

OIL EXTRACTION FROM OIL CAKE

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Abstract

In this research, the extraction of oil was done using the sunflower and peanut oil cakes by the Soxhlet extraction method and the operation continued until the oils are obtained. Five physical and chemical tests (Viscosity, Specific gravity, Refractive index, Free Fatty Acid and Peroxide Value) were performed on the extracted oils. The Statistical Package for the Social Sciences (SPSS) was used to analyze the results of the five tests. Since the mentioned oil cakes contained an estimated percentage of oil, it was necessary to re-extract the amount of oil remaining in them to take advantage of all the existing quantity and several chemical solvents (N-hexane and ethanol) to compare them against each other and adopt the solvent that extracted the largest amount of oil. The results of the sunflower's oil cake extraction are represented by recovery percentages of 80.7% and 68.7% for N-hexane and ethanol respectively and the percentages of the extracted oil of 4.35% and 3.8 % for N-hexane and ethanol respectively, while the peanut's oil cake recovery percentages of 86.7% and 73.33% for N-hexane and ethanol respectively and the percentages of the extracted oil of 5.4% and 4.85% for N-hexane and ethanol respectively. Based on the SPSS results and taking standard physical and chemical properties into consideration, N-hexane was found to be the best solvent for both sunflower and peanut. This research is hoped to help researchers and investors by offering the proportions and properties of oils extracted from each oil cake with two effective solvents and obtaining oil-free extraction residues suitable for other uses.

Key words-oil cake, Soxhlet extraction, oil percentages, physical and chemical tests, SPSS.

I. INTRODUCTION

Leaching process (as know industrially) is a often used to separate the components of a mixture. In this experiment, Soxhlet was used as the extractor. In this research work, the oil is the desired substance and was extracted from sunflower and peanut oil cake using N-hexane and ethanol as solvents. The high value of the residual protein in the oilseed meal is one desirable property the makes is suitable for further processing into food-grade powders. Due to the annual increase in global production and consumption of major edible oils such as sunflowers and peanuts, all the remaining oils in the oil cake has to be extracted.[1] Sunflower oil is the nonvolatile oil extracted from healthy sunflower seeds (*Helianthus annuus* L.) which are ranked as one of the most produced oilseeds crops.[2][3] As well its oil cake is the principal by-product obtained after the oil extraction from the seeds, which contains approximately (15-20 %) oil.[4][5] The peanut (*Arachis hypogaea*) is a plant of the Fabaceae family (legumes) and is an excellent source of oil, Oil, and food production are the two main uses of peanuts.[6][7] And not to forget that its oil cake generally considered a source of bioactive compounds, can also serve as sub substrate produce enzymes and antibiotics, which contains approximately (5-20 %) oil.[8][9] Since the sunflower and peanut seeds contain a large percentage of edible oil ranging between (35-50%) and (45-52%) respectively, mechanical extraction (press) is the most widely used in all factories, which results in large quantities of oil cakes containing estimated proportions of edible oil as mentioned above.[10][11] Therefore it was necessary to obtain the maximum possible percentage of edible oil and oil-free oil cakes that is suitable for other uses, so based on the previous studies, the solvent extraction method of this oil cake extracted the maximum residual amount of oil. And in a relation to the cost of extraction in this way, it

was necessary to compare solvents such as hexane and ethanol to know which one is effective in extracting high percentages and good properties of the oil using the appropriate tests for that.[12] [13] Thus, the extraction of the oil by two solvents (N-hexane and ethanol) is a main objective, the determination of the oil amount that extracted from each cake, investigation of the solvent recovery, characterizing the extracted oil by determining the selection of the main physical and chemical properties of the oil, analyzing the data using the SPSS and comparing the yields obtained to the standard with selection of the suitable solvent are specific objectives.

