MICROWAVE ASSISTED EXTRACTION (MAE) OF CASTOR OIL FROM CASTOR BEAN

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ABSTRACT

The purpose of this research is to extract the castor oil by using the microwave assisted extraction (MAE) by using ethanol as solvent.Beside that,this research also to investigate the influence of extraction time on castor oil yield.As for the last objective is to characterize the main composition from the castor oil by using the GC-MS.The solvent used in this method is ethanol due to relatively good absorber for microwave energy.In this research, the methods used were drying, grinding, extraction, separation and analysis.From the research, the highest oil yield is at 60 minute with 58% ,followed by by 50 minute with 55%,40 minute with 53 %, 30 minute with 50 %,20 minute with 47 % and lastly 10 minute with 45%.The major components of castor oil detected by GC-MS are ricinoleic acid,linoleic acid and oleic acid.

MIKROWAVE PENGEKSTRAKAN BANTUAN (MAE) MINYAK JARAK DARI KACANG JARAK

ABSTRAK

Tujuan kajian ini adalah untuk mengeluarkan minyak jarak dengan menggunakan pengekstrakan yang dibantu oleh mikro (MAE) dengan menggunakan etanol sebagai pelarut.Selain itu, kajian ini juga untuk menyiasat pengaruh masa pengekstrakan terhadap minyak jastor.Objektif yang terakhir adalah untuk mengenal pasti ciri-ciri komposisi utama dari minyak jarak dengan menggunakan GC-MS.Pelarut yang digunakan dalam kaedah ini adalah etanol kerana penyerap yang agak baik untuk tenaga mikro.Dalam kajian ini, kaedah yang digunakan adalah pengeringan, pengisaran, pengekstrakan, pemisahan dan analisis.Hasil daripada penyelidikan,minyak jarak yang tertinggi terhasil pada 60 minit dengan 58%, diikuti oleh 50 minit dengan 55%, 40 minit dengan 53%, 30 minit dengan 50%, 20 minit dengan 47% dan akhir sekali 10 minit dengan 45%. Komponen utama minyak jarak dikesan oleh GC-MS adalah asid ricinoleik, asid linoleik dan asid oleik.

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LIST OF SYMBOLS

%	Percentage
°C	Degree celcius
έ	Dielectric constant
g	Gram
L	Litre
mm	Millimeter
mL	Mililitre
µl	Microlitre
µm	Micrometer
RPM	Revolution per minute
Tan σ	Dielectric loss
W	Watt
y1	weight of beans before (g)
y2	weight of beans after (g)

LIST OF ABBREVATIONS

FID	Flame ionization detector
FTIR	Fourier Transform InfraRed
GC-MS	Gas chromatography/Mass Spectrometry
MAE	Microwave assisted extraction
Nh	No heat under microwave
PD	Physiological dormancy
PM	Particulate matter
VOC	Volatile organic compounds
et al.	An others

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays with dwindling petroleum resources, to find alternative sources of energy has become the world urgent need resolve issues. Castor oil is renewable resources, majority of the series petroleum products can be obtained from the castor oil deep process. Regarding by the experts castor oil can be great potential for development of renewable oil resources. Therefore, the promotion of cultivation of castor-oil plant is a strategic choice. Castor is one of the world's top ten oil-bearing crops and it is important industrial raw materials also. The chemical derivatives of castor oil generated more than 170, series of products over 3000 items, and has a special purpose and tremendous

value. The United States marked castor oil as one of the eight strategic materials; France use castor oil to produce nylon 11 resin technology as the country-level secrets. Castor oil and its deep process products such as nylon 11 resin, 12 - hydroxy stearic acid is widely used in medicine, aerospace, aviation, military, communications, machinery manufacturing, fine chemicals and other high-tech fields.

