COMPARISON OF *MORINGA OLIEFERA* SEED OIL CHARACTERIZATION PRODUCED BY CHEMICAL AND MECHANICAL METHOD

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MUHAMAD KHAIRUL NAIM BIN SAAD

Thesis submitted in partial fulfilment of the requirements
For the award of the degree of
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SUPERVISOR'S DECLARATION

I hereby declare that i have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Chemical Engineering (Gas Technology).

Signature :
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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree

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Dedication

To my father Saad bin Salleh who always support and keep praying for my success and to my beloved mother, Hindun binti Jusoh for her caring and understand me. For, lastly for my supervisor Dr Eman N Ali who help me to finish my thesis.

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ABSTRACT

In this developed world today, we have many people who concerned about the nature, the energy being used every day, and it effects to our future generation. Moreover,problems regarding to the diease has killed more people. An attempt has been made here to review the nutritive and medicinal value of miracle tree *Moringa oleifera*. It is established that virtually every part of the tree (leaves, stem, bark, root, flower, seeds, and gum, oil(from seed)) is beneficial in some way hence regarded as the tree with greatest benefits on planet earth. The tree is rich in proteins, vitamins, minerals. All *Moringa oleifera* food products have a very high nutritional value. They are eaten directly as food, as supplements, and as seasonings as well as fodder for animals. The purpose of the research is to compare *Moringa oliefera* oil characterization produce by chemically method and mechanically method. The effect of different size of sample in oil extraction using chemically method is also studied. The *Moringa oleifera* seeds were grinded and the oil is extracted through solvent extraction process using three different size of sample. The average yield was produce are 36.1% for 2mm,40.8% for 1mm and 38.9% for 500µm, for the properties of *Moringa oliefera* oil was analysed and for the density the value is 873(kg/m3) for mechanically 880(kg/m3) and chemically method. For kinematic viscosity 42.2 for mechanically and 9.12 for chemically method, pH value is 6 for both and cloud and pour point are 18°C and 12°C respectively. For the fatty acid was found the present of Oleic acid is higher about 73.60% from mechanicallyand 75.39 from chemically method. In conclusion, *Moringa oleifera* seeds oil appear to be an acceptable good source for oil rich in oleic acid that can be used in medical treatment and as an alternative for olive oil.

Key words: Solvent extraction; *Moringa oleifera*; supplements; oleic acid

ABSTRAK

Dalam dunia maju hari ini, kita mempunyai ramai orang yang mengambil berat tentang alam semula jadi, tenaga yang digunakan setiap hari, dan ia kesan kepada generasi masa depan kita. Selain itu, masalah mengenai untuk diease yang telah membunuh lebih ramai orang. Percubaan telah dibuat di sini untuk mengkaji semula nilai pemakanan dan perubatan pokok Moringa oleifera keajaiban. Ia ditubuhkan bahawa hampir setiap bahagian pokok (daun, batang, kulit kayu, akar, bunga, biji, dan gula-gula getah, minyak (dari benih)) memberi manfaat dalam beberapa cara oleh itu dianggap sebagai pokok itu dengan manfaat terbesar di planet bumi. Pokok itu adalah kaya dengan protein, vitamin, mineral. Semua produk makanan oleifera Moringa mempunyai nilai pemakanan yang tinggi. Mereka dimakan secara langsung sebagai makanan, seperti makanan tambahan, dan sebagai perasa dan juga sebagai makanan bagi haiwan. Tujuan kajian ini adalah untuk membandingkan Moringa oliefera pencirian minyak hasil dengan kaedah kimia dan mekanikal kaedah. Kesan saiz yang berbeza sampel dalam pengekstrakan minyak menggunakan kaedah kimia juga dikaji. The Moringa oleifera benih telah dikisar dan minyak yang diekstrak melalui proses pengekstrakan pelarut menggunakan tiga saiz yang berbeza sampel. Hasil purata adalah hasil adalah 36.1% bagi 2mm, 40.8% untuk 1mm dan 38.9% bagi 500µm, kerana sifat-sifat Moringa minyak oliefera dianalisis dan ketumpatan nilai adalah 873 (kg / m3) bagi mekanikal 880 (kg / m3) dan kimia kaedah. Untuk kelikatan kinematik 42.2 untuk mekanikal dan 9.12 untuk kaedah kimia, nilai pH adalah 6 untuk kedua-dua dan awan dan tuangkan titik masing-masing adalah 18 ° C dan 12 ° C. Asid lemak yang ditemui semasa asid oleik lebih tinggi kira-kira 73,60% dari mechanicallyand 75,39 dari kaedah kimia. Kesimpulannya, Moringa oleifera benih minyak muncul untuk menjadi sumber yang baik yang boleh diterima bagi minyak yang kaya dengan asid oleik yang boleh digunakan dalam rawatan perubatan dan sebagai alternatif kepada minyak zaitun.

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LIST OF ABBREVIATIONS

MOME	*Moringa oleifera* methyl ester.
FFA	Free fatty acid.
IEA	International Energy Agency.
MoO	*Moringa oleifera* oil
PO	palm oil
PKO	palm kernel oil
VCO	virgin coconut oil

INTRODUCTION

1.1 MOTIVATION AND PROBLEM STAEMENT

Moringa oleifera commonly called drumstick, horseradish or miracle tree is native to southern foothills of the Himalayas and possibly Africa and Middle East. Today, it is the most widely cultivated species in the genus and in many other places including central and southern America, Mexico and Malaya (Adedokun et al., 2010; Odebode et al. 2010; Phiri, 2010). It belongs to the family Moringaceae. It is a multi-purpose tree crop with great potentials. the seed oil contain 35 and 47%, *Moringa oleifera* is considered as a species with great bioenergy potentials (Onyekwelu and Olabiwonnu, 2010). The plant is grown for food and it is an exceptionally nutritious vegetable tree with varieties of potential value (Ozumba, 2011). Drumstick grows well on all type of soils, humus rich forest soil being the most ideal. *Moringa oleifera* is one of the nature's gifts to humanity because of its numerous wealth in vitamins and minerals as well as natural anti-oxidants.*Moringa oleifera* is considered as one of the world's most useful trees because almost every part of the tree is useful in one way or another (Anwar et al, 2007) .

Noted that in the tropics, *Moringa oleifera* is used as forage for livestock (Dahiru et al, 2006). As a traditional food plant item in Africa, Moringa oleifera has the potential of improving nutrition, boost food security, and foster rural development by enhancing and sustaining rural households as well as supporting sustainable land use and care (Adedokum et al., 2010; Odebode et al., 2010). All parts of the plant are used in a variety of traditional medicines. The press cake, obtained following oil extraction, is useful as a soil conditioner; the plants are grown as live fences and windbreaks. It is also used as fuel wood source after coppicing (cutting back the main stem to encourage side shoots); as an intercrop with other crops and the wood pulp may be used for paper-making. The green pods, fresh and dried leaves are used as vegetable (Monica and Sharma, 2013).