II. MATERIALS AND METHOD

A. Materials

The materials used are sunflower oil cake which was taken from a mechanical press (the remainder of the season for a very long time after the pressing process), peanut oil cake which was taken from a traditional mill (immediately after the pressing process) and (N-hexane and ethanol) were taken from the central laboratory

B. Method

Soxhlet extraction method is a repeated cycle of solvent extraction. Commonly, the oil cake's fine powder is placed in a porous cartridge that is in turn placed in the extractor. The solvent of choice is then boiled leading it to transfer to the upper part. Here, it is condensed through a refrigerant located at the top of the installation and accumulates around and inside the cartridge. The pressure difference causes the solvent to return to the its original flask upon reaching the top of the siphon and goes through another extraction cycle. Vacuum rotary evaporator will be used to purification the oil from the remaining solvent.[14] Based on this method 200g

of each oil's cake and 150 ml of each solvent are used for the extraction, which results on 8.7g of sunflower oil and 10.8g of peanut oil that are extracted by N-hexane besides 7.6g of sunflower oil and 9.7g of peanut oil that extracted by ethanol. Then the physical and chemical analysis (Refractive index, Specific gravity, Viscosity, Free fatty acid, and Peroxide value) have been done on the extracted oils, with three test values of each one and the mean value was taken.

III. RESULTS

A. Results of the extracted sunflower's oil

The results of the sunflower's oil quantity, the percentage of the extracted oil, the percentage of the recovered solvents which were extracted by N-hexane and ethanol, and the available literature values were shown in table (I):

The below tables (II and III) show the results of the mean chemical and physical properties of sunflower's oil that are extracted by n-hexane and ethanol, which are represented because of three experiments with their mean literature values:

The below table (IV) represents the standard error of mean for all the physical and chemical properties of sunflower's oil by the two solvents, which give us an indication for good value or result of the property when its value is small.

The SPSS analysis results that were represented by charts for each of the mean chemical and physical properties with the two solvents that was used for the sunflower's oil extraction were shown in (figure 1 to figure 5) below:

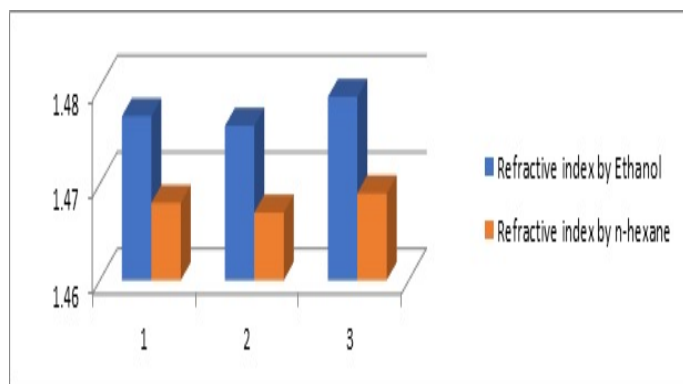


Fig. 1. Refractive index chart for extracted sunflower oils

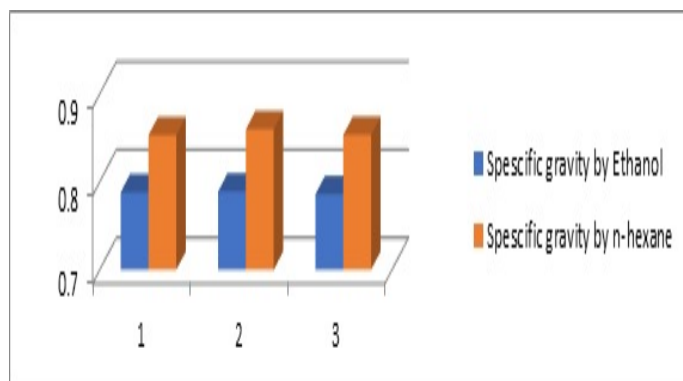


Fig. 2. Specific gravity chart for extracted sunflower oils.