The castor bean (Ricinus communis) plant belongs to the Euphorbiaceae family (Rosid clade) and is a perennial shrub with large, palmate lobed leaves and sharply toothed leaf margins. The leaves are usually deep green, but in some strains they have a reddish cast. The fruit is a quarter-sized, round, spiny capsule, often reddish, containing up to three shiny, smooth, mottled seeds. Beside that, castor bean, has been widely accepted as an agricultural solution for all subtropical and tropical location with low input costs. In other hand, castor bean also does not compete with food crops, as castor bean can be grown on marginal lands, which are not competitive with food production lands .Castor bean seeds are highly toxic to humans and many animal, ingestion of two beans can be lethal to humans. The action of ricin, the toxic water-soluble protein, is well characterized. Ricin accumulates in the seeds, but is also found at lower concentrations in the leaves. The seed coat must be damaged to allow water to penetrate the seed interior for ricin to be absorbed in the intestines.

The castor oil has been known for a long time as industrial oil and also has reputation for its medicinal use. In addition, castor oil and its chemical derivatives are used as a raw materials for different types of products in many chemical industries .The widely uses of castor oil comes from its main components, ricinoleic acid (12-hydroxy-9-cis-octadecenoic acid), which show almost 90 % of the vegetables triglycerides. (

Nezihe, Elif, Ozlem and Tuncer, 2011).According to Windholz (1976), the castor oil is characterized by a fatty acid composition of ricinoleic acid (87%), oleic acid (7%), linoleic acid (3%), palmitic acid (2%),stearic acid (1%), with trace amount of dihydroxy stearic acid. Among vegetable oils, castor oil is distinguished by its high content (over 85%) of ricinoleic acid. A crude castor oil is a pale straw color, but turn colourless or slightly yellowish after refining and bleaching. The crude oil has distinct odors, but is can be easily deodorized in the refining process (Akpan,Jimoh& Mohammed,2006).

The oil is not only a naturally-occuring resource, it is also inexpensive and environmentally friendly.Relative to other vegetable oil, it has a good shelf life ,but it cannot be left to freeze while kept in storage in order to kept the quality of the oil.India is the world's largest exporter of castor oil,other major producers being China and Brazil.(Ramos, Tango, Savi,&Leal,1984).The characteristics of castor oil from other countries such as Brazil,Nigeria,India,China and Africa had been studied.However,only a few research has been carried out on castor oil of Malaysia (Salimon,Mohd Noor,Nazrizawati, Mohd Firdaus& Noraishah,2010).

Castor oil has been used for coating fabrics and other protective coverings, in the manufacture of high grade lubricants, transparent typewriter and printing inks (Duke, 1983).Beside that, castor oil is a non-traditional raw material used for the production of biodiesel. Biodiesel is a fuel made from vegetable oils,animal fats and microbial oil (Garnica, Da Silva & Wolf Maciel, 2009).The raw materials are converted into biodiesel through a chemical reaction involving alcohol and a catalyst (Salimon et al.,2010).

There are many technologies used to obtain vegetable oil such as mechanical pressing, solvent extraction ,soxhlet extraction,hydraulic pressing , expeller pressing and microwave assisted extraction .Hydraulic pressing,expeller pressing and solvent extraction are far the most commonly employed technique for oil extraction (Goss, 1946). Expellers are generally used for oilseeds having very high oil content (above 20%). For oilseed feedstocks with relatively low oil content (18 -20%) ,direct solvent extraction is utilized for oil recovery (Gunstone, 1986 ; Bernardini, 1976).

1.2 Problem Statements

Until recently, much effort has been put on developing process for the production of castor oil. Some of the extraction method are soxhlet extraction ,mechanical pressing ,solvent extraction and so forth. However, these methods have their own disadvantages such as time consuming in soxhlet extraction and for mechanical pressing it have low recovery. Meanwhile, as for the solvent extraction need longer processing time and high amounts of solvents required and hazardous operating conditions as compared to others methods like pressing .

Currently, Malaysian castor plantation sector lagged behind other Southeast Asian countries, lack of castor plant cultivation enterprises and raw material processing plant. However, because of Malaysia's geographical and climatic conditions are very suitable for cultivation of castor oil plant, therefore, we believe that future prospects for the cultivation of castor oil plant in Malaysia is in advantages. For economic, ecological and agricultural development prospects are very bright.

