# Study on the Extraction of Date Palm Seed Oil using Soxhlet Apparatus

Amna Al-Sumri, Noof Al-Siyabi, Raya Al-Saadi, Samya Al-Rasbi, Ahmed Al-Dallal

**Abstract**— Al-farth date stones were used in this study for extraction of oil. Four particle size ranges were used, namely, 0.212 – 1, 1 - 2.36, 2.36 - 3.35 and 3.35 – 5 mm. Three solvent were used for extraction of date seed using Soxhlet apparatus, namely, methanol, ethanol and acetone. The temperature selected for extraction is 15 °C above the boiling point of each solvent. The effect of particle size, type of solvent and time of extraction on the performance of extraction of date seed oil as measured by wt% yield were studied. In general, it was observed that the best particle size that gives higher percentage of oil yield was the range of 0.212 - 1mm. The relatively higher oil yield was obtained using methanol as solvent with the higher polarity. In general, long period taken for extraction (up to 4 hours) gives better results of oil yield. Only for methanol for size range smaller than 1 mm, the time of contact has no effect on oil yield. As a final choice, methanol can be used successfully for the extraction of date seed oil due to the extraction results obtained, availability and its moderate boiling point.

**Index Terms**— Date seed oil, Date stones, Leaching, Solid-liquid extraction, Solvent extraction, Soxhlet apparatus,.

## 1 INTRODUCTION

Dates are the fruit of the palm tree. It has a very important nutritional value. It has been considered an important food in the past. Dates contain a large proportion of important minerals for the human body in its construction and protect it from many of the disease [1]. Date seed has also many benefits for human and animals and it is an important part of date represented the steel body, and is rectangular in shape, and pointed at both ends, and occupies the centre of the fruit, and weighing between 0.5 - 4 g with length of 12-20 mm and usually the length of the seed is equal to three times the width. Date seeds represent 10-20% of the total weight of the fruit and contain protein, carbon hydrate, fiber, foodstuff, ash, fat water and oil [2]. It also contains many of important elements such as sodium, Potassium, Calcium, Iron, Copper, Magnesium, Manganese, Zinc and phosphorus. The common names are, date seeds, dates pits, date kernels, date stones, date pips [2].

Oil from date palm (Phoenix dactylifera) seeds is a promising new source for production of bio-fuels. Solvent extraction is one of the traditional techniques of extracting vegetable oil from oilseeds is one of the cheapest method, applied to produce oil from seeds like Jojoba oil, soybean oil, palm oil, jatropha oil and many other seeds [3].

Many factors affecting the performance of solid - Liquid extraction which then determine extraction rates and hence equipment size. These factors include particle size, physical and chemical properties of the solvent, solubility dependences on temperature, and solvent agitation. The design of an extraction system generally requires that careful consideration be given to safety and environmental factors, particularly with regard to solvent and dust loadings in the atmosphere of the working environment. Applications of this operation include obtaining oil from oil seeds or leaching of metal salts from ores. Rate of extraction of oil from date seed depends on type of solvent, partial size of date seed, time of extraction and temperature. All the published work on oil extraction from date seeds is performed using the standard Soxhlet solvent extraction apparatus [3-15].

The main objective of this research work is to study the extraction of oil from Date Palm seeds using Soxhlet apparatus. It is intended to study the effect of particle size of the crushed seeds, extraction time, and type of solvent on the yield of oil.

## 2 THEORY

The dissolution of a sample from the solid to the liquid phase depends on the rate of mass transfer from the solid surface to the solvent as the controlling factor. The mass transfer rate of a solute "A" being dissolved in a solvent of volume V ($m^3$ ) is [16] :

$$N_A = k_L A\ (C_{AS} - C_A) \tag{1}$$

where, $N_A$ is the kg/mole of "A" dissolving to the solution per second, A = inter-surface area of the particles ($m^2$), $k_L$ = mass transfer coefficient (m/s), $C_{AS}$ = saturation solubility of the solute (kg/mole/m3 ) $C_A$ = time dependent concentration of the solute.