Usually solvents are used to extract fats and oils. Solvents, however, are not environmentally friendly. Enzymes, on the other hand, are green catalysts, and are often used to improve the efficiency of oil extraction. The use of enzymes in the extraction of oil, protein, and other components from oil-containing seeds and fruits. This technology has been developed to extract oil on a laboratory and pilot scale from many oil-bearing materials (Nwaedozie, 2013).Due to high dependency of humans on oil for both domestic and industrial uses.

Moringa oleifera is a tropical multipurpose tree that naturally grows in India, South-Saharan Africa and South-America (Jahn, 1988). Almost every part of the plant (leaves, flowers, seeds, roots and bark) can be used as food or with medicinal and therapeutic purposes (Anwar et al., 2007), specially in developing countries. *Moringa oleifera* seeds also contain between 30-35 % (w/w) of vegetable oil (Sengupta, 1970), known as “Behen” or “Ben” oil. This oil resembles olive oil in its fatty acid composition and is oleic acid-rich, which makes it suitable for edible purposes. Moreover, other applications have been pointed out as preparation of cosmetics, mechanical lubricant, and lately for potential biodiesel fuel elaboration. *Moringa oleifera* seeds are also used as a primary coagulant in drinking water clarification and wastewater treatment due to the presence of a water-soluble cationic coagulant protein able to reduce turbidity of the water treated. Seeds are powdered and added to the water straight or after preparing crude extract.

However, the presence of oil along many other organic compounds in crude extract increases the content in organic matter of the treated water (Ndabigengesere, 1998) and prevents its storage and consumption for more than 24 hours (Jahn, 1988). This fact represents a disadvantage for its application at full-scale water treatment and highly recommends purification of crude extract (Ghebremichael et al., 2005). Extraction of seed oil before crude extract preparation can be a suitable purification option allowing to recover oil for industrial and food procedures and valuates defatted residues. Though a number of uses for Moringa oil has been spelt out, only little information is available on Moringa seed oil extraction. Previous researchers have extracted *Moringa oleifera* oil by using different methods as solvent and aqueous enzymatic extraction (Abdulkarim et al., 2005) but focussed on the study of the physicochemical properties of the oil obtained. Information on the influence that oil and oil extraction method could have over the primary coagulant protein of *Moringa oleifera* seed extract and its coagulant activity has not been supplied yet. The current work studies two method to produce moringa oil. Extraction procedures (chemically) of *Moringa oleifera* oil and its influence of oil yield extraction over different size of samples and cold press method (manually). The results of our study allow to develop the best method to produce *Moringa oilefera* oil that recovers oil for other industrial purposes and increases the value of the defatted residues generated in production of a natural coagulant from *Moringa oleifera* seeds. *Moringa oleifera* seed are shown in figure 1.1, 1.2, 1.3 and 1.4.

Figure 1.1Ripe *Moringa oleifera* pods Figure1.2 Inside the pod

Figure1.3 *Moringa oleifera* seeds with shell Figure1.4 *Moringa oleifera* kernels

A highly valued plants and fast-growing *Moringa oleifera* able to tolerate with a wide range of environmental conditions. It can resist a light frost and best grows between 25 ^{o}C to 35 ^{o}C but able to tolerate up to 48oC in the shade. The drought-tolerant tree also able to adapt in poor soil condition, receive wide range of rainfall amounts of 25cm to 150cm, adaptable best below 600m altitudes and soil pH of 5.0–9.0 (Palada and Chang, 2003). Oil extracted from *Moringa oleifera* can be used as raw material to produce biodiesel just like palm oil. Bark, roots, seeds, flowers and leaves of this tree can be used for various purposes such as treat various ailments, combating malnutrition, culinary, production of cosmetic, soap and many more but besides that it also can be used to produce biodiesel (Ramachandran et al, 1980).

1.2 OBJECTIVE OF STUDY

While other countries are starting to develop the uses *Moringa oliefera* in their daily life as a food, medicine, oil cooked, and so on, The aim of this research study is

1. to compare the method effectiveness between chemically and mechanically method by measuring oil yeild percentage.
2. the quality of oil produced from different size of samples.

1.3 SCOPE OF STUDY

The study will focus on comparison the percentage of yield produced by chemically and mechanically method. Then compare the oil properties produced by each method.

1.4 MAIN CONTRIBUTION OF THIS WORK

The main contribution of this work is it will help choose the best method for oil extraction from *Moringa oleifera* to fit the final use of product.

1.5 ORGANISATION OF THIS THESIS

The structure of the reminder of the thesis is outlined as follow:

Chapter 2 provides a description of extraction of *Moringa Oleifera* there are two method that been used to extract oil from seed which is using oil press and the other method using Soxhlet extractor. Then the yield that obtain from both method will be make comparison to show what method give good result.

Chapter 3 give the review of materials and chemical reagent used in this research which is *Moringa oleifera,* hexane soxhlet extractor and oil press. Besides that, in this chapter it is describes the methods of extraction of oil from Moringa seeds using soxhlet and oil press and compare the yield of the oil that obtained.

2 LITERATURE REVIEW

2.1 overview

As a traditional food plant item in Africa, *M.oleifera* has the potential of improving nutrition, boost food security, and foster rural development by enhancing and sustaining rural households as well as supporting sustainable land use and care (Adedokum et al., 2010; Odedode et al., 2010). The plant has been found to be rich is vitamins, minerals and edible oil called Ben oil (Ofoh et al., 2011). Generally, the tree offers hope, nutrition, and medicinal and economically devastating poor third world countries. *Moringa Oleifera* is a miracle tree that has been cultivated for a long period of years and it is now found throughout the tropics. It is grown commercially around the world as food, drink and medicine (Hadiza, 2011). *M.oleifera* grows fast and reaches up to 12m. The bark is grey and thick and looks cork, peeling in patches. It loses its leaves from December to January and new growth starts in February to March. Moringa produces cream coloured flower when it is 8 months old and the flowering season begins in January and continues through to march. The fruit ripens from April to June and the pods are triangular in cross section, 30 to 50cm long and contain oily, black winged seed. is an evergreen plant. It remains evergreen from January to December. *M.oleifera* is Nigeria's evergreen gold because if compared with other tree species, there is a clear difference that M.oleifera is more financially rewarding (Ozumba, 2011).