Beside that, in Malaysia , the castor seeds have been planting in order to fulfill the request of castor seeds from the China. Casa Kinabalu Sdn.Bhd. is one of the company in Malaysia that responsible for plantation and production of castor seeds .However, the castor bean is exported to the China .In contrast, India is the world leader in castor bean production followed by China and Brazil.They not only plant the castor

plant but also processing the castor oil for various users such as for the production of biodiesel, coating,lubricants and greases.

Based on the above situation, we are proposing to use the Malaysian castor seed in the extraction. In this study, MAE technique may not be novel but the process of extraction of castor oil with this technique is novel.Microwaves-assisted extraction (MAE) has the advantages over the conventional methods as it result into better yield and highly pure products within a short time. Beside that's, lower amount of solvent needed, drastic decrease in the extraction time and operation at a relatively lower temperature are added advantages to this technique.

1.3 Research Objectives:

Firstly, to cover on the production of castor oil from Malaysian castor seeds by using the MAE.Secondly, we want to characterize the main composition of castor oil product.

1.4 Scope Of Research

The scope of this research are :

(1) To extract the castor oil from Malaysian castor bean by using the microwave assisted extraction (MAE) method .

(2) To investigate the influence of extraction time on castor oil yield.

(3) To characterize the main composition from the castor oil by using the gas chromatography that is ricinoleic acid, linoleic acid and oleic acid .

1.5 Significance Of The Research

There are several significant of this study that can be review from the previous research paper .The most important thing is to find the alternative method for the better extraction for the castor seeds. Moreover, this microwave technique is cost effective simple, reduce the energy and also time .The amount of solvent also can be reduced. In other hand, the attractive feature of using ethanol for oil extraction from castor seeds include low cost, easy synthesis from a large variety of biological feedstock, and it is less toxic nature. In fact, the significant of this study also for a better yield of production of castor oil that can be improved by using the microwaves assisted extraction method .Therefore, MAE is slowly replacing the conventional methods.

Castor bean is chosen in this research because it is become naturalized in tropical and warm temperate regions throughout the world including Malaysia. In addition, it is the source of castor oil , which has a wide variety of uses.The seeds contain between 40 % to 60 % oil that is rich in triglycerides mainly ricinoleic acid. Moreover, castor bean does not compete with food crops as castor bean can be grown on marginal lands which are not competitive with food production lands .

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this part, we divided into four main part. Firstly, we discuss about the cross section of castor seeds .Secondly, we elaborate about the fatty acid composition in the castor oil. Third, we explain more about the various type of extraction method for castor seeds. Lasly,we explain on the factors that affecting MAE.

2.2 Cross Section Of Castor Seeds

As it can be seen in figure 2.1, the bulk of castor bean seeds are endospermic , the embryo is spatula teaxile, and the seed has physiological dormancy (PD). The cotyledons are thin and broad and the endosperm is the major storage tissue. Castor bean seeds are a classical system for studying endosperm reserve breakdown, especially for lipid and protein mobilization. The cells of the endosperm of castor bean seeds undergo programmed cell death after their oil and protein reserves have been mobilized. Castor bean seed germination is epigeal and the cotyledons of the seedling absorbed the nutrients from the endosperm, which encloses the cotyledons until its obliterated.(Endospermic seed structure (Eudicots); Euphorbiaceae – castor bean- Ricinus communis, n.d)