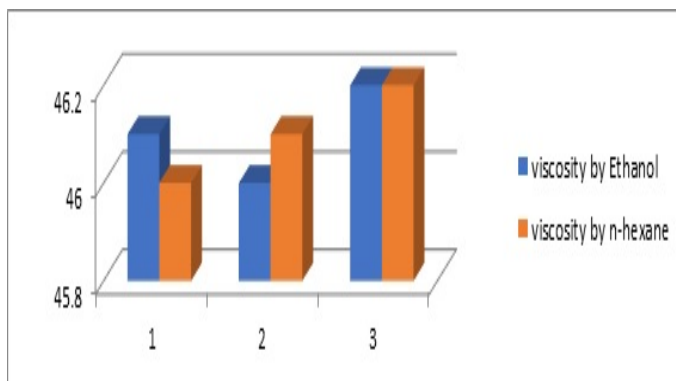


Fig. 3. Viscosity chart for extracted sunflower oils.

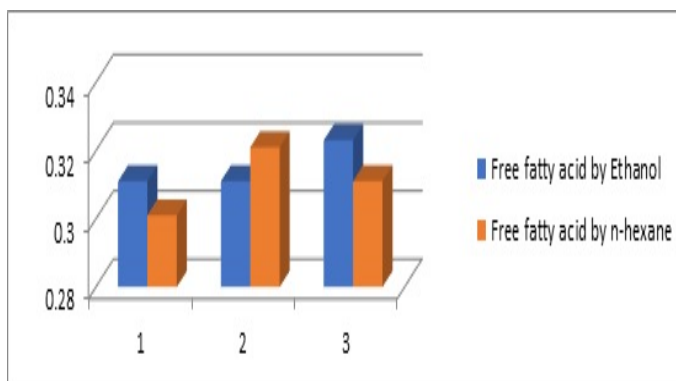


Fig. 4. Free fatty acid chart for extracted sunflower oils.

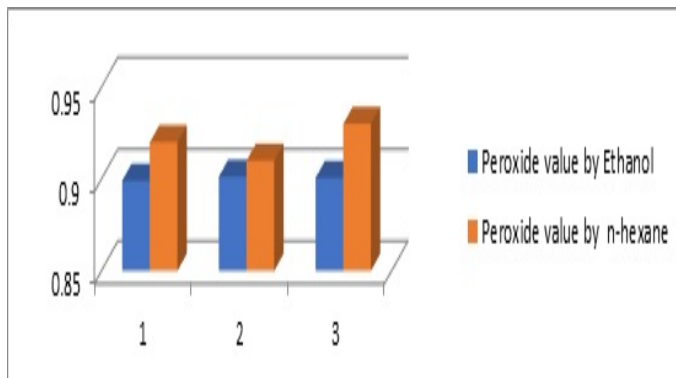


Fig. 5. Peroxide value chart for extracted sunflower oils.

B. Results of the extracted peanut's oil

The results of the peanut oil quantity, the percentage of the extracted oil, the percentage of the recovered solvents which were extracted by n-hexane and ethanol, and the available literature values were shown in table (V):

The below tables (VI and VII) show the results of the mean chemical and physical properties of peanut oil that are extracted by N-hexane and ethanol, which are represented because of three experiments with their mean literature values:

The below table (VIII) represents the standard error of mean for all the physical and chemical properties of peanut oil by the two solvents, which give us an indication of good value or the result of the property when its value is small.

TABLE I
THE SUNFLOWER OIL QUANTITY AND THE PERCENTAGE THAT IS EXTRACTED BY EACH SOLVENT.

Solvent (ml)	oil cake (g)	Oil (g)	Percentage of the extracted oil (%)	literature percentage of the extracted oil (%)	Percentage of the recovered solvent (%)
N- Hexane (150)	200	8.7	4.35	4.44 –7.72	80.7
Ethanol (150)	200	7.6	3.8	2.8 - 8	68.7

TABLE II
THE MEAN CHEMICAL AND PHYSICAL PROPERTIES OF SUNFLOWER'S THAT ARE EXTRACTED OIL BY N-HEXANE

Property	Test value	Literature value
FFA(%)	0.301	1.4± 0.07
	0.321	
	0.311	
	Mean: 0.311	
PV (M.Eq/Kg)	0.920	1.04 - 1.48
	0.910	
	0.930	
	Mean:0.920	
Refractive index	1.468	1.4735±0.02
	1.467	
	1.469	
	Mean:1.469	
Specific gravity (g/ml)	0.8530	0.923±0.016
	0.8599	
	0.8533	
	Mean:0.8535	
Viscosity (c.p)	46.0	49.14
	46.1	
	46.2	
	Mean:46.1	

TABLE III
THE MEAN CHEMICAL AND PHYSICAL PROPERTIES OF SUNFLOWERS THAT ARE EXTRACTED OIL BY THE ETHANOL.