The rate of accumulation of "A" into the solvent by material balance is:

$$\frac{VdC_A}{dt} = k_L A(C_{AS} - C_A) \tag{2}$$

By setting specific area, a = A/V and integrate equation (2) for t = 0, $C_A = C_{A0} = 0$, $t = t_f$, $C_A = C_{AS}$, we get:

$$\ln \frac{(C_{AS} - C_A)}{(C_{AS} - C_{AO})} = -\ (k_L a)t \tag{3}$$

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## 3 EXPERIMENTAL WORK

Three solvents were used in this study, namely methanol (99.85%), ethanol (>99.95%) and acetone (>99.95%). The Soxhlet extraction apparatus was supplied by Shanghai CC Instruments Co., Ltd as shown in Fig.1.

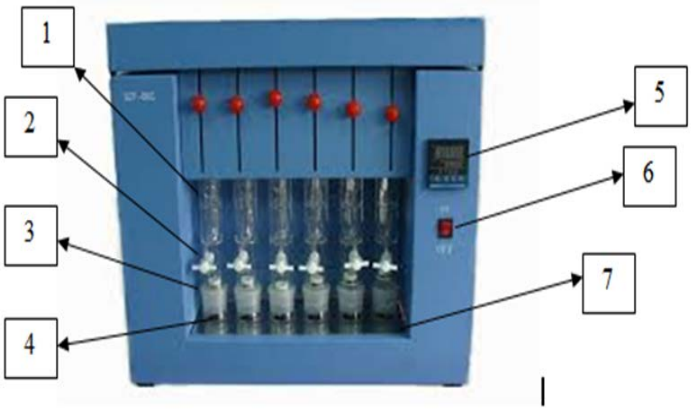


Fig. 1: Soxhlet extraction appataus, (1) Condenser pipe, (2) Cock, (3) Extractor, (4) Extraction flask, (5) Temperature Indicator, (6) Power switch, (7) Water bath.

The dates pit are crushed to a particle size < 5 mm in size particles using a desk-top continuous hammer mill at a rate of 15 kg/h. The mill is supplied by a stainless steel mesh to control the particle size of grinding. A sieving apparatus is used for classification of particle sizes to th following ranges; 0.212 – 1, 1 - 2.36, 2.36 - 3.35 and 3.35 – 5 mm.

Date seeds from Al-farth date were washed by fresh water and then dried for one week at room temperature. This was followed by drying in an oven at 50 °C for 24 hour. The date seeds was then grounded using Hammer mill followed by sieving process to separate the particles according to the required size range. The date seed sample is dried for 4 hours at 50°C before extraction to be sure that all the moisture is separated from sample. Then 5 g of dried date seeds was weighted and then introduced in a medical gauze and about 100 mL of solvent was introduced in the extracting flask. The Soxhlet extractor was then switch on and temperature was set at suitable temperature for a certain time. For each solvent, preliminary experiments were done to determine the suitable temperature which gives reasonable circulation for each solvent. For all solvents, setting the water bath in Soxhlet apparatus at 15 °C above the boiling point of solvent gives reasonable circulation. The Soxhlet extractor was then switched off and the solid sample is removed dried for 24 hr at room temperature and then for 4 hours at 50°C in order to remove the solvent and moisture completely and then weighted. The % yield can then be calculated according to weight loss of sample using equation 4:

$$\%\ Oil\ Yield = \frac{(S1 - S2)}{S1} \times 100 \quad (4)$$

Where: S1: Sample weight before extraction
S2: Sample weight after extraction

## 4 RESULTS AND DISCUSSION

As the solvent vapor goes up to the condenser in the Soxhlet extraction apparatus, it condenses and accumulates inside the extractor. Here, the solvent comes in contact with the seeds and oil is leached out of the seeds. When the condensate moves down through the bed of seeds, mass transfer takes place. However, major amount of mass transfer of oil from the seeds to solvent occurs when the accumulated solvent moves up purely due to the hydrostatic pressure head so, surface area offered by the bed the seed-solvent contact time, seed solvent ratio and the solvent type are the major factors for the yield of the oil production [3].

