Solvent Extraction of Oil from *Arachis hypogaea* Seed – The Effect of Extraction Time and Type of Solvent

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***Abstract*— Vegetable oils are being used extensively due to their wide application mainly in food industry and can be derived from various seeds, nuts and fruits. *Arachis hypogaea* or better known as peanut or groundnut is popular as reliable oil source with wide applications and potential. In this study, the extraction of oil from *Arachis hypogaea* was performed by using solvent extraction technique. Optimization of parameters which are the extraction time (hr) and the type of solvents were investigated by using one-factor-at-a-time (OFAT) method. Meanwhile, the temperature, solid-to-liquid ratio and particle size were kept constant at 60°C, 1:6 and 710 µm respectively. The optimum values obtained for extraction and type of solvent were found to be 4 hr and ethyl acetate respectively with oil recovery of 48.27 %.**

Keywords*— *Arachis hypogaea, peanut, seed oil, solvent extraction

I. INTRODUCTION

Peanuts are recognized by other names such as earthnuts, ground nuts, goober peas, monkey nuts and pygmy nuts. The peanut plant is a herbaceous plant consisting of a few type, which are Boro red, Boro light, Ela, Mokwa, Guta and Campala [1]. It is believed to have originated from southern Bolivia and North Western Argentina. Currently, the crop is mostly cultivated in the tropical and temperate regions of the world. The peanut plant can grow from 30 to 50 cm tall. It has two major subspecies in which the pattern of their branching differs from one another. For instead *Arachis hypogaea* subsp. *hypogaea* have an alternate branching and *Arachis hypogaea* subsp. *fastigiata* have sequential branching [2]. The colour of flowers range from light yellow to deep orange and sometimes white in colour. Usually, the plant blooms three flowers per inflorescence at the axils of the leaves [3]. The pod zone where the pod is located, is usually at a depth of 7-10 cm in the soil [4]. The pod usually contains between two to five seeds. The seed shape may be elliptical or round and is covered with a protective coat that ranges in colour from off-white to deep purple [3].

Cooking and deep frying have been the greatest use of peanut oil. This is because it has a high smoking point of 227 °C allowing food to cook faster with minimum oil absorption [5]. In India, peanut oil is popular in the manufacturing of Vanaspati which is the vegetable version of ghee, a type of clarified butter [6]. Other than that, peanut oil is also used to create soft conditioning bar soap with long lasting lather [7].

Vegetable oils are oils that can be found in various seeds, nuts and fruits. Other than being extensively used in the food industry such as cooking oil, vegetable oil are also popular in the soap production, candles and perfumes [8]. Oil from different sources has different characteristics because of their respective composition which determines their usefulness in variable of applications [9]. Some research has been done to study the application of vegetable oil in phytocosmetology. From the research, grapes and argan oil triggered a decrease in the concentration of melanin which leads to the recommendation of such oils to be utilized in dermo-cosmetic products that aims to reduce skin pigmentation [10]. Examples of vegetable oils include coconut oil, olive oil, corn oil, palm oil and peanut oil. An oilseed may be enclosed by a protective coating known as hull, husk or shell. These protective coatings are usually removed prior to processing the oilseed as it has very minimum utility [11].

Vegetable oils has been increasing in demand because of their wide applications. Nowadays, there are many people who started practicing vegetarianism and they have been shifting their diet to the vegetarian base. In the past few years, the demand for vegetable oil has been increasing steadily. This is mainly due to the increase in human population which leads to the increase in consumption. Also, various health benefits have been proven because of the high bioactive lipid level in the vegetable oil [7]. Hence, it is important to find alternative sources for vegetable oil in order to meet the world’s rising demand towards vegetable oil.

