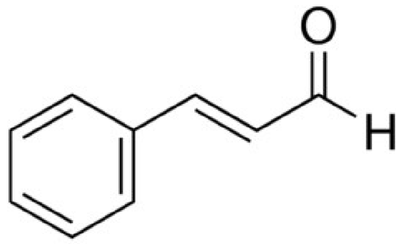
2.2 Cinnamon

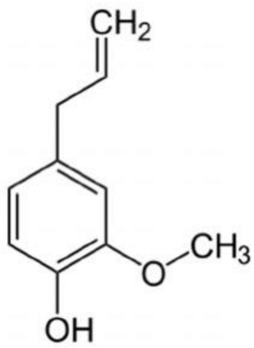
Cinnamon is spice collected from the bark of several trees from the genus Cinnamomum and Lauracea family (Kasim et al., 2014). Cinnamon is often used for medicinal purpose due to its unique properties. The essential oil from cinnamon bark is high in trans-cinnamaldehyde with antimicrobial effects against animal and plant pathogens, food poisoning and bacteria (Wong et al, 2014). Chemical composition of cinnamon oils is aromatic compounds show in table 2.2. The important components with antimicrobial are cinnamaldehyde (C_9H_8O) and eugenol ($C_{10}H_{12}O_2$).

Figure 2.1 Cinnamon bark

Table 2.2 Chemical composition of cinnamon oils from bark.

Components of cinnamon oils	Percent of component oil in cinnamon bark
Cinnamaldehyde	60.0-75.0
P-cymene	0.6-1.2
α-pinene	0.2-0.6
Eugenol	0.8
Cinnamyl acetate	5.0
Caryophyllene	1.4-3.3
Benzyl benzoate	0.7-1.0





Cinnamaldehyde **Eugenol**

Figure 2.2 Structure of cinnamaldehyde and eugenol

The antibacterial activity of cinnamon oil has a wide range of antimicrobial properties (Gupta et al., 2006). Minimum Inhibition Concentration (MIC) values of cinnamon oil against E. coli, B. subtilis and S. aureus strains of 1.6, 1.6 and 3.2 respectively and MIC values against Listeria monocytogenes and Klebsiella sp. Equal to 1.25 % by volume. Cinnamon oils have antifungal activity such as Candida albicans. Cinnamon that has antibacterial is Cinnamaldehyde. It is aldehyde group is active by inhibition bacterial metabolism and cell division by cross-linked amino groups between protein in cells, affecting the inhibition and death of infection[4] (Nirmala et al., 2013).

2.4 Solvent Extraction

Solvent extraction is the process of removal of a solute component from the solid by using a liquid solvent, it is called leaching or solid-liquid extraction. This technique for removing concentration materials from a solid by liquid solvent. Type of solvent, particle size, temperature, ratio of solid and liquid and time of extraction are the most important for extraction process[5]. Ratio of extraction resulted to mass transfer ratio and consequently extraction yield. Extraction is most quickly in the beginning when most concentration gradient (Tian et al., 2007). Try of solvent have variation in the polarity of extraction solvents[6]. The influence of temperature on extraction was investigated since it affects both the equilibrium (solubility) and mass transfer rate (diffusion coefficient). Increase of temperature result in increase of solvent velocity and quicker mass transfer. When high temperatures occur, the thermal transformation of the cell wall and the cell membrane can reduce the resistance to diffusion of intercellular solutes through intact cell walls and membranes increasing their permeability result in enhancing solubility of solute and diffusion coefficient.

Extraction time effect of concentration of solute in solvent when increase time, yield increase until constant.

Selection of solvent during the extraction of biomass is important as the chemical solvent has high selectivity and solubility the essential oils. The organic solvent should be nonpolar of oil extraction. The most popular of organic solvents as Petroleum ether Benzene or hexane. The solvent used in experiments was hexane. Hexane is a non-polar solvent. This is used to extract non-polar or hydrophobic substances such as essential oil. There are three methods of extraction of this type for solvent extraction (1) Hot water extraction. (2) Soxhlet extraction. (3) Ultrasonic technique.