In this study the effect of particle size, solvent type and time of extraction were studied at constant seed to solvent ratio of 5g/100 ml.

### 4.1 Oil Content of Seeds Using Different Solvents

A preliminary study was done for the maximum yield obtained for each solvent. For this purpose 100 ml of each solvent is introduced in the flask for 4 days with 5 gm of seed powder for a size range of 0.212 – 1 mm. The extraction efficiency of oil from seed date as determined by the % yield of oil is shown in Fig. 2. In general, the percentage yield of oil was is approximately the same with an average value of 9.78%. This percentage represents the actual % of oil in our date stones.

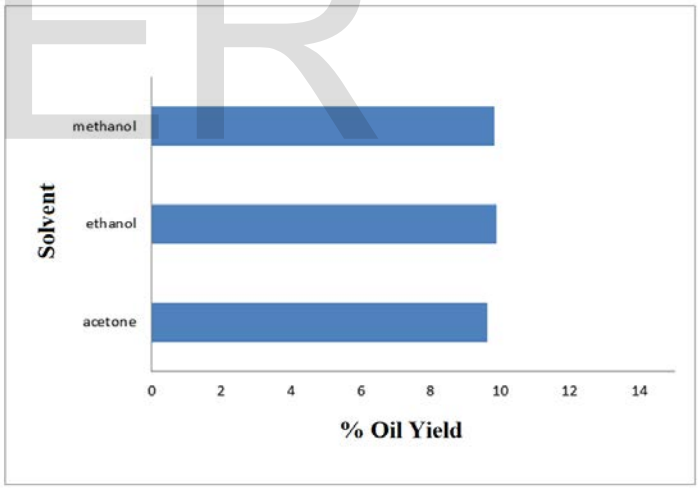


Fig. 2: Percent oil yield for three different solvents.

### 4.2 Effect of Particle Size

Selection of equipment used for solid extraction is influenced by the factors which are responsible for limiting extraction rate [16]. If diffusion of the solute through the porous structure of the residual solids is the controlling factor, material should be of small size so that the instance the solute has to travel is small. If diffusion of the solute from the surface of the particles to the bulk of the solution is the controlling factor, a higher degree of agitation of liquid is required.

In our case, diffusion of the solute through the porous structure of the residual solids is the controlling factor, so the particle size is reduced to four group ranges, namely 0.212 - 1 mm, 1-2.36 mm, 2.36 - 3.35 mm and 3.35 - 5 mm. Fig. 3-5

shows the relationship between particle size and oil yield for different solvents. It appears that, the decrease in particle size leads to increase of oil yield. This relation is occurred due to increase in surface area of grounded seed, so the contact between seed and solvent increased so, the mass transfer of oil from the solid phase from grounded seed to the solvent (liquid phase) increased. Moreover, the time needed for the solvent to diffuse inside the small particle seed is lower than large particle. For that reason, the particle range 0.212-1mm is the best range which gives high percentage of oil yield.

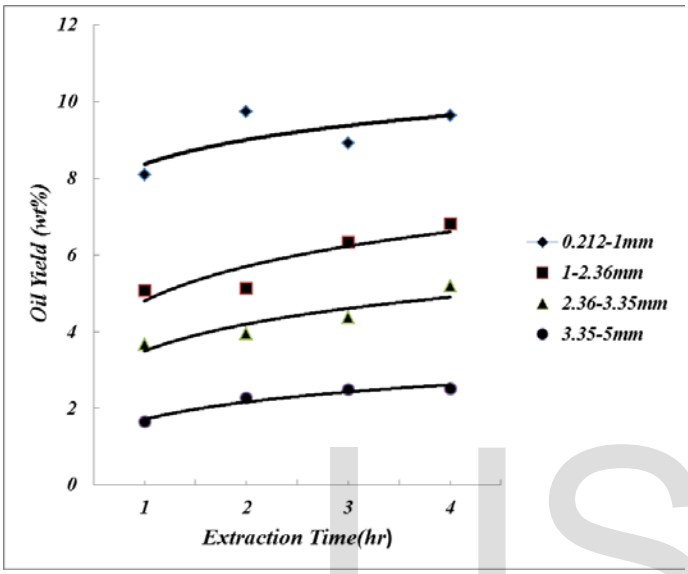


Fig. 3: The effect of extraction time and particle size range on oil yield for acetone.