Extraction of oil by mechanical pressing is the oldest and simplest technique that is known. In this technique, crushing and pressing are the fundamentals in its operation, where mechanical tools such as screw expeller and piston are usually used. Due to its simplicity, economical and low maintenance, mechanical extraction is the most common technique being used for oil extraction globally. However, it does not have high extraction efficiencies and needs further treatments, such as filtering and degumming [12]. Another technique that is available for oil extraction is the Soxhlet extraction. It is a very simple technique which can be easily operated and can extract higher sample mass. However, this technique requires a long time for extraction and also a large amount of solvent is wasted [13].

Solvent extraction is the use of chemicals as solvents in the extraction of oil from oilseeds. It is suitable to extract oil from oilseed with low oil content and is capable to extract almost all the oil presents and leaves behind only 0.5% to 0.7% oil residual [14]. Solvent extraction method is preferred over other extraction method because its processes has many advantages in terms of cost, yield and also time. In solvent extraction, one of the important factor that

greatly influences the quality of the oil extracted is the type of solvent used.

Enhancements can still be made to the existing method of extraction to give the best oil yield. The extraction process can still be improved by optimizing the process variables that are available such as temperature, extraction time and also the liquid to solid ratio [15]. Therefore, this research intends to study the optimum conditions in the solvent extraction of *Arachis hypogaea* seed oil by using one-factor-at-a-time (OFAT) method. Two process variables which are the type of solvents used and different extraction time will be considered.

II. METHODOLOGY

A. Preparation of Raw Materials

The peanut (*Arachis hypogaea*) used in this study was purchased from Tesco Hypermarket. Firstly, peanuts that are of good quality was chosen to be used in the extraction while spoilt seeds were disposed. The peanuts was milled using a dry mill and sieved through a 25-mesh sieve (710 µm) shaker. Afterwards, the peanut was dried in an oven at 100℃ for 8 hr to remove moisture. The peanut samples from the sieve with size of 710 µm were used for the experiment. Prior to the extraction, 5 g of the peanut powder was weighed and placed in an Erlenmeyer flask [16].

B. Solvent Extraction

The solvent extraction was performed in an incubator shaker with controlled temperature at 60 and constant shaking speed of 150 rpm. A predetermined amount of ethyl acetate solvent 30 ml (solvent to solid ratio 6:1) was added to the Erlenmeyer flask containing 5g of sieved peanut. The flask was then sealed with a parafilm and covered with aluminum foil and was placed in the shaker for 1 hr. After the extraction, the mixture was allowed to be cooled and after then was subjected to a centrifuge in order to separate the liquid and solid layer at 10,000 rpm for 10 min. Thereafter, the solvent was removed from the liquid extract by a rotary evaporator. The extracted oil was allowed to cool and then was weighed until a constant weight was achieved. The extraction was repeated using different extraction time (2 hr, 3 hr, 4 hr, 5 hr) and using different types of solvent (methanol, ethanol and ethyl acetate).

C. Determination of Arachis hypogaea oil yield

The yield of *Arachis hypogaea* seed oil was calculated using Equation 1 shown below [16]

$$\text{Oil yield (\%)} = \frac{\text{Mass of extracted oil (g)}}{\text{Mass of sample (g)}} \quad (1)$$

The experiment was performed in replicates and the oil yield obtained was based on an average measurement.

D. GC-MS Analysis of Chemical Constituents of Arachis hypogaea Seed Oil

In the analysis of *Arachis hypogaea* seed oil, 1 ml of sample oil was injected into a gas chromatography mass spectrometer (GC-MS) equipped with flame ionization detector and capillary column. Helium was used as the carrier gas at a constant flow rate of 3.0 mL/min. The column temperature was first set to 60℃ and later increased to 180 ℃ at a rate of 10 ℃/min and was maintained at 180℃ for 10 min, followed by an increase to 270℃ at a rate of 5 ℃/min, where it was held for an additional 5 min. The temperatures of the injector, ion-source, and detector were set to 260℃, 230℃, and 150℃, respectively.