Moleifera helps the environment by releasing a lot of oxygen into the atmosphere. Unlike crude oil, *M.oleifera* has no environmental hazards (Khoramnia et al, 2013). If you are looking for money, *M.oleifera* present sample opportunity and if you are looking for knowledge, *M.oleifera* is both a science and an art (Ozumba, 2011).*M.oleifera* has so many potentials; the first step towards realizing these potentials is to put a Moringa seed into the soil. Juice from Moringa leaves can be used to produce an effective plant growth hormone, increasing yields by 25-30% for nearly any crops onion ball, pepper, Soya, maize, sorghum, coffee, tea, chili, melon. Moringa provides wind protection and shade. Burying Moringa leaves into the soil before planting serve as a natural pesticide. Crushed leaves of *Moringa oleifera* can be used to clean cooking utensils. The bark of *M.oleifera* can be beaten into a fiber that can be used to make rope, mats; the wood produces a blue dye (Adeyemi et al., 2012). The tree also produces viscose resin that is used in the textile industry. *M.oleifera*, due to its canopy orientation and type of leaf formation(compound leaf), is regarded a carbon sink ultimately useful in carbon sequestration. The potentials of *Moringa oleifera*

2.1.1 As a food security item

All *Moringa oleifera* food products have a very` high nutritional value. Every part of the tree can be eaten especially the leaves, young shoots, young pods, flowers, roots and the bark (Adeyemi et al., 2012).Moringa has long been considered a panacea for improving the nutrition of poor communities in the tropics and sub tropics(Agbogidi and Ilondu, 2012). Protein content of leaves is high (20-35% on a dry weight basis) most important is that the protein is of high quality having significant quantities of all the essential amino acids. This amino acid balance is very unusual in plant foods. Moringa leaves also contain high quantities of nutrients (per 100g fresh weight) vitamin A, vitamin C (51.7mg), calcium (185mg) and potassium (337mg) (Radovich, 2010). The leaves of *M.oleifera* both fresh and dried are eaten in African countries such as Ghana, Nigeria, Ethiopia, East Africa and Malawi. They may be eaten as spinach in soup, in curies and in salad. *M.oleifera* leaves are the only source of extra protein, vitamins and minerals. The leaves are mixed with various dishes because they are very nutritious. *M.oleifera* is a complete plant that has more ABCD iron and protein more than anything else in planet earth. *M.oleifera* is used to make Filipino chicken soup. Dehydrated *M. oleifera* leaves contains Seven times the vitamin C found in orange, four times of the calcium found in milk, three times of the potassium found in banana, two times of the protein found in yogurt, nine times the iron in spinach, two times the vitamin A found in carrot and four times fiber in oats as well as other minerals for healthy living.

Moringa trees have been used to prevent malnutrition, especially among infants and nursing mothers. Three non-governmental organizations in particular Trees for Life, Church World Service and Educational Concerns for Hunger Organization have advocated Moringa as "natural nutrition for the tropics." Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. Moringa is especially promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce (Dahot and Memon, 1985). *Moringa oleifera* also serves as animal forage (leaves and treated seedcake). The flowers can be cooked and mixed with other food. The flower provides good source of protein and potassium. They also serve as a good source of nectar for honey producing trees (Adeyemi et al., 2012). The pods are cooked like green beans and have a similar flavor to asparagus.

Table 1 shows the nutritional value of *Moringa oleifera* leaves and pods per 100gm. The seeds are eaten like peas (boiled or fried) when still green (Fuglie, 2000). Moringa oil is of excellent quality (73% oleic acid, similar to olive oil) for cooking (Dhar and Gupta, 1982; Price, 2007). *M.oleifera* is a very popular species in Visayas region of Philippine; the immature pods are prepared as green peas while the matured ones are fried. The gum that is produced from the bark can be used to season food. The Studies have shown that *M.oleifera* seeds gave high yield of oil, which has good antioxidant capacity with great potential for industrial, nutritional and health applications (Onyekwelu and Olabiwonnu, 2010; Agbogidi and Ilondu, 2012). Large scale cultivation of this economic plant could be used as poverty alleviation strategy in Nigeria. Moringa seed kernels contain oil that is valued for culinary and cosmetic use (Duke 1987; Adedokum et al., 2010). If oil is extracted through pressing, costs may be further reduced if press cake is used to replace replace fertilizer for plantation (Emonger, 2009).

The oil contains 60-75% oleic acid and is comparable to olive oil in taste and value in cooking characteristics. The oil has an antioxidant content, which makes it slow to go rancid. Low-tech extraction methods (e.g. grinding and boiling toasted seed) may be used but are relatively slow and inefficient. One low-tech method involves dehulling and grinding the kernels, then boiling them for 5 minutes in water. After boiling the mixture is strained and allows sitting overnight during which time the oil separates from the water. Low-tech oil expellers have been successfully used for extracting Moringa oil. One such press (the Komet press is reported to produce 6.5litres (7.2qt) in 8 hours with a 12% yield of oil. The report maintained that 10kg (22.1b) of seed yielded 1.2kg (2.641b) or 1.3l (1.4qt) of oil. Ram and screw presses have also been for Moringa oil extraction with yields of 5.6%. Dehulling can improve oil yielded, but the increase is small and may not justify the extra effort (Rajangam, 2001; Radovich, 2010). Yields using a screw press can be improved to 20% if the seed is first crushed; 10% by volume of water added, followed by gentle heating over low heat for 10-15 minutes, taking care not to burn the seed. Producing Moringa oil on a small scale might be economically feasible if it were marketed to restaurants, hotels and others high-end venues as a locally produced alternative to imported olive oil. From another journal reported 25 grams daily intake of Moringa leaf powder will give a child 42% protein, 125% calcium, 61% potassium, 41% magnesium, 71% iron, 272% vitamin A and 22% vitamin C (Agbogidi and Ilondu, 2012).

Table 1.Nutritional value of Moringa oleifera leaves and pods per 100gms

Component analyzed	Pods	Leaves	Leaf Powder
Moisture (%)	86.9	75	7.9
Calories	26	92	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.3
Carbohydrate (g)	3.7	13.4	38.2
Fiber (g)	4.8	0.9	19.2
Minerals (g)	2	2.3	-
Ca (mg)	30	440	2,003
Mg (mg)	24	24	368
P (mg)	110	70	204
K (mg)	259	259	1,324
Cu (mg)	3.1	1.1	0.57
Fe (mg)	5.3	7	28.2
S (mg)	137	137	870
Oxalic acid (mg)	10	101	1,600
Vitamin A - β carotene (mg)	0.11	6.8	16.3
Vitamin B -chlorine (mg)	423	423	-
Vitamin B1 -thiamin (mg)	0.05	0.21	2.64
Vitamin B2 -riboflavin (mg)	0.07	0.05	20.5
Vitamin B3 -nicotinic acid (mg)	0.2	0.8	8.2
Vitamin C -ascorbic acid (mg)	120	220	11.3
Arginine (mg)	3.6	6	1.33%
Histidine (mg)	1.1	2.1	0.61%
Lysine (mg)	1.5	4.3	1.32%
Tryptophan (mg)	0.8	1.9	0.43%
Phenylalanine (mg)	4.3	6.4	-
Methionine (mg)	1.4	2	0.35%
Threonine (mg)	3.9	4.9	1.19%
Leucine (mg)	6.5	9.3	1.95%
Isoleucine (mg)	4.4	6.3	0.83%