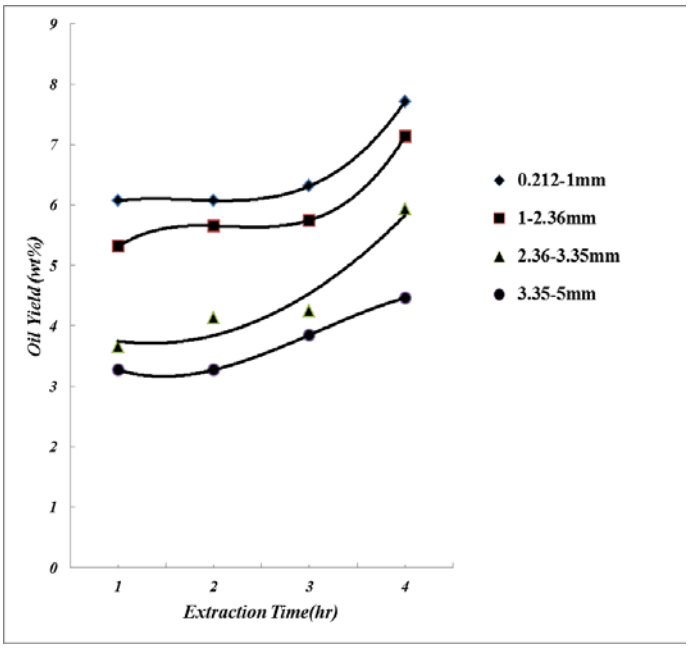


Fig. 4: The effect of extraction time and particle size range on oil yield for ethanol.

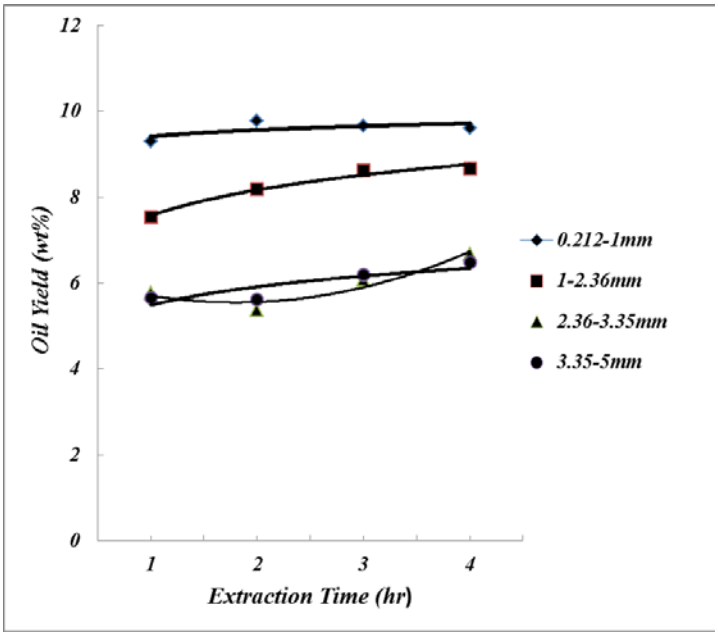


Fig. 5: The effect of extraction time and particle size range on oil yield for methanol.

### 4.3 Effect of Type of Solvent

One of the critical factors in this kind of thermal-solvent leaching is to select the proper solvent. Generally a good solvent should; dissolve the desired compounds, have an appropriate boiling point, easily removed at the end of the extraction. The principle of solvent extraction is that when a solid material comes in contact with a solvent, the soluble components in the solid materials move to the solvent. Thus, solvent extraction of plant material results in the mass transfer of soluble active principle to the solvent, and this takes place in a concentration gradient. The rate of mass transfer decreases as the concentration of the active principle in the solvent increases, until equilibrium is reached. Thereafter, there will no longer be a mass transfer of the active principle from plant material to the solvent.