III. RESULTS AND DISCUSSION

A. Effect of Extraction Time on Peanut (Arachis hypogaea) Oil Yield

In solvent extraction, time is an important parameter as appropriate extraction time will result in time and cost saving. Figure 1 shows the effect of extraction time on the oil yield extracted from peanut. The oil yield increases gradually from 20.47% to 48.27% with increasing extraction time from 1 hr until 4 hr. Such observation could be due to constant shaking or stirring which aids in the disruption of the cell wall barrier and also allows better solvent penetration into solid matrices and facilitates dissolution of solute which is the oil into the bulk solvent [17].

However, the oil yield began to decline after 4 hr where the oil yield dropped to 45.97% at 5 hr. This observation confirmed that the oil yield has attained equilibrium at 4 hr. The phenomenon could be related to Fick's second law of diffusion which explains that equilibrium will be attained after a certain period of time, between the solute concentration in the solid matrix and in the bulk solution [18]. Furthermore, Chew, et al. [19] in his study on the effect of solvent concentration, extraction time and extraction temperature on the extraction of phenolic compounds of *Orthosiphon stamineus* reported that by extending the extraction time, it may lead to a decrease in the extract yield as the extraction is further exposed to unfavourable environment factors such as light, temperature and oxygen which may causes the oxidation of compounds. Sun, et al. [20] in his study on the optimization of phenolic antioxidants extraction from kudingcha made from *Ilex kudingcha* C.J. Tseng by using response surface methodology reported similar finding where the phenolic antioxidants extracts started to decline over 1 hr due to the prolonged extraction time.

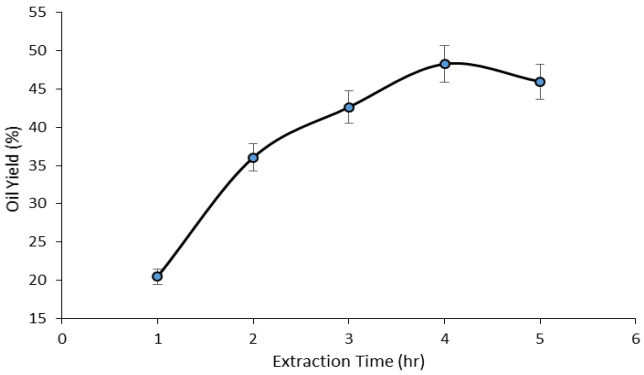

Fig 1: Effect of different time of extraction on peanut (*Arachis hypogaea*) oil yield. (Conditions: ethyl acetate as a solvent, extraction temperature 60℃, solid-to-liquid ratio 1:6 g/mL)

B. Effect of Type of Solvents on Peanut (Arachis hypogaea) Oil Yield

Figure 2 shows the results of oil yields extracted from peanut under experimental conditions for different extraction time and solvents. From the results reported, it can be seen that ethyl acetate presented remarkably higher yield followed by ethanol and methanol with yield percentage of 48.37%, 26.63% and 23.94% respectively. Chauhan, et al. [21] in his study reported that the oil yield from peanut at 29% and 29.88% were obtained by using ultrasound assisted extraction technique and soxhlet extraction technique respectively. The extraction was done by using n-hexane as the solvent for 4 hr.

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The efficiency of solvent in the extraction varies with the nature of the solvent itself [22]. Polar solute is soluble in polar solvent and vice versa. Methanol, ethanol and ethyl acetate have polarity indexes of 4.3, 5.3 and 6.6 respectively. From the observation, it can be said that the maximum oil yields from peanut seems to correspond with the polarity of the solvent where oil yield obtained is lesser as the polarity index of the solvent increases. Peanut has high content of oleic acid which render them a non-polar lipid [23]. This explains further on why oil yield obtained is maximum when ethyl acetate was used. In comparison with the study done by Dasari and Goud [22], it was reported that the highest extraction of oil from castor seeds which was at 49.1% was obtained by using ethyl acetate.

