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Separation and physicochemical properties estimation of Soybean (*Glycine max* L.) seeds oil

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Abstract:

The goal of this work was the extraction of oil from the seeds of soybean (Glycine max L.)plant. Several parameters were compared in terms of the extraction yields, including solvent extraction (N-hexane and mixture of N-hexane : Isopropanol in a ratio of 3:2), the repeating of extraction (2,3 and 4 times) and the form of seeds (broken seeds and powdered seeds).Proximate properties such as moisture ,density and specific gravity were analyzed. The results showed that the use of N-hexane was the most acceptable in terms of oil production amounted to oil ratio of 20.4%, and the re-extraction 4 times was the better at a rate of 88.6%. In addition the use of seeds powder was the best in the oil production. The best moisture content in the soybean seeds was 5.96%. Density and specific gravity of the oil were 0.912 g/cm³ and 0.915 respectively.

Key words: Soybean, Extraction, Oil, Hexane, Isopropanol, Moisture, Density, Specific gravity.

Introduction

Soybean (*Glycine max* L.) is a species of grain legume native to East Asia , they are now a major crop in the United States, Brazil, Argentina, India, and China. It became important

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oilseed crop through the world and there are continuous efforts to improve it through various techniques from field to laboratory (Riaz, 2006).

The oil content of soybean seed is about 14-23% on dry weight basis, with other constituents of proteins, carbohydrates, fatty acids, inorganics and minerals, amino acids, phospholipids and sugar (Erickson,1995). Per 100gm, soybean oil has 23gm of saturated fat, 16gm of mono-unsaturated fat, and 58gm of poly-unsaturated fat. The major unsaturated fatty acids in soybean oil triglycerides are the poly-unsaturates , alpha-linolenic acid (C-18:3), 7-10%, linoleic acid (C-18:2), 51%; and the mono-unsaturate, oleic acid (C-18:1), 23%. It also contains the saturated fatty acids, stearic acid (C-18:0), 4% and palmitic acid (C-16:0), 10% (Ivanov *et al.*,2010) .

Plant oils including soybean oil are mainly triacylglycerol (TAG) which represents an important edible and industrial resource (Hildebrand *et al.*, 2008).

Vegetable oil is a promising alternative fuel because it is renewable, environ-friendly, biodegradable and non-toxic, unlike conventional mineral based oils (Thames and Yu, 1999), and can be produced easily in rural areas, where there is an acute need for modern forms of energy. In recent years systemic efforts have been spent by several investigators to use vegetable oils as fuel in engines (Masjuki and Sohif ,1991).

There are many solvents that are used to extract oil, such as isopropanol and hexane. Hexane is extensively used for oil extraction from soybeans and other oilseeds because of its low vaporization temperature, high stability, low corrosiveness and low greasy residual effects (Becker 1978; Johnson and Lusas, 1983)

In this study, two types of solvent were used (Normal hexane and a mixture of hexane : isopropanol in a ratio of 3:2) for the extraction of oil from soybean seeds which were grown

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successfully in Iraq in order to use this oil later for the production of biofuels (biodiesel).

Material and Methods

Soybean Processing

Soybean (*Glycine max*) seeds were purchased from the local market at Mosul town. The seeds were selected according to their condition where damaged seeds and some foreign materials were discarded. Seeds were cleaned thoroughly with tap water, sun dried in the open, cracked and de-hulled. The de-hulling was done by cracking the seeds using mortar and pestle , separation of the hulls and cracked seeds were achieved using a tray to blow away the hulls in order to obtain very high yield. The de-hulled seeds were heated to 105°C for 35 min to coagulate the soy proteins to make the oil extraction easier and to a constant weight to reduce the moisture content. The de-hulled and heated seeds were broken to two forms: small pieces (form1) and powder (form2) using a grinder prior oil extraction(Ozioko, 2012).

Determination of Moisture Content of the Seeds

Thirty grams of the cleaned soybean seeds were placed in a crucible ,oven dried at a temperature of 105°C for 6 hrs. and the weight was taken every 2 hrs. until a constant weight was obtained .Each 2 hrs., samples were removed from the oven, placed in desiccator for 30 min. to cool, then removed and re-weighed (Akpan *et al.,* 2006). The percentage of moisture in these samples was calculated as in below :

$$\% \text{ Moisture Content} = 100 (W1- W2) / W2$$

W1 = Original weight of the sample before drying
W2 = Weight of the sample after drying

Operation of Soxhlet Extractor

In this study two different solvents (Normal hexane and a mixture of hexane: isopropanol in a ratio of 3:2) were used for oil extraction from soybeans (Li *et al.,* 2004). Volume of 300 ml of solvent was poured into round bottom flask. Small pieces of seeds 90-100 gm (form1) was placed in the thimble made from thick filter paper and was inserted in the center of the extractor. The Soxhlet equipped with a condenser was placed onto a flask containing the solvent.

The Soxhlet was heated at 60°C. When the solvent was boiling, the vapour travels up to the distillation arm and floods into the chamber housing the sample canting-thimble. The condenser ensures that any solvent vapours cools, and drips back down into the chamber housing the sample. The extract seeps through the pores of the thimble and fills the siphon tube, where it flows back down into the round bottom flask. This was allowed to continue for 30 min. Repeat this extraction (2 ,3 and 4 time) until disappear the color from solvent. Then it was removed from the tube, dried in the oven, cooled in the desiccators and weighed again to determine the amount of oil extracted(Kyari, 2008).The same procedure was repeated with powdered seeds(form 2).

