Extraction of oil from Sunflower (*Helianthus Annuus)* seed by Solvent Extraction method

Nur Farahin bt Zakaria, Faiznur bt Mohd Fuad

Faculty of Chemical Engineering, Universiti Teknologi Mara

***Abstract*—This research was conducted to determine the optimum percentage of oil yield from the sunflower seed through Solvent Extraction method. The oil yield was determine by using one parameter at one time method (OFAT). Four parameters has been tested in this method which are the type of solvent used, effect of temperature, effect of time, and the solid to liquid ratio. Then, the oil collected was tested by using the Gas Chromatography-Mass Spectrum machine (GCMS) to identify the chemical constituent consist in the oil. According to the result, the optimum oil yield is 60.4% of oil has been extracted by using Ethyl acetate as the solvent. For the effect of temperature, the optimum oil yield was collected at temperature 40°C, while for the effect of time, the optimum yield was collected at time 15 minute. As for the solid to liquid ratio, the optimum percentage of oil yield obtain is 60.4% which the ratio used are 10:1.**

Keywords— Helianthus annuus, One Factor at a Time (OFAT) method, Solvent Extraction method, Sunflower seed oil, Vegetable oil, GCMS

I. INTRODUCTION

Helianthus Annuus or sunflower is one of the largest flowering family which is ubiquitous sunflower family. Sunflower was first found by Native Americans in the Eastern United States in about 3000 BC[1]. Sunflower has been widely cultivated as the seed contains of edible vegetable oil[2]. Sunflower seeds contain a high amount of oil which is in the range of 40% to 50% where it is an important source of polyunsaturated fatty acid (linoleic acid) of potential health benefits [3]. Sunflower oil is usually determined by the ratio between oleic and linoleic acids. The component of fatty acid in sunflower oil are linoleic acid (55–65%), oleic acid (20–30%), and the remaining fatty acids (FAs), palmitic and stearic, and the minor ones[4].

Normally, the vegetable oil can be extracted by several method of extraction which is solvent extraction method, distillation method, supercritical extraction method, ultrasonic extraction, steam distillation and microwave assisted extraction method. Among these extraction method, the most widely used extraction method in industry is the steam distillation because it is cheap compared to other modern method such as supercritical extraction method[7]. In order to extract the oil from the seed, several parameters can affect the amount of oil yield such as, the type of solvent, the effect of temperature, the effect of extraction time, and solid to liquid ratio[8]. Oil bodies are located inside the cell of the sunflower seed. Oil yield is therefore dependent on how effectively these cells are ruptured during the extraction process[9].

The extraction method used in this research is the solvent extraction method. This method is widely used in the laboratory range, where the method is easy to be done since the equipment involved in this process is not the complex equipment and used lower cost to be compared to the other method. The process involves two types of liquid which are the dissolved sample and the solvent[10]. The extracted target liquid will be mix with the solvent and normally the amount of solvent is larger than the liquid. Two layer of liquid will be formed since the liquid have different density [11].

The sunflower seed oil is generally used as the source of frying oil. However the proteins present in the sunflower seeds have the beneficial amino acid distribution and has been used widely in pharmaceutical area. The large amount of tocopherols, minerals, and vitamins are also provided by the sunflower seeds is good for human health[12]. Besides being used as the clinical sources, sunflower seed oil also has been introduced in the Cosmeceuticals area. The emollient and antioxidant properties of topical applied sunflower oil are shown in the perspective of repair and maintenance of the epidermal barrier which can be used as a skin care product[13]. In addition, sunflower seed oil also been used as sources of biodiesel. Biodiesel is one of the renewable fuels that is produced mainly from soybean, canola, sunflower, and other oilseed crops. Biodiesel offers environmental, economic, and national security benefits[14].