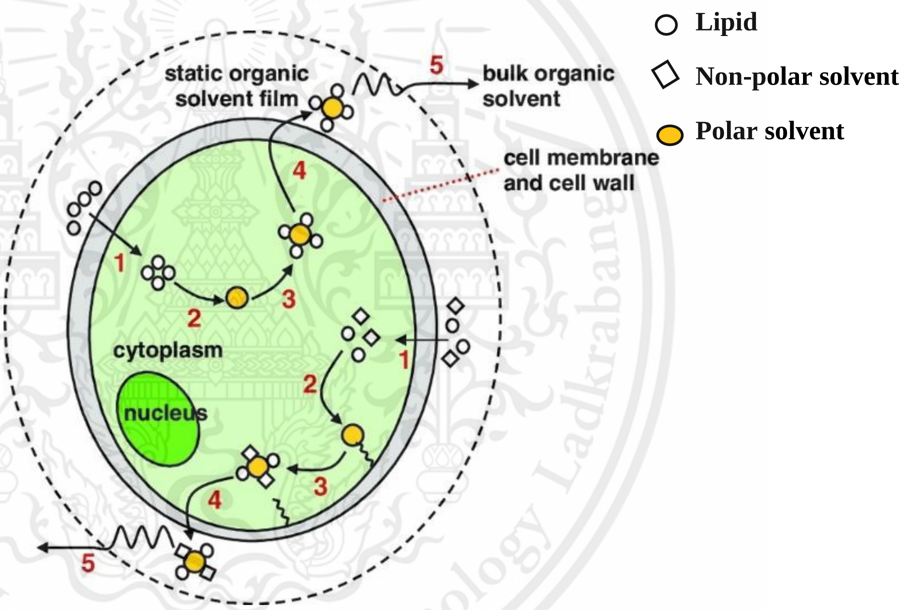


Figure 2.3 The mechanism for organic solvent extraction 5 steps.

The mechanism for organic solvent extraction is shown in figure 2.3 this can be seen into 5 steps[7].

Step 1: the organic solvent penetrates through the cell membrane into cytoplasm.

Step 2: interacts between the solvent and the solute.

Step 3: formation of organic solvent-lipids complex.

Step 4: diffusion of organic solvent-lipids complex penetrates through cell membrane, by concentration gradient.

Step 5: diffusion of organic solvent-lipids complex through solvent film into the bulk organic solvent. As a result, the oil are extracted out of the cell and remain dissolved in the non-polar organic solvent.

Diffusion

Diffusion is mass transfer process of individual molecules of substance a resulted of random molecular motion. The driving force for diffusion is usually the concentrated gradient. Diffusion moves to molecules from area in highly concentration to area in less concentrated. Rate of diffusion through unit area was Fick's first law, this equation.

$$J = -D\frac{dC}{dx} \qquad \text{2-1}$$

Fick's first law about of the diffusive flux to gradient of the concentration which a solute will move from high concentration to low concentration across a concentration gradient. Change in concentration of diffusant with time at any distance was Fick's second law, this equation.

$$\frac{dC}{dt} = D\frac{d^2C}{dx} \qquad \text{2-2}$$

That is, the diffusion coefficient (D) no ordinarily remains constant this affected by concentration, temperature, pressure, solvent properties, and the chemical nature of the diffusant. Diffusion process based in terms of solute concentration in the solid.

Sample	Solvent	Condition	Method	Analysis	Essential oil (yield)	Compound oil	Ref.
Cinnamon	Hexane	65 °C, 1 atm, 6h	Soxhlet	GC-MS	3.84%	Cinnamaldehyde 86%	[8]
	Ether	60 °C, 1 atm, 6h	Soxhlet	GC-MS	3.71%	Cinnamaldehyde 68%	[8]
	Dichloromethane	40 °C, 1 atm, 6h	Soxhlet	GC-MS	5.22%	Cinnamaldehyde 79%	[8]
	N-butane	45 min, 40 °C, ratio2	Subcritical extraction	GC-MS	3.45%	Cinnamaldehyde 62%	[9]
	Ethanol	60 min, 150 °C, ratio 15	Subcritical extraction	HPLC-MS	12.49%	Cinnamaldehyde 67.92%	[9]
	Ethanol	100 °C, 5 and 10 h	Soxhlet	HPLC-MS		5h Cinnamaldehyde 73.16% 10h Cinnamaldehyde 62.73%	[10]
Clove (bud)	Methanol 80%	72 h	Mecerater	By the Aluminum trichloride method described	16.05%	Flavonoid, phenolic	[11]
	Acetone 80%	72 h	Mecerater	By the Aluminum trichloride method described	18.33%	Flavonoid, phenoile	[11]
	Ethanol	6 h	Soxhlet	GC-MS	41.80%	Eugenol 51.24%	[12]

Table 2.3 Research related of essential oil of cinnamon and clove

CHAPTER III

EXPERIMENTAL

Cinnamon oils

3.1 Materials and equipment

1. cinnamon powder
2. hexane
3. shaker extraction
4. vacuum filtered
5. rotary evaporator vacuum

3.2 Procedures

3.2.1 Plant material

Cinnamon bark from market. The collected samples were ground to fine powder by a cutting mill and pass through a 500-250 µm.