Property	Test value	Literature value
FFA(%)	0.311	1.4± 0.07
	0.321	
	0.323	
	Mean: 0.315	
PV (M.Eq/Kg)	0.8991	1.04 - 1.48
	0.9013	
	0.9006	
	Mean:0.9003	
Refractive index	1.477	1.4735±0.02
	1.476	
	1.479	
	Mean:1.477	
Specific gravity (g/ml)	0.788	0.923±0.016
	0.789	
	0.786	
	Mean:0.7876	
Viscosity (c.p)	46.1	49.14
	46.0	
	46.2	
	Mean:46.1	

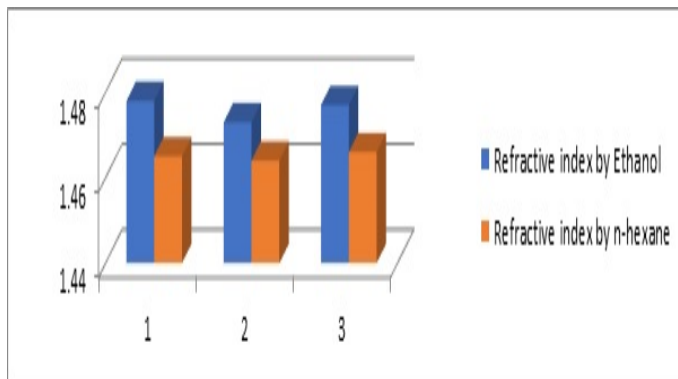


Fig. 6. Refractive index chart for extracted peanut oils.

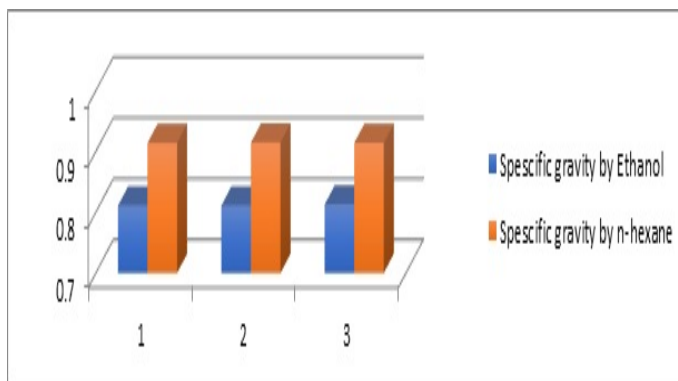


Fig. 7. Specific gravity chart for extracted peanut oils.

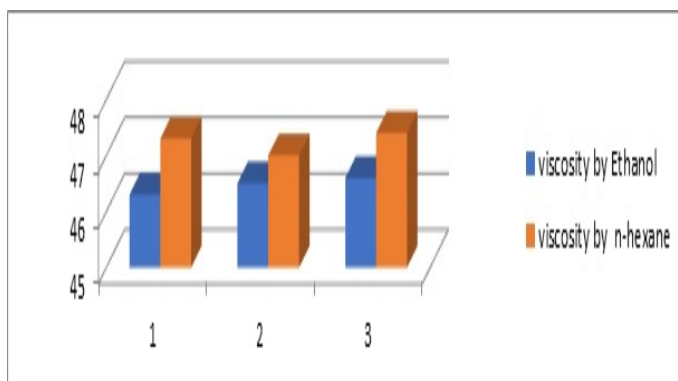


Fig. 8. Viscosity chart for extracted peanut oils

The SPSS analysis results that are represented by charts for each of the mean chemical and physical properties with the two solvents that have been used for the peanut oil extraction are shown in (figure 6 to figure 12) below:

The below ANOVA tables (IX and X) show the tests of significance for solvents effect in the extraction of the two types of oils, which give us an indication of the good solvent effect for the extraction when the value of a specified analysis

TABLE IV
STANDARD DEVIATION AND STANDARD ERROR OF THE MEAN (SUNFLOWER'S OIL).