The objectives of this research is to examine the optimum oil yield from sunflower seeds by testing one factor at a time (OFAT) method. The parameters that has been tested include the type of solvent, the effect of temperature, the effect of extraction time, and the solid to liquid ratio. Temperature is commonly related to the kinetic energy of the material. Every extraction method is highly depending on the solvent effect [5]. Normally, by increasing the temperature, the kinetic energy and rate of reaction will increase[6]. Thus, the extraction of oil will increase with temperature. In order to observe the trends of the oil yield, the graph of type of solvent, effect of temperature, effect of time, and solid to liquid ratio versus the oil yield has been plotted. The expected result of this research would be the amount of oil yield from sunflower seed.

II. METHODOLOGY

A. Materials

The raw sunflower seed was obtained from the supermarket in Shah Alam. The raw sunflower seed was used instead of the commercial sunflower seed in order to maintain the moisture of the sunflower seed. Four chemical reagent has been used as the solvent which is Ethyl Acetate, methanol, ethanol, and acetone.

B. Methods

1. Sample preparation

The raw sunflower seed was stored in the room temperature in order to maintain the moisture. It was grounded by using blender to increase the surface area of the sunflower seed. The grounded sunflower seed was sieved by using 850 micron sized sieved test to ensure the particle size are <850 micron. 5 g of the

grounded sunflower seed was used in every test for every parameters.

2. One factor at a time test (OFAT)

In order to let the fatty acid in the sunflower seed to break down in the form of oil, 5g of sunflower seed that has been grounded was mixed with the solvent. For the first parameter, which is the type of solvent used, four type of solvent has been used as the solvent which is ethyl acetate, methanol, ethanol and acetone. The grounded sunflower seed was mixed with 50 ml of solvent for 20 minute. The temperature of the hot plate was set at 40°C. After 20 minute, the solution containing solvent and sunflower seed was centrifuged to remove the solid from solution of oil and solvent. The solution was evaporated by using the rotary evaporator until all the solvent has been remove by evaporation process. The temperature of water bath at the rotary evaporator was set at 85°C since the boiling point of ethyl acetate is 77.1°C, methanol 64.7°C, ethanol 78.37°C, and acetone 56°C. The liquid resulting from the evaporation process is expected to be the sunflower seed oil.

Then, for the second parameter, which is the effect of temperature, ethyl acetate was used as solvent for every temperature in this parameter test. The other constant variable for this test is the ratio of solid to liquid which is 10: 1 and the extraction time which is 20 minutes. The steps was similar to type of solvent test excluding the temperature use. The temperature has been used was 30, 35, 40, 45, 50, 55, and 60°C.

As for the third parameter, the extraction time used for the solvent to be mixed with solid used was 5, 10, 15, 20, 25, and 30 minutes. The temperature, type of solvent and the solid to liquid ratio was fixed with the temperature was set to 40°C, Ethyl Acetate as solvent, and the solid to liquid ratio is 10:1.

Ratio of solid to liquid was manipulated to 1:5, 1:10, 1:15, 1:20, and 1:25. While the fixed variable for this parameter are the temperature of the hot plate was set to 40°C, the type of solvent used is ethyl acetate, and the time taken for the solid and liquid to mix is 20 minutes. The process of was repeated twice for all parameters in order to obtain the accurate result.

After the result was collected, the amount of oil yield was calculated and the graph was plotted. The percentage of oil was calculate by using equation below.

$$\text{Oil yield}(\%) = \frac{\text{Mass of oil obtained, g}}{\text{Mass of plant material, g}} \times 100$$

Mass of oil obtained is the mass of oil collected from the rotary evaporator flask. The mass of the empty rotary evaporator flask was taken before the evaporation process. After the evaporation process, the mass of the flask with the remaining oil was recorded. To obtain the mass of oil, the mass of rotary evaporator after evaporation process subtracted the mass before evaporation.

III. RESULTS AND DISCUSSION

A. One factor at a time test (OFAT)

Figure 1 shows the result obtained from the effect of the type of solvent towards oil yield test. The graph shows that the oil yield from the extraction process using Ethyl Acetate as a solvent has yielding the optimum of oil yield, which is 60.4% of oil obtained. By using ethanol, 25.99% of oil yield has been collected following with acetone 16.38% and methanol is 3.49% of oil yield.