3.2.2 Condition for effect of parameter to essential oil extraction by solvent extraction

Table 3.1 Condition for effect of parameter in experiment

parameters	Effect of time	Effect of ratio	Effect of solvent
Cinnamon powder	5 g	2 g	5g
Solvent	75 ml	40,60,80 ml	75 ml
Extraction of time	1, 3 hr	50 min	3 hr
temperature	60 ºC	60 ºC	60 ºC
Shaker	150 rpm	150 rpm	150 rpm

3.2.3 Effect of different solvent on the yield of the extract

1. 5g cinnamon and 75 ml solvent (ethanol, hexane), under condition at 60 ◦C, 1 hour and 150 RPM of shaker extraction.

2. Then the extract was vacuum filtered and products were collected and purified using rotary evaporator vacuum.

Table 3.2 Adjust rotary evaporator vacuum condition of hexane.

Temperature	50 °C
Rotary	19 rpm
Time	15 min
Pressure pump	360 mbar
Cooling water	25 °C

3. After rotovap, the samples were left under fume hood for one hour to make sure all the solvent left in the oil was completely vaporized to environment.

4. Calculate cinnamon oil yield.

<u>The yield of the extract (%)</u>

Cinnamon oil yield = [Cinnamon oil (g)/ Cinnamon powder(g)] x 100

Figure 3.1 Essential oil of cinnamon by hexane extraction

3.2.4 Effect of ratio on the yield of the extract

1. 2g of cinnamon powder and 40, 60, 80 ml of hexane respectively mixed in Erlenmeyer flask Then loaded into the shaker.

2. Adjust condition of shaker extraction, 60 ◦C of temperature, 50 min of time and 150 RPM of shake.

3. Then the extract was vacuum filtered and products were collected and purified using rotary evaporator vacuum.

4. After rotovap, the samples were left under me hood for one hour to make sure all the solvent left in the oil was completely vaporized to environment.

3.2.5 Effect of extraction time on the yield of the extract

1. 5 g cinnamon and 75 ml of hexane mixed in Erlenmeyer flask Then loaded into the shaker.

2. Adjust condition of shaker extraction 60 ºC temperature 1 hour and 3 hours of time and 150 RPM of shake.

3. Then the extract was vacuum filtered and products were collected and purified using rotary evaporator vacuum.

4. After rotovap, the samples were left under fume hood for one hour to make sure all the solvent left in the oil was completely vaporized to environment.

5. Calculate cinnamon oil yield each time.

CHAPTER IV

RESULTS AND DISCUSSION

In this study, effect of parameter influencing to essential oil extraction by solvent extraction. Four independent variables were extraction temperature (ranging from 40 to 60 ◦C), extraction time (ranging from 50 to 150 min), ratio of solid to liquid (1:20, 1:30,1:40, 1:50 g/ml) and solvent (ethanol and hexane). The dependent (response) variable was cinnamon extraction yield.

4.1 Effect of solvent on the yield of the extract

Figure 4.1 Extract of cinnamon oil by different types of solvent (A) Ethanol and (B) Hexane

This experiment investigated the chemical components of cinnamon oil by different solvent extractions. As a result, it was found that cinnamon oil extraction by ethanol solvent has a darker oil color and extraction by hexane have a light-yellow color which was shown in figure 4.1, Because of different solvent polarity and different solubility. Ethanol a polar solvent for extracting hydrophilic substances effectively extracts in flavonoids and their glycosides, catechols, and tannins from raw plant materials [13]. Thus, the extract by ethanol has a brown color because extracts other substances in addition to essential oils. Flavonoids were major components in the polar extract of cinnamon by ethanol solvent. Hexane was a non-polar solvent extracting hydrophobic substances. The essential oils were major components in a non-polar extract of cinnamon by hexane solvent. So, the hexane extract has a light-yellow color.

The different extractability of antioxidants by solvent extraction caused by the polarity of the solvents may be responsible for the differences in the antioxidant activity (Banji Adaramola et al. 2016). A report of Ying Liang et al. (2017) showed extracts of cinnamon oil, it was found that n-butane was more sensitive to L. monocytogenes, S.aureus, E.coil, and S.anatum than ethanol extracts[9]. Due to n-butane was non-polar like hexane which can extract more Cinnamaldehyde than ethanol. So, the comparison on antioxidant activity of extracts from hexane was better than ethanol. Extracts obtaining from hexane had better antibacterial activities and more potential to be used as food preservatives than ethanol extracts.