Treatment		Refractive index	Specific gravity (g/ml)	Viscosity (c.p)	FFA (%)	PV (M.Eq/Kg)
N-hexane	Mean	1.477	0.788	46.100	0.315	0.900
	Std. Deviation	0.002	0.002	0.100	0.007	0.001
	Square root	1.732	1.732	1.732	1.732	1.732
	Std. Error of Mean	0.001	0.001	0.058	0.004	0.001
Ethanol	Mean	1.468	0.855	46.100	0.311	0.920
	Std. Deviation	0.001	0.004	0.100	0.010	0.010
	Square root	1.732	1.732	1.732	1.732	1.732
	Std. Error of Mean	0.001	0.002	0.058	0.006	0.006

TABLE V
PEANUT OIL QUANTITY AND PERCENTAGE ARE EXTRACTED BY EACH SOLVENT.

Solvent (ml)	oil cake (g)	Oil (g)	Percentage of the extracted oil (%)	literature percentage of the extracted oil (%)	Percentage of the recovered solvent (%)
N- Hexane (150)	200	10.8	5.4	4.44 –7.72	86.7
Ethanol (150)	200	9.7	4.85	2.8 - 8	73.33

TABLE VI
THE MEAN CHEMICAL AND PHYSICAL PROPERTIES OF PEANUT EXTRACTED OIL BY N-HEXANE.

Property	Test value	Literature value
FFA(%)	0.360	1.1-2.8
	0.360	
	0.363	
	Mean: 0.361	
PV (M.Eq/Kg)	0.620	0.287 - 1.536
	0.600	
	0.610	
	Mean:0.610	
Refractive index	1.465	1.46 - 1.465
	1.464	
	1.466	
	Mean:1.465	
Specific gravity (g/ml)	0.9140	0.881 - 0.901
	0.9146	
	0.9141	
	Mean:0.9142	
Viscosity (c.p)	47.3	45.6
	47.0	
	47.4	
	Mean:47.35	

TABLE VII
THE MEAN CHEMICAL AND PHYSICAL PROPERTIES OF PEANUTS WHICH ARE EXTRACTED OIL BY ETHANOL.

Property	Test value	Literature value
FFA(%)	0.350	1.1-2.8
	0.353	
	0.353	
	Mean: 0.352	
PV (M.Eq/Kg)	0.6110	0.287 - 1.536
	0.600	
	0.601	
	Mean:0.604	
Refractive index	1.478	1.46 - 1.465
	1.473	
	1.477	
	Mean:1.479	
Specific gravity (g/ml)	0.8110	0.881 - 0.901
	0.8110	
	0.8130	
	Mean:0.8116	
Viscosity (c.p)	46.3	45.6
	46.5	
	46.6	
	Mean:46.7	

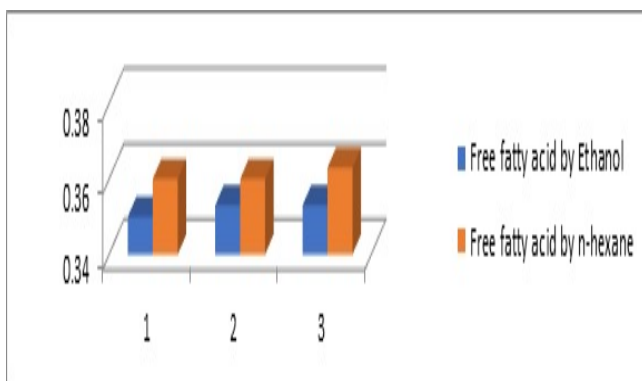


Fig. 9. Free fatty acid chart for extracted peanut oils.