Several solvents were used to extract date seed oil such as ethanol, methanol and acetone. Generally, solvents with di-electric constants greater than about 5 are considered "polar" and those with dielectric constants less than 5 are considered "non-polar". Dielectric Constant of methanol, ethanol and acetone are 32.6, 24.3 and 21 respectively. Ethanol and methanol are polar protic solvents while acetone is polar aprotic solvent. In general terms, any solvent that contains labile H+ is called a protic solvent. The molecules of such solvents readily donate protons (H+) to reagents. Conversely, aprotic solvents cannot donate hydrogen.

Fig. 3-5 shows the effect of solvent type on oil yield for different contact times and different particle size ranges. In general, the relatively highest oil yield was found for methanol. For particle size smaller than 1 mm ethanol gives relatively higher oil yield. This result shows that palm seed oil yield is better with higher polarity solvent which is here methanol. The boiling point of methanol is relatively lower than ethanol but

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it is higher than acetone. Methanol is available in Sohar/Oman, so it will be the wright choice as a solvent.

### 4.4 Effect of Extraction Time

Fig. 3, 4 and 5 shows the effect of extraction time on oil yield for different particle size ranges. In general the yield increases as the time of contact increases until saturation is reached. This appears clearly for extraction of acetone and ethanol and at lower extent for methanol. This performance is in agreement with equation 3, where an increase in contact time will case an increase in solute concentration CA and hence increase the oil yield [16]. This can be discussed as follows; a layer of liquid solvents that will attack the solid particles will be always at saturation (CAS) and the concentration in the bulk of solvent (CA) will be increased with time so yield will be increased until CA reaches equilibrium value (CAS). At this point the effect of extraction time will be disappearing.

Fig. 3 shows the impact of extraction time on oil yield for 4 different particle sizes using acetone. In this type of solvent, the oil yield generally increased with increasing the time of extraction. Moreover, for the particle size (0.212-1 mm and 1-2.36 mm) the oil yield approximately was the same, i.e. the time of extraction has little effect on oil yield. Fig. 4 shows the impact of extraction time on oil yield for 4 different particle sizes by using ethanol. In this type of solvent the oil yield relatively increases with increasing the contact time of extraction process.

Fig. 5 shows the impact of extraction time on oil yield for 4 different particle sizes by using methanol. For the particle size larger than 1 mm, the oil yield increased with increasing contact time. For particle size smaller than 1 mm, the time of contact has little effect on oil yield.

## 4 CONCLUSION

Oil from date palm (Phoenix dactylifera) seeds is a promising new source for production of biofuels. Solvent extraction is one of the traditional techniques of extracting vegetable oil. Oil seeds is one of the cheapest sources, applied to produce oil from seeds. Rate of extraction of oil from date seed depends on type of solvent, partial size of date seed, time of extraction and temperature.

The following conclusions can be drawn from this study:

- It was noticed that three factors affect the performance of extraction of date seed oil, namely particle size, type of solvent and time of extraction.
- Oil extraction were studied for four particle size ranges (0.212-1mm, 1-2.36mm, 2.36-3.35mm, 3.35-5mm) using different solvents. In general, it was observed that the best particle size that gives higher oil yield was the range of 0.212 - 1mm.
- In general, the relatively highest oil yield was found for methanol. For particle size smaller than 1 mm ethanol gives relatively higher oil yield. These results show that date seed oil yield is better with higher polarity solvent which is here methanol.
- In general, long extraction time (up to 4 hours) gives better results of oil yield. Only for methanol for size range smaller than 1 mm, the time of contact has no effect on oil yield.
- As a final choice, methanol can be used successfully for the extraction of date seed oil due to the extraction results obtained, availability and its moderate boiling point.

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