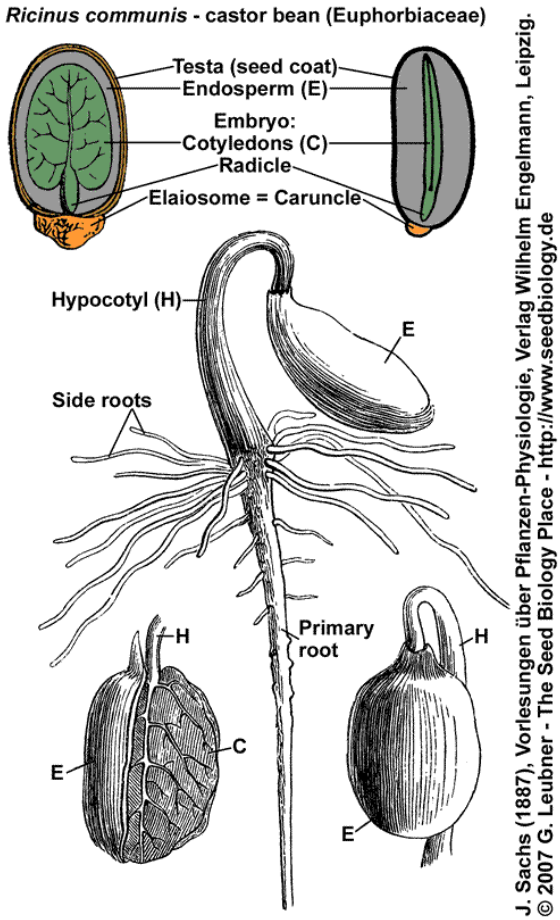

Figure 2.1 : Cross section of castor seed

Source : Endospermic seed structure (Eudicots); Euphorbiaceae – castor bean- Ricinus communis, n.d.

2.3 Fatty Acid Composition

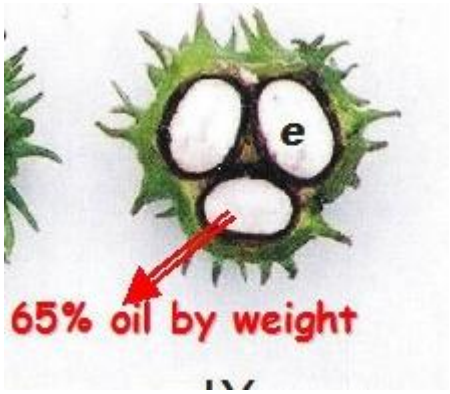

Figure 2.2 : The cross section of castor seed that contain oil

Source : Plaxton & Shane n.d.

Meanwhile, in the figure 2.2, it show that , in the cotyledons contains 65 % oil by weight .The castor oil is rich in very unique hydroxyl fatty acid, that is ricinoleic acid $C_{18}H_{34}O_3$, structurally as cis-12 hydroxyoctadeca-9-enoic acid, 18 carbon hydroxylated fatty acid having 1 double bond. As mention by Nezihe *et al.(*2011), the fatty acid composition of the oil was determined (87.2% ricinoleic acid, 5.5 % linoleic acid, 3.8 % oleic acid, 1.6 % stearic acid, 1.4 % palmitic acid, and 0.5% linolenic acid). The percentage of crude lipids extracted from castor beans and their chemical properties are shown in Table 2.1.In this table, it shows that Malaysian castor seeds contain relatively high percentage of total lipids content 43.3 % which is still in the same range as reported by Gupta and Hilditch (1951); (35.7% -51.9%) for the African castor oil. As mention by Koutroubas, Papakosta and Doitsinis (1999) reported that oil content was affected by both locations and castor oil genotypes.

Table 2.1 : Characteristics of Malaysian castor oil

Parameters	Value
Lipid content (%)	43.3
Moisture content (%)	0.2
Iodine value (mg/g)	84.5
Acid value (mg/g)	4.9
% free fatty acid	3.4
Peroxide value (meq/kg)	10.2
Saponification value (mg/g)	182.9
Unsaponifiable matter	3.4
Viscosity (cP)	332
Refractive Index at 25°C	1.47
Average molecular weight	937.7

Sources : Salimon *et.al*.,2010

In the table 2.2, shows the fatty acid composition of castor oil for different countries such as Malaysia, Brazil,and India.The highest fatty acids shows for all country are ricinoleic acid .As for Malaysian castor oil shows the ricinoleic acid comprise over 84.2% of the total fatty acid composition.Other fatty acids present were linoleic (7.3%), oleic (5.5%), palmitic (1.3%), stearic (1.2%) and linolenic (0.5%). The unsaturated fatty acids content was 97.5% of the total fatty acids composition. The ricinoleic acid content from India and Brazil castor bean oils were 94.0% and 90.2% (Gupta et al. 1951) which were higher than Malaysian sample. Low ricinoleic acid content of Malaysian castor bean oil was possibly due to the different in climatic