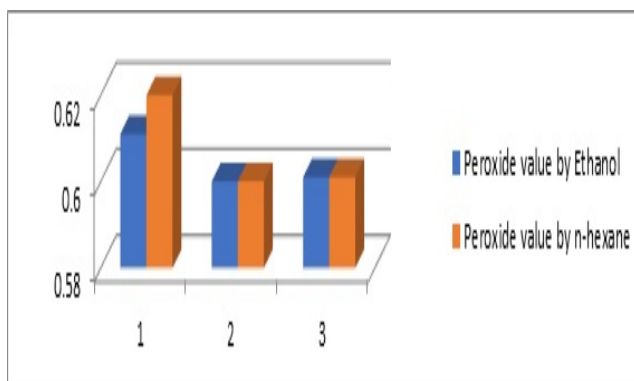


Fig. 10. Peroxide value chart for extracted peanut oils.

TABLE VIII
STANDARD DEVIATION AND STANDARD ERROR OF MEAN (PEANUT OIL).

Treatment		Refractive index	Specific gravity (g/ml)	Viscosity (c.p)	FFA (%)	PV (M.Eq/Kg)
N-hexane	Mean	1.476	0.812	46.467	0.352	0.606
	Std. Deviation	0.003	0.001	0.153	0.002	0.008
	Square root	1.732	1.732	1.732	1.732	1.732
	Std. Error of Mean	0.002	0.001	0.088	0.001	0.004
Ethanol	Mean	1.464	0.914	47.233	0.361	0.607
	Std. Deviation	0.001	0.000	0.208	0.002	0.011
	Square root	1.732	1.732	1.732	1.732	1.732
	Std. Error of Mean	0.000	0.000	0.120	0.001	0.007

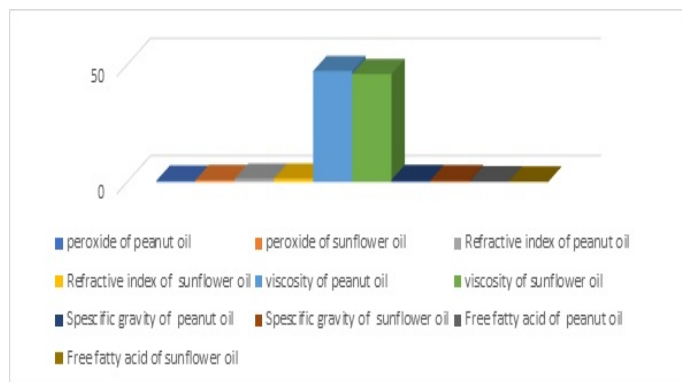


Fig. 11. Physical and chemical analysis for extracted sunflower oil and peanut oil by N-hexane.

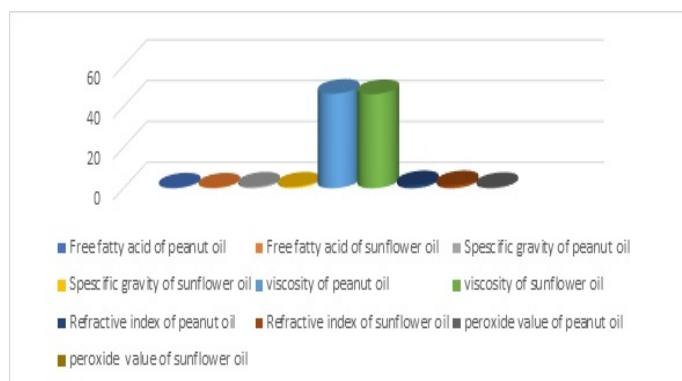


Fig. 12. Physical and chemical analysis for the extracted sunflower oil and peanut oil by ethanol.

is less than or equals 0.05.

TABLE IX
ANOVA TABLE (TESTS OF SIGNIFICANCE) FOR N-HEXANE

Test trial	Sig.
1	0.000
2	0.000
3	0.000

IV. DISCUSSION

Substantial variations in the amount and the percentage of oil extracted, the oil quantity, and the percentage of solvent recovery we observed. For sunflower oil, because that the

TABLE X
ANOVA TABLE (TESTS OF SIGNIFICANCE) FOR ETHANOL EFFECT
(SUNFLOWER'S OILS AND PEANUT'S OILS).