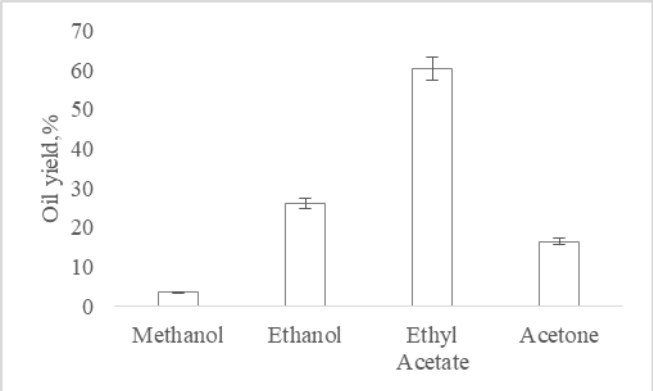

Fig 1: Effect of type of solvent on oil yield extracted from sunflower

Ethyl acetate has two chemical and biological characteristics which is medium polarity and minimum toxicity on test strains. They can help to extract many biological compounds (polar and non-polar) and evaluate their activities[15]. Solvents like dichloromethane chloroform, ethyl acetate, diethyl ether, or ethyl ester will form two layers in contact with aqueous solutions if they are used in sufficient quantities during the extraction process. Ethanol, methanol, and acetone are usually not suitable for extraction because they are totally miscible with most aqueous solutions[16]. Thus, by using the ethyl acetate as the solvent, will separate the oil from the particle by contacting to the solvent and the particle.

Figure 2 below shows that the result obtain from the extraction process by manipulating the temperature. Firstly, at temperature 30°C, the oil yield was 34.28% and it is increasing to 42.25% as the temperature increase to 35°C. At temperature 40°C, the oil yield is at optimum yield which the amount of oil yield is 60.4%. The graph started to descend as the oil yield decrease to 49.89% at t=45°C, and 31.66% at t=50°C.

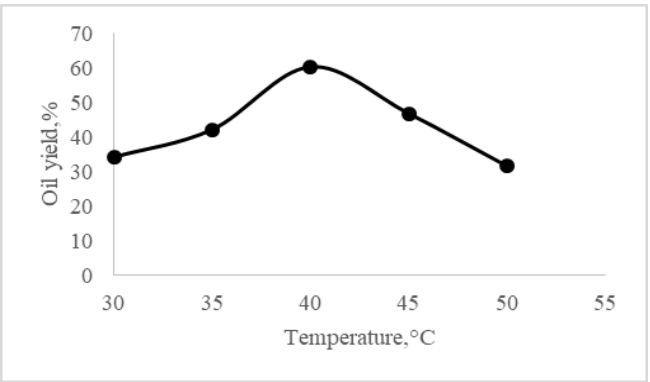

Fig 2: Effect of temperature on oil yield extracted from sunflower

The temperature influence in the extraction process. From the graph the amount of oil yield increase as the temperature increase, but at some point it started to decrease[6]. This is because, as the temperature increase, the extraction will continue progresses, more and more solvent convert the triglyceride in the sunflower seed into oil, the solvent will evaporate slowly, and hence, it will decrease the conversion of triglyceride into oil. From the graph, it shows that at temperature 50°C, the oil yield is 31.66%. After the optimum value, the oil yield must not be lower than the first one, which is at temperature 30°C. This error might occur due mistake during weighing the rotary evaporator flask. The flask must be cleaned after being used so that no leftover oil inside the flask. It is recommended to wipe the flask so that no additional weigh will affect the result. Then, during the evaporation process, make sure that the solvent has already fully evaporate before taking the mass of the flask. Thus, the weighing process will be more accurate.

Figure 3 below shows that the optimum amount of oil yield was collected at time 20 minute with the oil yield is 60.4%. The trends of the graph shows, the oil yield is increasing with time. But, at time 25 minute, the graph started to descend. The oil yield at time 5, 10, 15, 25, and 30 minute are 46.8%, 46.44%, 56.68%, 33.87%, and 22.99%.