4.2 Effect of time on the yield of the extract

The result from this experiment was fixed by 50 ml hexane solvent, 5 g cinnamon powder, temperature 60 ◦C, and carried out with extraction time of 1 and 3 hours. The essential oil yield for 1-hour extraction was 0.78 % and the yield for the 3 hours extraction was 0.8% as shown in figure 4.2. These results showed that the longer the extraction process, the higher of oil yield. So, the result from this experiment agreed with the result of the report by Ibtehal K. Shakir. However, time does not significantly support the final total oil yield because of the diffusion and driven nature of oil extraction where the rate of oil is controlled by liquid to solid ratio[7].

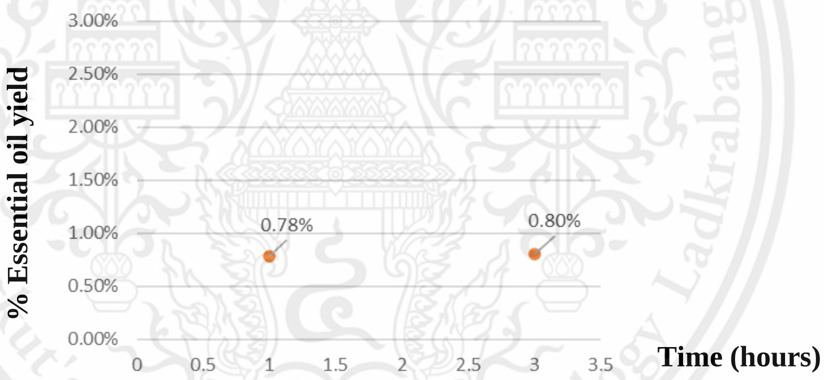


Figure 4.2 The effect on oil extraction yield with time for experiment

Ibtehal K. Shakir from University of Baghdad et al. (2018) investigated the effect of different times of essential oil extraction from the myrtus communis L. plant. It was found that, at start time the yield will increase faster in range 10-100 min and constant in over time. The mass transfer of the solute from solid to liquid solvent have two steps of process. The first step is the diffusion from the inside of the solid material to its surface, and second step is the mass transfer from the surface of the solid material to liquid solvent. This resulted in Figure 4.3 different the extraction time. It can be seen that the rate of oil extraction yield increased first at gradually increase time due to the plant matrix contacted to the solvent, the free oil on the surface of matrix extracted quickly resulted in a high extraction rate. After that, the concentration of oil will increase in the solvent with increased time but decrease the rate of diffusion[14]. The extraction yield will reach a constant value by increasing time and equilibrium will reach according to Fick's second law equation.

$$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2} \qquad 4\text{-}1$$

Diffusion coefficient (D) depends on concentration (C) of diffusion in the concentration of solute dissolving in the solvent with time (t) is $\frac{\Delta C}{\Delta t}$. So, concentration increase in the solvent with increases time until concentration gradient equal to zero resulted in flux equal to zero (diffusion stop) that into equilibrium.

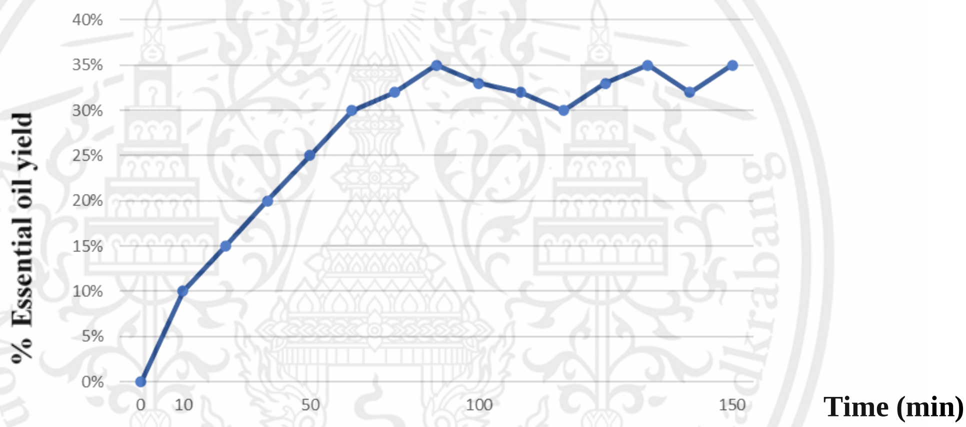


Figure 4.3 The effect on oil extraction yield with time for Ibtehal K. Shakir[14]