2.1.2 *Moringa oleifera* as a rural medicinal item

In many parts of the world, every part of the *Moringa oleifera* tree has been used effectively against various ailments (Onwuliri and Dawang, 2006; Ozumba. 2008). In many other countries, Moringa micro-nutrient liquid, a natural anti-hermitic and adjuvant is used as a metabolic conditioner to act against endemic diseases in developing countries. *M. oleifera* has a lot of medicinal uses. It is a healing plant used for the treatment of many ailments and troubles (Dahiru et al., 2006; Ozumba, 2008; Damilola, 2011). *Moringa oleifera* leaves contain specific antioxidants and health promoting ingredients that offers veritable answer to malnutrition and diseases. *Moringa oleifera* leave is a strong antioxidant, effective against prostrate and skin cancers, an anti-tumor and an anti aging substance. *M.oleifera* leaves help men to produce more sperm (Damilola, 2011). *M.oleifera* leaves provide immunity against HIV and AIDS and manage fibroid, while preventing other diseases. In many warmclimate countries today, health workers are now treating malnutrition in small children, pregnant and nursing women with *M.oleifera* leaf powder (Adekitan et al., 2012). Table 2 below presents the recommended daily allowance (RDA) of various nutrients supplied to nursing mothers and children. The nutrients help to build up the immune system of both nursing mothers and children (Agbogidi and Ilondu, 2012)

Table 2. Percentage of the recommended daily allowance (RDA) of various nutrients supplied to nursing mothers and a 1-3 years old child by *Moringa oleifera* leaf powder (6 tablespoons per day for a nursing mother, 1 tablespoon three times per day for a 1-3 years old child).

Table 2. Percentage of the recommended daily allowance (RDA)

Nutritional component supplied	RDA	
	Parent	Child
Protein	21	42
Calcium	84	125
Magnesium	54	61
Potassium	22	41
Iron	94	71
Vitamin A	143	272
Vitamin C	9	22

The flower juice improves the quality and flow of mother's milk when breast feeding. The flower encourages urination. The flower also prevents cough, asthma, muscle diseases and enlargement of spleen. It is eaten raw; pods act as a dewormer and treat liver and spleen problems as well as pains of the joint. Due to high protein and fiber content, the pod can play a useful part in treating malnutrition and diarrhea. The seeds are used for their antibiotic and anti-inflammatory properties to treat arthritis, rheumatism, gouts, cramps, sexually transmitted disease, boils and epilepsy.The roots is use to prevent tuberculous glands in the neck, to destroy tumors, ulcer, earaches, shuttering of ear and as a fermentation to relieve spas (Adeyemi et al., 2012). The stem and bark removes all kinds of pain. It is authelmintic and useful to cure eye disease.

2.2 Physicochemical Properties and Potential Food Applications of Moringa oleifera Seed Oil Blended with Other Vegetable Oils

2.2.1 FA composition

The FA composition of MoO, PO, PKO, VCO and the binary mixtures of MoO with each mentioned oil in ratios of 70:30, 50:50 and 30:70 w/w were obtained by calculating the weighted average for each fatty acid. MoO contained high amounts of oleic acid（C18:1, 81.73%）which is higher than those in the range of 67.9-74.4%(Abdulkarim et al, 2005). PO was found to be abundant in oleic acid（C18:1, 46.86%）followed by palmitic acid（C16:0, 36.38%）while PS contained high amounts of C16:0 54.66% followed by C18:1, 33.14%. PKO and VCO were composed mainly of saturated FAs ranging from C8:0 to C18:0 in which lauric acid as a medium chain fatty acid（MCFA）was the most abundant FA found in PKO（C12:0, 50.63%）and VCO（C12:0, 51.26%）(Sarafhana et al, 2014). Addition of PO to MoO significantly（$p < 0.05$）increased the composition of C16:0 ranging from 17.17% to 23.52% and 31.04% in 70:30, 50:50 and 30:70 w/w MoO/PO blends, respectively, and decreased C18:1 from 69.73% to 62.81% and 56.77% respectively. The other FAs that showed a decrease in concentration with the addition of PO were stearic, arachidic, behenic and lignoceric acids, while the FAs that showed an increase in relative concentration were myristic and linoleic acids. The 70:30（w/w）MoO/PO blend was found to contain the highest amount of unsaturated FA（72.76%）which may be considered having better oxidative stability and characteristics compared to PO alone and other MoO/PO blending ratio. The partial replacements of C16:0 with C18:1 resulted in the least increment in total polar content（TPC）and viscosity of the oil blend after frying. High oleic acid oils have been proven to be high resistant to thermal oxidative rancidity during frying. (Anwar et al, 2007) also demonstrated the important role of MoO in appreciable oxidative stability improvement of oil blends with linoleic rich oils. As food habits of most of the Malaysian population are based on deep fried foods, MoO/PO blends that are locally abundant sources would be excellent options for oxidative-resistant oils (Sarafhana et al, 2014).

2.2.2 Free fatty acid（FFA）content, Iodine value（IV）and Saponi-cation value（SV）

The refined, bleached and deodorized PO and PKO contained much lower levels of FFA in compared to those in manually extracted MoO and VCO. IV is a reasonable measure of the degree of unsaturation of oil34). The IV of MoO was found to be 67.46 g I2/100g oil which was significantly higher（$p<0.05$）compared to PO（61.04 g I2/100g oil）, PKO（21.32 g I2/100g oil）, PS（19.85 g I2/100g oil）and VCO（8.30 g I2/100g oil）due to its degree of unsaturation. PS has IV ranging from 20 g I2/100g for hard stearin and to about 50 g I2/100g for soft stearin (chong, 1994). From the results, the PS under study can be classified as hard stearin. Generally, the IV of MoO was significantly（$p<0.05$）decreased when blended with other oils especially when the proportion of MoO in the mixtures was lower indicating higher degree of saturation blends were produced. In general, PS is a source of fully natural hard component that is used for making edible fat products such as margarine, shortening and pastry. Combining liquid oils and PS is used to obtain fat mixtures with better spreadability needed in products like margarine and shortening with modified physical and chemical properties (Adhikari et al, 2010). The IV of the extracted VCO was comparable to the IV（, 4.47 to 8.55 g I2/100g）for commercial Malaysian and Indonesian VCO but higher than（, 4.35 to 6.85 g I2/100g) (Marina et al, 2009）. Coconut oil including VCO contains approximately 90% saturated FAs that make it low in IV (Sarafhana et al, 2014).