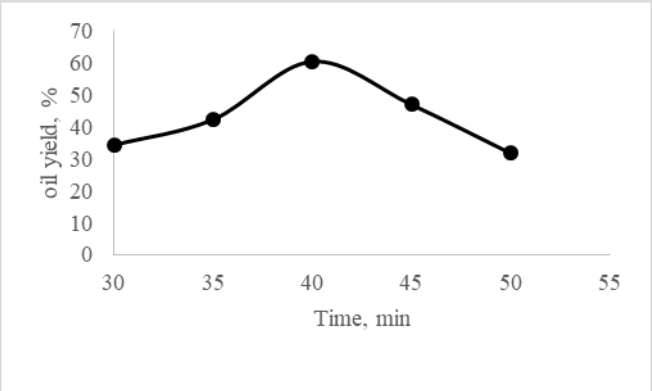

Fig 3: Effect of time on oil yield extracted from sunflower

The extraction time is the time taken for the extraction process to perform. If the extraction time increase, the mixing process between solvent and the sunflower seed particle will also increase until it achieve the optimum value[17]. But, after reaching the optimum time, as the time increase, the extraction will decrease but will not be lower than at time 5 minute. From the graph there are 3 points that not following this theory which is at time 10, 25, and 30. The graph is supposedly descending after the optimum value but it should not be lower than the first value. The amount of oil might be too low because of the solvent evaporates during the mixing process. In order to avoid this, the beaker used during mixing must be fully covered so that the solvent will not evaporates to the air. During transferring the solution from the beaker to the centrifuge tube, ensure that all the solution are transferred into the tube so that the amount of the solution will not decreased.

Based on figure 4 below, at ratio of solid to liquid 10:1, the oil yield obtained is at the peak where, the oil collected at this ratio was 60.4%. The oil yield was increase as the amount of solvent use increase. At the ratio, 1:05, 1: 15, 1:20, and 1:25, the percentage of oil yield recorded was, 35.95%, 56.43%, 43.66%, and 37.86%.

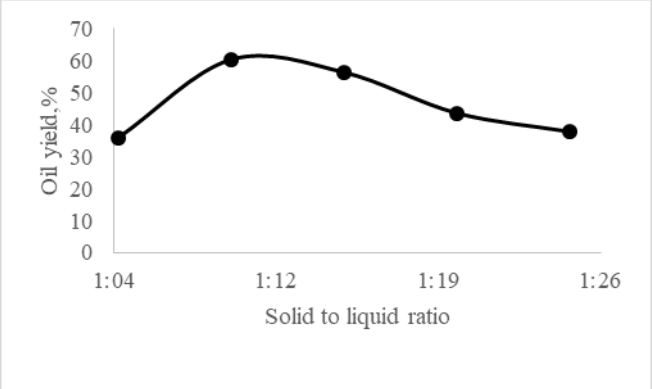

Fig 4: Effect of solid to liquid ratio on oil yield extracted from sunflower

There is a study stated that the ratio of sample to solvent have no significant effect on the amount of oil yield. It is also stated that large amount of solvent is not convenient to increase the oil yield[5]. From the graph, the oil yield was first increasing but then started to decrease at ratio 1: 15 and above. Though, the more solvent has been use, the extraction cannot increase since the raw material which is sunflower seed particle has already finish break into oil. In this case, even the solvent was increase, the extraction cannot continue.

IV. Conclusion

The amount of oil yield from the sunflower seed is influenced by several factors which are the type of solvent used, the temperature used, the time taken for the extraction process, and the solid to liquid ratio. The reaction between the solvent and the sunflower seed particle will increase with time, temperature, and amount of solvent. But, after reaching the optimum value, the reaction rate will started to decrease and will affected the amount of oil yield. The highest yield was obtained when the solvent used to extract the oil is ethyl acetate, at the temperature of 40°C, extraction time 20 minutes, and the solid to liquid ratio is 1:10 which the percentage of oil yield is 60.4%.