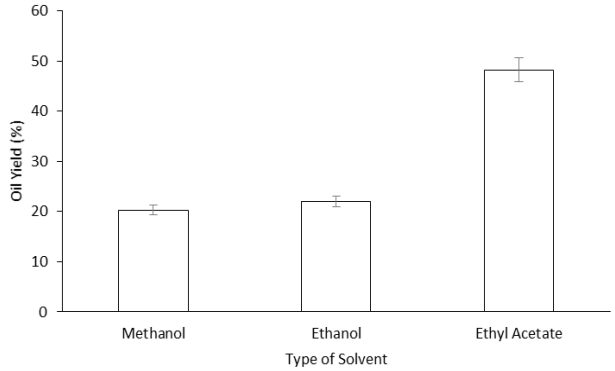

Fig 2. Effect of different types of solvent on peanut (*Arachis hypogaea*) oil yield. (Conditions: extraction time 4 hr, extraction temperature 60°C, solid-to-liquid ratio 1:6 g/mL)

C. Chemical Constituents of Peanut (Arachis hypogaea) Oil

The chemical components of extracted peanut oil was analyzed using gas chromatography-mass spectrophotometer (GC-MS). The chemical constituent of peanut oil was listed in Table 1. Fatty acid found in vegetable oils is composed by saturated and unsaturated fatty acids which are further classified as monounsaturated or polyunsaturated fatty acids [24]. Usually, oil from peanut has the highest content of saturated fatty acids which consists of 16 to 18 carbon atoms [25].

Oleic acid which was detected at retention time 26.83 min is an unsaturated fatty acid that can be naturally found in animal and vegetable fats. Lim, et al. [26] in his study has discovered that oleic acid normalizes and increase fat oxidation which helps to increase fat burning. Also, in the study done by de Silva, et al. [27], people that consume more oleic acid is less likely to develop ulcerative colitis compared to those who consumes less. In addition to its health benefits, oleic acid is being used in the production of aerosol as an emulsifier [28].

Palmitic acid was found at retention time 24.12 min. It is also known as hexadecenoic acid, a saturated fatty acid with 16 carbon atoms. It is one of the most naturally abundant saturated acid that can be found in plants like palm oil, milk and beeswax. Due to its special structure it has a functional role in fetal development and during infancy [29].

Stearic acid with IUPAC name of octadecanoic acid is a saturated fatty acid with 18 carbon atoms that was found in the peanut at retention time of 26.51 min. It is mainly used in the production of detergent and soap by saponification. Apart from that, stearic acid is also listed by Food and Drug Administration (FDA) in the 1981 product formulation data table as it mostly found in every cosmetic products [30].

At retention time 25.73 min, 9,12-Octadecadienoic acid was detected. It is also known as linoleic acid, an unsaturated acid which contains two double bonds [31]. In skincare applications, it is found to be a natural component of sebum which can also strengthen the lipid barrier of epidermis and prevents skin dehydration [32]. Aside from skincare benefits, recent study shows that linoleic acid is capable to reduce body fat levels [33].

Table 1. Chemical constituents of Peanut (*Arachis hypogaea*) Oil

No	Retention Time (min)	Component
1	20.94	Pentadecanoic acid, 14-methyl-, methyl ester
2	24.09	1-Methylbutyl hexadecanoate
3	**24.12**	**Hexadecanoic acid**
4	24.34	Palmitic anhydride
5	25.05	1-Tripropylsilyloxydodecane
6	25.72	11,14-Octadecadienoic acid, methyl ester
7	**25.73**	**9,12-Octadecadienoic acid**
8	26.03	Oxiraneoctanoic acid, 3-octyl-, methyl ester
9	**26.51**	**Octadecenoic acid**
10	**26.83**	**Oleic acid**

IV. CONCLUSION

In this study, the effect of extraction time and type of solvents were investigated by using solvent extraction method. It was observed that the optimum extraction time to achieve maximum oil yield was at extraction time of 4 hr while using ethyl acetate as the solvent where the oil yield recorded was at 48.27 %. The extracted peanut oil was found to contain oleic acid, palmitic acid, steric acid and linoleic acid.

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