Test trial	Sig.
1	0.000
2	0.342
3	0.426

sunflower cake was used as the remainder of the season for a very long time after the pressing process, thus it has taken a long time for extraction. It was obtained when N-hexane was used due to its good evaporation, and it has a high percentage of the oil extracted and solvent recovery comparing with the oil that results from ethanol which evaporated well too. Comparing the obtained sunflower oil properties with the standard ones, the physical and chemical properties are a good match with the standard properties when using N-hexane because the extracted oil has high (purity, concentration, and quality control for polymer material), freshness and heavy. So, it is obvious that the sunflower oil extracted using N-hexane is better than that extracted using ethanol. After conducting the statistical analysis on the obtained results from the physical and chemical analysis as shown in the previous tables and figures, it was found that there is a small standard error of mean when using N-hexane as solvent rather than ethanol, it shows clearly in PV, FFA and specific gravity. For peanut oil, because that the peanut cake was used immediately after the pressing process, thus it has taken short time for extraction compared with sunflower cake. It was obtained when N-hexane was used due to its good evaporation, and it has a high percentage of oil extracted and solvent recovery compared with the oil that results from ethanol which evaporated well too. The physical and chemical properties were found to match with the standard ones when using N-hexane because the extracted oil has high (purity, concentration, and quality control for polymer material & suitability for edible oil), freshness and heavy. Based on this, it is clear that the peanut oil extracted using N-hexane is superior to the ethanol-extracted one. The results of the statistical analysis on the results of the physical and chemical analysis showed that there is a small standard error of mean when using N-hexane as solvent rather than ethanol, and it shows clearly in PV, FFA and viscosity. Moreover, significant differences were observed for those analyses which are less than or equal to 0.05 and those differences appear clearly in the sunflower oil and peanut oil that extracted by N-hexane. Thus,

based on the above discussion we found that the sunflower oil and the peanut's oil which are extracted by N-hexane have a good chemical and physical properties rather than ethanol.

A. Conclusion

In this research, oil was extracted from the different oil cakes (sunflower and peanut) by Soxhlet Extraction Method using two types of solvents. The extracted oils varied in quantity, purity, percentage of oil extracted, and the percentage of solvent recovery based on the solvent used. The percentage of the extracted oil by N-hexane and ethanol for sunflower's oil are 4.35% and 3.8% respectively. The percentage of the extracted oil by N-hexane and ethanol for peanut's oil are 5.4% and 4.85% respectively. Three physical tests and two chemical tests were conducted on the oils obtained by each solvent separately. The sunflower's oil results extracted by N-hexane of viscosity, Specific gravity, Refractive index, FFA and PV were 46.1 cp, 0.8535 (g/ml), 1.468, 0.311% and 0.920 (M.Eq/Kg) respectively compared to 46.1 cp, 0.7876 (g/ml), 1.477, 0.315% and 0.9003 (M.Eq/Kg) respectively using the ethanol. The peanut's oil results that extracted by N-hexane of viscosity, Specific gravity, Refractive index, FFA and PV were 47.35 cp, 0.9142 (g/ml), 1.465, 0.361% and 0.610 (M.Eq/Kg) respectively compared to 46.7 cp, 0.8116 (g/ml), 1.479, 0.352% and 0.604 (M.Eq/Kg) using the ethanol. The above results were compared with standard ones and then statistical analysis was performed. Thus, we found that the sunflower's extracted oil by N-hexane has a good property of Refractive index, Specific gravity, and PV. The peanut's oil that extracted by N-hexane have a good property of Refractive index, Specific gravity, FFA and PV. N-hexane being the best solvent was the most important outcome of the research as the oils extracted (from sunflower and peanut oil cake) by N-hexane were the purest, concentrated, had high quality and the best-matched the standard properties.

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