2.3 Properties and use of Moringa oleifera biodiesel and diesel fuel blends in a multi-cylinder diesel engine.

Moringaceae is a monogeneric family with a single genus Moringa. This family includes 13 species. All these species are known as medicinal, nutritional and water purification agents. This study reports, for the first time, on characterization of the biodiesel derived from crude Moringaperegrina seed oil and its blends with diesel. The crude oil was converted to biodiesel by the transesterification reaction, catalyzed by potassium hydroxide. High ester content (97.79%) was obtained. M. peregrina biodiesel exhibited high oxidative stability (24.48 h). Moreover, the major fuel properties of M. peregrina biodiesel conformed to the ASTM D6751 standards. However, kinematic viscosity (4.6758 mm2/s), density (876.2 kg/m3) and flash point (156.5 °C) were found higher than that of diesel fuel. In addition, the calorific value of M. peregrina biodiesel (40.119 MJ/kg) was lower than the diesel fuel. The fuel properties of M. peregrina biodiesel were enhanced significantly by blending with diesel fuel. In conclusion, M. peregrina is a suitable feedstock for sustainable production of biodiesel only blended up to 20% with diesel fuel, considering the edibility of all other parts of this tree(Mohammed et al, 2015)

2.3 Soxhlet Extractor

Normally a solid material containing some of the desired compound is placed inside a thimble made from thick filter paper, which is loaded into the main chamber of the Soxhlet extractor. The Soxhlet extractor is placed onto a flask containing the extraction solvent. The Soxhlet is then equipped with a condenser. The solvent is heated to reflux. The solvent vapour travels up a distillation arm, and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapour cools, and drips back down into the chamber housing the solid material. As shown in Figure 2.1

The chamber containing the solid material slowly filled with warm solvent. Some of the desired compound will then dissolve in the warm solvent. When the Soxhlet chamber is almost full, the chamber is automatically emptied by a siphon side arm, with the solvent running back down to the distillation flask. This cycle may be allowed to repeat many times, over hours or days. During each cycle, a portion of the non-volatile compound dissolves in the solvent. After many cycles the desired compound is concentrated in the distillation flask. The advantage of this system is that instead of many portions of warm solvent being passed through the sample, just one batch of solvent is recycled. After extraction the solvent is removed, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains in the thimble, and is usually discarded (Zhang et al., 2010)

Figure 2.1 soxhlet extractor

2.4 Solvent Extraction Method

Moringa oleifera seed oil exraction using the solvent extraction method. The proximate analysis of the oil was carried out. The results of the proximate composition of Moringa oleifera oil are presented in Table 1(Orhevba et al, 2013).

Table 3: Proximate composition of Moringa oleifera seed oil (Orhevba et al, 2013)

Nutrient	Composition (%)
Moisture content	0.60± 0.07
Ash	1.50±0.01
Crude protein	2.19±0.21
Crude fat	39.30±1.00
Carbohydrate	56.42±0.72

The results of the physicochemical properties of Moringa oleifera oil are presented on Table 4

Table 4: Physicochemical properties of Moringa oleifera oil

Characteristics	Moringa oleifera
pH	5.96±0.03
Saponification value	164.09±1.58 mg/g
Iodine value	68.23±0.60 g/mol
Free fatty acid	8.27±0.19 mgKOH/g
Specific gravity	0.86±0.01

Values are mean ±Standard deviation of triplicate determinations .(Orhevba et al, 2013)

2.5 Cold Press Method

Moringa oil extraction from seed part of *Moringa oleifera* tree, which is a leafy tree species that is native to Himalayas. The seeds which are harvested from pods yield around 35–40% of non-drying *Moringa* oil which is also called Ben oil or Behen oil. The oil extraction is using Cold Pressing method with the oil extracted being clear and odorless. The oil has a large presence of antioxidants in it that ensures it does not become rancid for several years after production. Finding extensive usage in health and beauty applications, the oil's chemical composition includes Oleic Acid: 65.7% • Palmitic Acid: 9.3% • Stearic Acid: 7.4% • Behenic Acid: 8.6%.Moringa oil can be used for cooking, manufacturing perfumes, cosmetic products and also as lubricants. Having potent antioxidant base, the oil has in it remarkable stability that makes these best for skin moisturizers, anti-aging creams and in other skin health products(Katyani.E et al,2014)

3.0 MATERIALS AND METHODS

3.1 Materials and Equipment

Moringa oleifera seeds was collected from some site in Gambang Pahang. The seeds were sun-dried. The dry seeds were grinded using domestic blended and keep at room temperature. Hexane will be supplied by Faculty of Chemical and Natural Resources Engineering of Universiti Malaysia Pahang.

3.2 Apparatus

1. Soxhelt Extractor with condenser

2. Rotary Evaporator

iii. Centrifuge

iv. Oven

v. Digital weighing machine

vi. Aluminium weighing boat

vii. Hot plate

viii. Reflux Condenser

ix. Heating mantle

3.3 Glasswere

i .Reagent Bottle (100ml, 250ml, 500ml & 1 litre)

ii. Beakers (500ml)

iii. Rotary flask (500ml)

v. Round bottom flask (1 litre)

3.4 Moringa seed preparation

Preparation starts with collection of *Moringa oleifera* pods and continues with the cleaning. Cleaning process is crucial because a clean seeds yield clean oil without any impurities. After undergo cleaning process, the seeds were put inside electric oven in order to further reduce the moisture content. Then, seeds were undergone size reduction by grinding using domestic blender. The Grinded seeds were sieved using 250 µm sieve and weighted using electronic weighting balance.