Determination of Oil Yield

Ground sample of 35 gm was placed in the thimble and about 150 ml of solvent was poured into the round bottom flask. The apparatus was heated at 60°C and allowed for 2 hrs. in Soxhlet apparatus. The experiment was repeated for different sample weights of 40, 45 and 50 gm . Finally, solvent was distilled and the percent of oil extracted was determined (Ozioko, 2012). The percent yield of soybean oil was calculated (AL-Harbawy and AL-Mallah, 2014) using the following formula:

$$\% \text{ Yield} = Y1- Y2/ Y1 \ (100).$$

Determination of Specific Gravity

Density bottle of 5ml capacity was weighed (W0), filled with oil, then stopper inserted and reweighed (W1). The oil was substituted with water after washing and drying the bottle and weighed (W2). The expression for specific gravity is:
Sp.gr = (W1-W0)/(W2-W0) = Mass of the substance / Mass of an equal volume of water (Akpan *et al.,* 2006).

Results and Discussion

The physicochemical properties of soybean seeds oil which extracted in this study by two different solvents N-hexane and mixture of N-hexane : Isopropanol in a ratio of 3:2 was listed in Table(1).

Table.1 Physicochemical properties of soybean (*Glycine max*) oil extracted by two different solvents.

Form of seeds	Types of solvent	Moisture content (%)	Extraction yield (%)	Density g/cm^3	Specific gravity
Broken seeds	N-hexane	7.10	17.5	0.916	0.919
	Hex.:Iso.*	7.23	14.2	0.925	0.928
Powdered seeds	N-hexane	5.96	20.4	0.912	0.915
	Hex.:Iso.	6.13	17.8	0.920	0.922

*N- hexane : Isopropanol mixture was in a ratio of 3:2 .

The obtained results of moisture content (Table .1) were varied from those recorded by the other researchers (Erickson, 1995; Seth *et al*., 2010) which were between 9% and 11%. The moisture level in the soybean before oil extraction was varied. Many studies reported that the moisture in new crop beans can be 15% to 16% , while in old crops can be 7% to 8% and the crude oil should be low in moisture to prevent hydrolysis (Hammond *et al*., 2005).

The data in the previous table indicate that both solvents can be utilize to isolate oil from soybean seeds. Concerning the quality and quantity of oil produced, N-hexane was favorable with both seeds' form. It seems likely that physicochemical properties of oil produced in this study were similar to those reported in other studies using the same plant species (Ozioko, 2012). The oil yield was fall within the standard range of oil content 14-23% of soybean seeds (Carter and Hopper, 1942) depending on the seeds' variety.

The results showed that the effect of particle size (broken and powder seeds) were highly significant in oil extraction. This difference may basically explained to the indirect proportional relationship between extraction rate and flake thickness (Norris, 1964). It was observed that the oil yield increased as the particle size was decreased and similar result was stated (Koc *et al*., 2011). The main reason for increasing oil yield by decreasing the particle size is due to the increase of surface area of oil seed interacting with the solvent (Han *et al*., 2009).

Again the results showed that the oil extracted from soybean seeds using two different solvents has specific gravity of 0.91 and 0.92 (Table.1). These results considered good since it will help in case of contamination with water (Hammond *et al*.,2005).

It was appeared that there are differences among the oil yield when re-extraction time was changed with broken and powder seeds by N-hexane and mixture of N- hexane – Isopropanol (Table .2) .

Table.2 Effect of re-extraction on oil yield from seeds of soybean (Glycine *max*) by two different solvents.

Form of seeds	Types of solvent	Oil extraction yield (%)		
		Re-extracted Two times	Re-extracted Three times	Re-extracted Four times
Broken seeds	N-hexane	14.1	15.3	17.5
	Hex.:Iso.*	11.1	12.5	14.2
Powdered seeds	N-hexane	16.2	17.8	20.4
	Hex.:Iso.	14.2	15.6	17.8

*N- hexane : Isopropanol in a ratio of 3:2 .

The data pointed out that oil yield which re-extracted 4 times was the best either by using the two solvents and the two forms of seeds. This perhaps due to the increase contact between oil molecules and the solvent which leached out with it (Ozioko, 2012).

The oil which extracted by N-hexane was different in color compared with oil extracted by N- hexane : Isopropanol mixture, it was yellowish and yellowish green respectively (Fig.1). This could be due to longer time during extraction by mixture of N- hexane and Isopropanol (Baker and Sullivan, 1983).

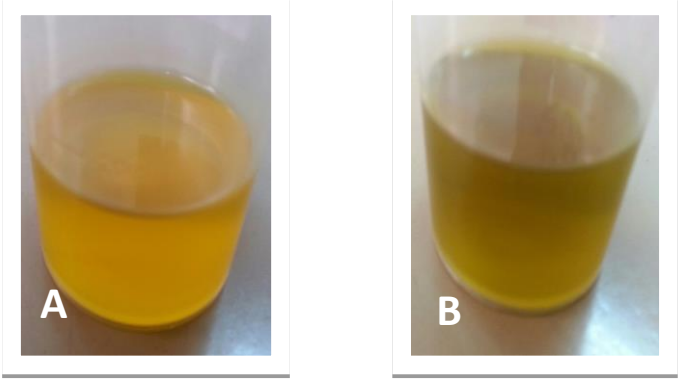

Fig.1 Oil extracted from Soybean (*Glycine max*) seeds by two different solvent. (**A:** N-hexane; **B:** Mixture of N- hexane and Isopropanol)

Generally the findings obtained of this study were not varied from those performed on soybean utilizing the similar solvents (Li *et al*., 2004 ; Seth *et al*., 2007 ; Wang and Weller, 2006).

The conclusion of this study that oil extracted from seeds powder by N-hexane was acceptable of yield 20.4% which mean 88.6 % of the total amount of oil in the seeds and the re-extracted 4 times was a good quantity.

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