4.3 Effect of ratio on the yield of the extract

The solid to solvent ratio on solvent extraction studied with four ratios (1:20, 1:30; 1:40, 1:50 g/ml) at 60 ◦C and 50 min. The experiment results in figure 4.4 showed that the highest yield was 1:30 solid to solvent ratio and decreased in 1:40 and 1:50 g/ml. This result was not in agreement with the principle of solvent extraction because extraction efficiency increased with the decreased ratio for this experiment. In this study, the lower yield of ratios 1:40, 1:50 might result from the evaporation of hexane during extraction. By taking into consideration the extraction time and cost the ratio, 1:30 was chosen as the optimum. The ratio that too high results in excessive consumption of organic solvent, while a ratio that too low leads to handling difficulties and incomplete extraction[15].

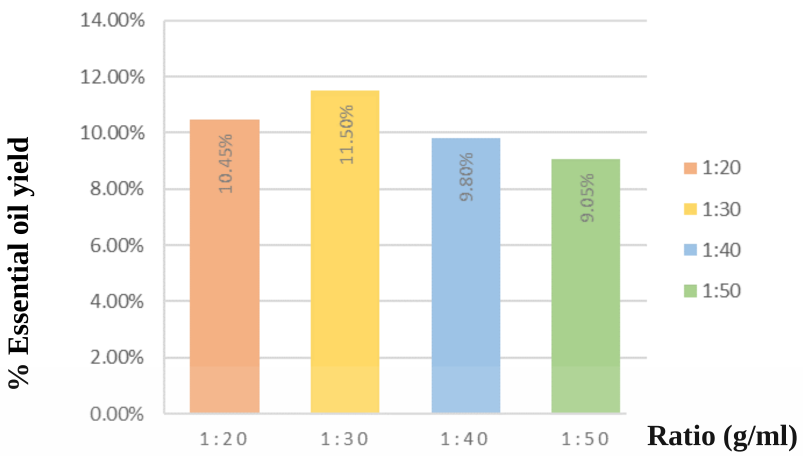


Figure 4.4 The effect of ratio on oil extraction yield for experiment

In a study by Ronald Halim and Paul A. Wedley (2012), extraction was most quickly in the first time when had the most concentration gradient. since solvent contacts with solid materials, solute in the solid materials transferred to the solvent phase[7]. When concentration in the solvent increased the rate of mass transfer decreased, finally reached equilibrium.

CHAPTER V
CONCLUSION

5.1 conclusion

In this experiment, study effect of parameters to condition for essential oil extraction by solvent extraction. The result show that three variables, extraction time, solid to solvent ratio and solvent all have influence on essential oil yield. It was found that, suitable extraction time of this solvent extraction was 1 hours with reduction energy cots and suitable solid to solvent ratio from this condition experiment was 1:30 g/ml ration because higher oil yield. Solvent extraction used hexane as solvent because polarity and solubility of hexane extract essential oil higher than ethanol as hexane was low boiling point, it easy to remove on essential oil. In part temperature, Increase of temperature resulted in increase of solvent velocity and quicker mass transfer (Elbashir et al. 2002)[16]. But if used high extraction temperature, will have the effect is polymerization, cinnamaldehyde might have lost its composition and thermal degradation of oil.

Therefore, all parameter in experiment affects both the equilibrium (solubility) and mass transfer rate (diffusion coefficient). It means that the mass transfer from surface of solid phase into liquid phase a result of diffusion coefficient influence by extraction time, ratio, solvent and temperature on extraction.

5.2 suggestion

5.2.1 Study on other solvent that affect the essential oil yield.

5.2.2 Study on other parameter such as temperature and particle size that affect the essential oil yield.

5.2.3 Study on optimize the essential oil extraction condition with solvent extraction.

5.2.4 The mass calculation to ensure the presence of essential oil in dried cinnamon.

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APPENDIX

APPENDIX

RESULT OF ESSENTIAL OIL

1. Cinnamon powder and hexane mixed in Erlenmeyer flask Then loaded into the shaker.

Figure A 1 Solvent extraction by shaker.

2. The extract was vacuum filtered and products were collected and purified using rotary evaporator vacuum.

Figure A 2 (A). vacuum filtered and (B). rotary evaporator vacuum.

3. The samples were left under me hood for one hour to make sure all the solvent left in the oil was completely vaporized to environment.

Figure A 3 Essential oil mixed solvent.

4. Calculate cinnamon oil yield by finding the weight of cinnamon oil.

Figure A 4 Weight to find yield.

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