3.4.1 Overall Methodology Flowchart

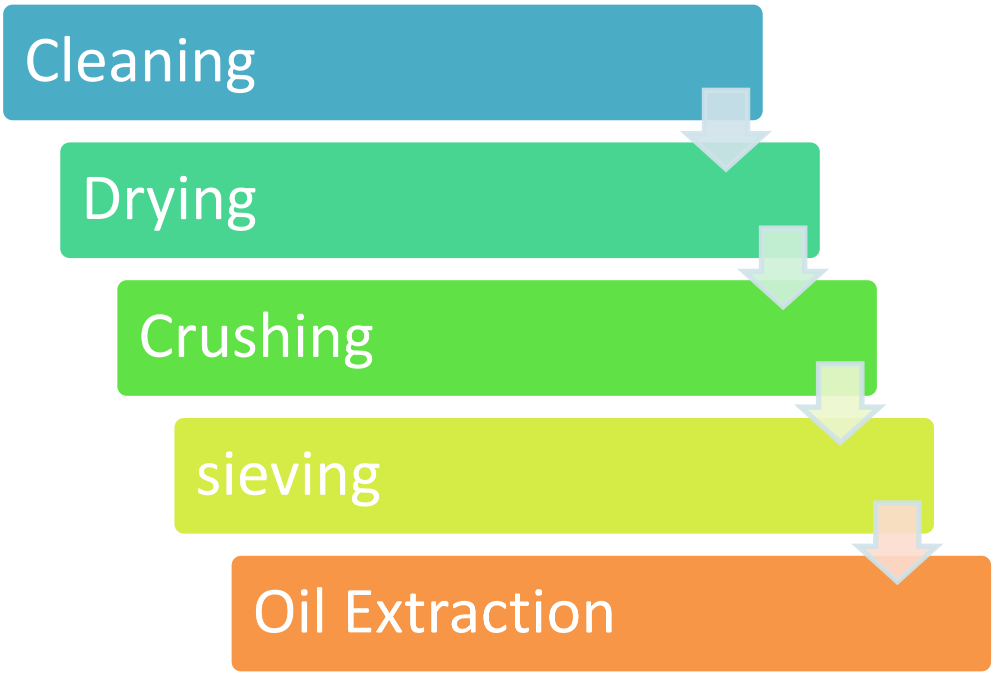

Figure 3.1 Methodology Flow chart

3.5 Pre-Treatment

Pre-treatment starts with collection of dry and green *Moringa oleifera* pods and continues with the cleaning. In order to get the ripe seeds, the dry pods were removed together with the three papery wing and light wooden shells. Cleaning process is crucial because a clean seeds yield clean oil without any impurities. After undergo cleaning process, the seeds were put inside electric oven in order to further reduce the moisture content. Then, seeds were undergone size reduction by grinding it using domestic blender. The Grinded seeds were sieved using 200mm, 100mm, 500 µm sieve and weighted using electronic weighting balance.

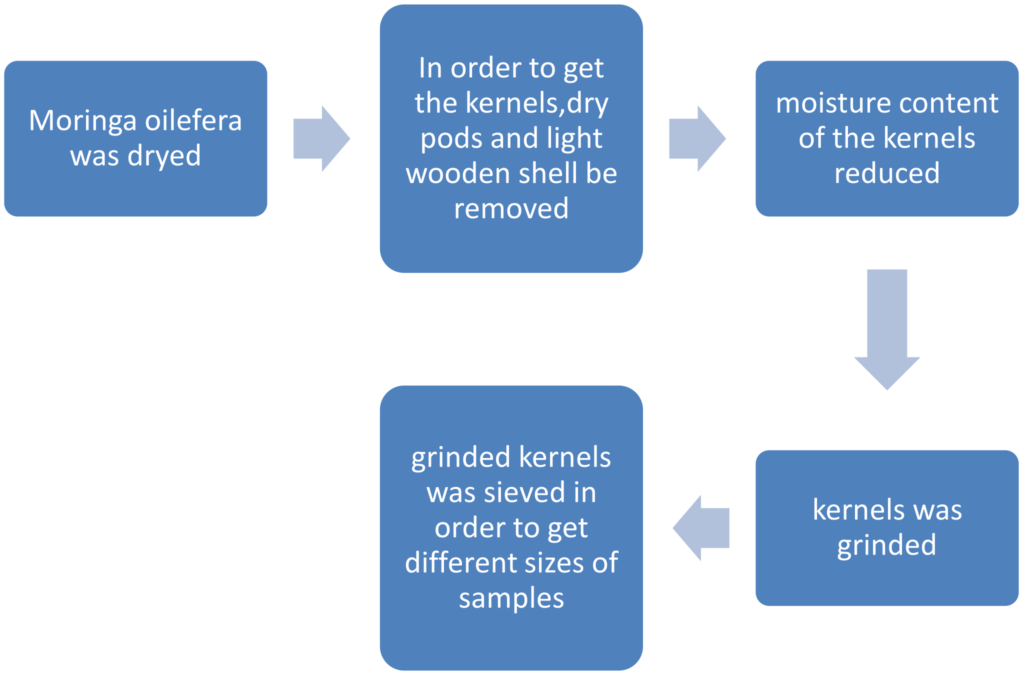

Figure 3.2 Pre-treatment process

3.6 OIL EXTRACTION

3.6.1 SOXHELT EXTRACTOR (chemically)

Oil extraction was carried out using Soxhlet apparatus with n-hexane as solvent. 20g of the grinded sample was poured into the thimble. Two third volume of the round bottom flask was filled with the solvent. The heating mantle was adjusted to about (60-70)ºC and heating commenced. As the solvent was heated continuously, it starts to evaporate and condenses back into the sample in the thimble. The oil extracted, containing some portion of the solvent was then recycled back to the round bottom flask as it refluxes and the total process of reflux continues until total oil extraction was observed. A rotary evaporator was used to separate the oil from the solvent, at the temperature of 65ºC. This process was repeated for 5 more runs to obtain a reasonable oil quantity.