Acknowledgment

Thank you to my supervisor and Universiti Teknologi Mara.

Reference

[1] F. Fernández-luqueño, F. López-valdez, N. Pariona, and R. Espinoza-zapata, “An Introduction to the Sunflower Crop Complimentary Contributor Copy,” no. March 2016, 2014.

[2] C. Pugliesi, M. Fambrini, and A. Cavallini, “Transgenic Sunflower (Helianthus annuus),” no. October 2015, 2000.

[3] A. I. Ismail, “Quality Characteristics Of High-Oleic Sunflower Oil Extracted From Some Hybrids Cultivated Under Egyptian Contribution / Originality,” vol. 1, no. 1, pp. 73–83, 2014.

[4] A. Chernova *et al.*, “UPLC – MS Triglyceride Profiling in Sunflower and Rapeseed Seeds,” pp. 2–11, 2019.

[5] A. Nn, “A Review on the Extraction Methods Use in Medicinal Plants, Principle, Strength and Limitation,” *Med. Aromat. Plants*, vol. 04, no. 03, pp. 3–8, 2015.

[6] M. Daoudi, “Temperature and Kinetic Energy Dependence to Rate Of Reaction,” *J. Vis. Lang. Comput.*, vol. 11, no. 3, pp. 287–301, 2000.

[7] E. Cassel and R. M. F. Vargas, “Experiments and Modeling of the Cymbopogon winterianus Essential Oil Extraction by Steam Distillation Article,” *Chem. Soc*, vol. 50, no. 3, pp. 126–129, 2006.

[8] M. Milutinović, N. Radovanović, M. orović, S. Šiler-Marinković, M. Rajilić-Stojanović, and S. Dimitrijević-Branković, “Optimisation of microwave-assisted extraction parameters for antioxidants from waste Achillea millefolium dust,” *Ind. Crops Prod.*, vol. 77, pp. 333–341, 2015.

[9] P. Evon *et al.*, “Direct extraction of oil from sunflower seeds by twin-screw extruder according to an aqueous extraction process : Feasibility study and influence of operating conditions To cite this version : HAL Id : hal-00727227 Direct extraction of oil from sunflower seeds by twin-screw extruder according to an aqueous extraction process : Feasibility study and influence of operating conditions,” 2012.

[10] F. F. Cantwell and M. Losier, “Liquid—liquid extraction,” *Compr. Anal. Chem.*, vol. 37, pp. 297–340, 2002.

[11] K. A. Varteressian and M. R. Fenske, “Liquid-liquid extraction: Exact Quantitative Relations,” *Ind. Eng. Chem.*, vol. 28, no. 11, pp. 1353–1360, 1936.

[12] R. Nandha, H. Singh, K. Garg, and S. Rani, “Available online at http // www.ijrdpl.com Review Article Therapeutic Potential Of Sunflower Seeds : An Overview,” vol. 3, no. 3, pp. 967–972, 2014.

[13] M. Stoia and S. Oancea, “Selected Evidence-Based Health Benefits of Topically Applied Sunflower Oil,” no. April, 2015.

[14] V. D. Zheljazkov *et al.*, “Yield, Oil Content, and Composition of Sun fl ower Grown at Multiple Locations in Mississippi,” pp. 635–642, 2008.

[15] S. P. J. Kumar, S. R. Prasad, R. Banerjee, D. K. Agarwal, K. S. Kulkarni, and K. V Ramesh, “Green solvents and technologies for oil extraction from oilseeds,” *Chem. Cent. J.*, pp. 1–7, 2017.

[16] E. Le Clef and T. Kemper, *Sunflower Seed Preparation and Oil Extraction*. AOCS Press., 2013.

[17] S. Education, A. Gupta, M. Naraniwal, and V. Kothari, “Modern extraction methods for preparation of bioactive plant extracts,” *Int. J. Appl. Nat. Sci.*, vol. 1, no. January 2016, pp. 8–26, 2012.