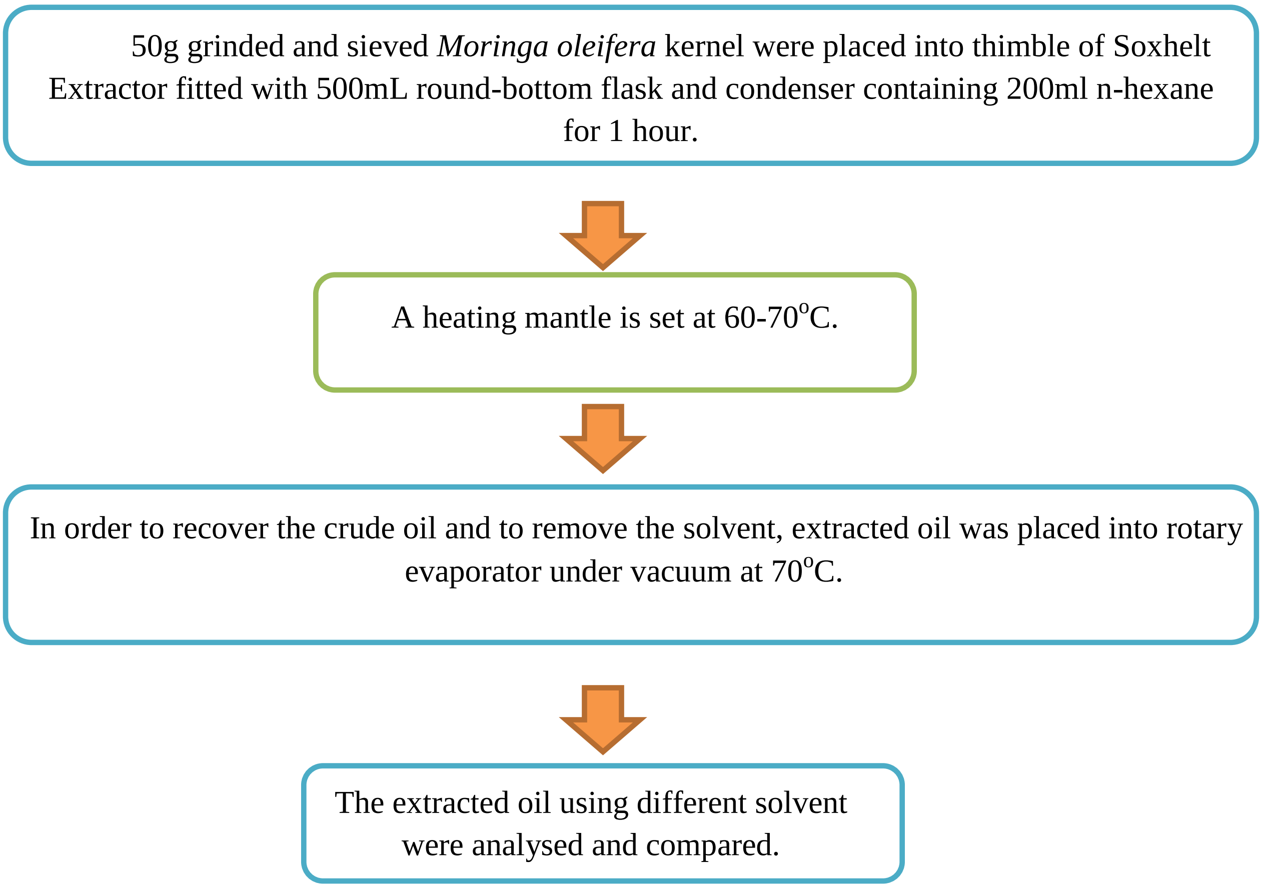

Figure 3.3 extraction process

After the process in Figure 3.3 was done,the experiment were repeated with the different particle size Moringa oliefera seed to find optimum of oil yield.

3.6.2 OIL EXTRACTION BY COLD PRESS

The oil extracted by mechanically was obtained from mitomasa Sdb.Bhd

3.7 Properties Determination

There are few properties that will be determined using specific methods such as Implementing ASTM D445 and Cannon–Fenske viscometers is used to obtain the kinematic viscosity of Moringa oleifera oil. Density was determined by ASTM D4052. Flash point was determined using Pensky-martens flash point – automatic NPM 440 (Normalab, France) by implementing ASTM D93 standard. Fatty acid composition was determined by gas–liquid chromatography (GLC) (T.T. Nkukwanaa et al, 2014)

3.7.1Kinematic viscosity

Kinematic viscosity was done because to compare which oil able to flow easily under pressure. According to ASTM D445 standard, viscosity number of No. 350 was used to measure the kinematic viscosity and about 10ml of moringa oil was needed to complete the test.

3.7.2 pH value

2g of the sample was poured into a clean dry 25ml beaker and 13ml of hot distilled water was added to the sample in the beaker and stirred slowly. It was then cooled in a cold water bath to 250C. The pH electrode was standard with buffer solution and the electrode immersed into the sample and the pH value was read and recorded.

3.7.3 Density

The density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume or oil concentration. To measure the density gas pycnometer was used and density for oil that obtained from manually and chemically method.

3.7.4 Fatty Acid Composition

Fatty acid composition was determined by gas–liquid chromatography (GLC) according to the method of (Tsaknis et al. (1999). Analysis was performed on a Varian 3600 gas chromatograph (Varian, Palo Alto, CA, U.S.A.) equipped with a Supelcowax 10 (Supelco, INC., Supelco Park, Bellefonte, PA) fused silica capillary column 30m0.32mm i.d., 0.25 mm film thickness. The temperature program was 60^{o}C for 10 min and then 21^{o}C/min up to 220^{o}C. Injector and FID temperatures were set at 160 and 2801C, respectively, sample volume was 0.2 mL, the carrier gas was N2 at a flow rate of 30mL/min, chart speed was set at 0.5 cm/ min and the attenuation at 101032. The internal standard used was nonadecanoic acid. Samples were prepared and measured separately in triplicate

4.0 RESULT AND DISCUSSION

4.1 Effect of different saiz of samples in extraction

Table 5 : Analysis of percentage of oil yield using three different saiz of samples

Saiz of samples	**Amount of solvents (ml)**	**Weight of seeds (g)**	**Percentage of oil yield (%)**		
			Batch 1	Batch 2	Batch 3
2mm	200	50	36.7	34.1	33.5
1mm	200	50	39.4	42.6	40.4
500µm	200	50	40.8	41.0	40.9

The percentage of oil yield was calculated using below equation:

$$\frac{Wo - W1}{Wo} \times 100\%$$

Where:

Wo- weight of *Moringa oleifera* seeds

W1- weight of *Moringa oleifera* cake residue

The percentage of oil yield was studied by carrying out 3 batch of oil extraction using different solvent with the same amount of seeds. The reason of doing 3 batch of extractions is because to get the average amount of oil yield. After each extraction, the residue cake was dried in oven for 1 hour at 50oC and as the drying process ended, the residue cake was weight using electronic weighing machine. From Table 5, it can be concluded that the oil yield was the same because the percentage of yield from different size of samples are only slightly different.

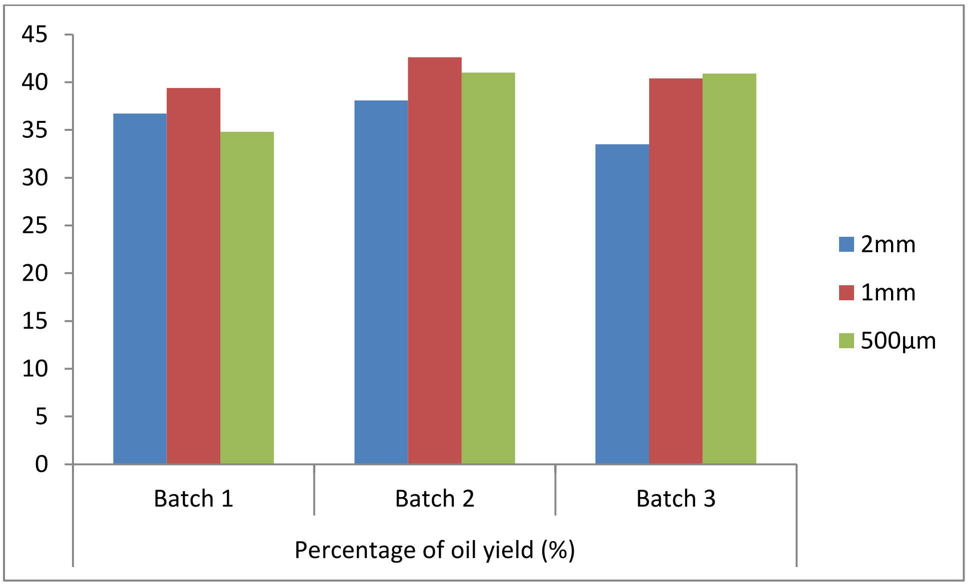

Figure4.1 shows the trend of the percentage of yield based on size samples,as we can see the trend are slightly different.

The oil yield was between 33.5 – 42.6% for the replicates, this was in agreement with (Solade, 2008) which got 35 – 40% oil yield in palm kernel. This is also in line with the results given by (Abdulkarim et al, 2005) that gave the value of oil yield from mature seeds of any plant to be between 22 – 43%. Variation in oil yield may be due to differences in variety of plant, cultivation climate, ripening stage and the method of extraction used (Orhevba, 2013). The oil content (33.50-42.60%) in the present analysis of *Moringa oleifera* seeds was found to be quite higher than some commonly grown oil seed crops such as cotton (15.0-24.0%) and soybean (17.0- 21.0%) and some what comparable with those of safflower (25.0-40.0%) and mustard (24.0-40.0%) (Pritchard, 1991).

4.2 Comparison of *Moringa oilefera* oil properties produced from manually and chemically method.

4.2.1 Kinematic viscosity

Kinematic viscosity was done because to compare which oil able to flow easily under pressure. According to ASTM D445 standard, viscosity number of No. 350 was used to measure the kinematic viscosity and about 30ml of moringa oil was needed to complete the test. After the average value acquired in Table 3, the kinematic viscosity for moringa oil produced from mechanically method was 42.2mm2/s and 9.12 mm2/s for moringa oil produced from chemically method,the different value of viscosity from this two method because,when we are found that in the oil from mechanically method was contaiminated with some solid particles. Thus it can be conclude that *Moringa oleifera* oil from chemically method had a lower kinematic viscosity value compare to mechanically method.

4.2.2 Fatty acid composition

Total unsaturated fatty acids were >80%; the major fatty acid was oleic (C18:1) at concentrations of 75.39% (chemically) and 73.60% (mechanically), followed by gadoleic (C20:1) [2.54% (chemically), and 2.40% (mechanically)]. Behenic acid at concentrations of 5.83% (chemically), and 6.73% (mechanically), followed by palmitic acid (C16:0). There was no statistical difference (at the level of 95%) in the fatty acid compositions of the oils produced from the two different ways of extraction. On the basis of the results obtained, the fatty acid composition of *Moringa oleifera* seed oil showed that it falls in the oleic acid oil category (Sonntag, 1982). The *M. oleifera* Mbololo seed oil had about the same content of C18:1 but much less C18:2 than olive oil. Moringa oil was less unsaturated than the olive oil. Results are shown in Table 6. This is similar to the (Nguyen et al, 2011) it is observed that oleic acid, palmitic acid, gadoleic acid and behenic acid are the main fatty acids present.

Table 6 Fatty Acid Composition

Determination fatty acid	%GLC	
	chemically	mechanically
Oleic acid (C18:1)	75.39	73.60
Gadoleic acid (C20:1)	2.54	2.40
Behenic acid (C22:0)	5.83	6.73
palmitic acid (C16:0)	5.73	6.04

The present fatty acid composition of the oil shows that it falls in the category of high-oleic oils and contains a high ratio of monounsaturated to saturated fatty acids. High-oleic oils, although genetically hard to reproduce, recently are gaining importance because of their superior stability and nutritional benefits (Delplanque, 2000).

4.2.3 Density

The density of Moringa oil depends on the method of extraction and was higher compared to olive oil (Table 7). There was no significant difference in the density of Moringa oils among the two methods of extraction. This value was compared with (Anwar and Rashid, 2007) was found that there is no difference between it.

4.2.4 Kinematic Viscosity

The viscosity of the oil obtained by mechanically method was the highest, possibly because of the water that was absorbed by the gums (phospholipids) during extraction. The viscosity of the oils extracted by the chemically methods was lower compared to that of virgin olive oil. (Nilani et al, 2012) reported that the value of kinematic viscosity is 45.1 mm^2/s was different with value from chemically method 9.12 mm^2/s and approaching to the same value with mechanically 42.2 mm^2/s method.

4.2.5 pH value

pH is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. For the pH, it was checked using pH meter. The result showed that oil obtained from soxhet and microwave has pH 6.

4.2.6 Cloud and Pour point

The cold flow properties of oil are characterized by Cloud Point (CP), Cold Filter Plugging Point (CFPP) and Pour Point (PP) (Rajagopala et al, 2012). The CP is the temperature at which the fuel shows a haze from the formation of crystals. The CFPP is the temperature at which the crystals formed will cause the plugging of the filters. The PP is the lowest temperature at which the liquid will flow (Soriano et al, 2005). About 50ml of moringa was pour into test tube until it reached the level indicator on the test tube. The sample was placed inside a refrigerator and observed for every one minutes until solid-crystals appeared. Cloud point was measured at the bottom of test jar while pour point was measured at the centre of moringa oil. After the test, the cloud and pour point for Moringa oleifera oil from chemically method were 18^{o}C and also the with mechanically method showed in table 4.3. Although cloud and pour point for *Moringa oleifera* oil is slightly higher compare to palm oil, the high content of saturated ester which possess higher melting point than saturated fatty acid in palm oil seem to compensate as the cold flow properties for oil are determined based on the amount of higher melting component and not their nature (Imahara et al, 2006).

Table 7 Comparison Properties of moringa oil

Properties	Mechanically	Chemically
Kinematic viscosity (mpas; 40^{o} C)	42.2	9.12
pH value	6	6
Cloud Point (^{o}C)	18	18
Pour Point (^{o}C)	12	12
Density (kg/m^3)	873	880

5.0 CONCLUSIONS AND RECOMMENDATION

Based on result in Table 5 shows the result of yield comparison between sizes of samples in extraction using n-hexane as a solvent there was no significant difference on the percentage of yield among of three sizes of samples this is about 33.5% – 42.6%. The properties of *Moringa oleifera* oil from chemically and mechanically method such as kinematic viscosity 9.12(mm^2 /s) and 42.2(mm2 /s), PH value 6, cloud point 18^{o}C, pour point 12^{o}C and density 873(kg/m3) and 880(kg/m3). For the fatty acid was compared chemically method is higher than mechanically method. The present fatty acid composition of the oil shows that it falls in the category of high-oleic oils and contains a high ratio of monounsaturated to saturated fatty acids. The oil produced from both methods has high percentage of oleic acid which is similar to olive oil. This product a very good which can supplement and replace olive oil in Malaysia. Moreover, this study will help to start commercialise the plantation of *Moringa oleifera* in Malaysia thus generating sustainable income

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APPENDICES

Production process

Appendix 1: Soxhlet extractor

Appendix 2: Thermal rotary evaporator

Appendix 3: moringa oil from mechanically

Appendix 4: sieving mechine

Appendix 5: moringa seed after grinded in different size

Appendix 6: grinding mechine.