International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 5, Issue 4, (July-August) 2017), PP. 43-47

SOLVENT EXTRACTION OF MANGO (MANGIFERA INDICA L.) SEED KERNEL OIL AND ITS CHARACTERIZATION

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Abstract— **Mango seed oil is an edible oil present in the seed kernel of Mangifera indica L. Mango seed kernel oil finds its application in the cosmetic industry, pharmaceutical industry, and food and confectionery industry due to its high stability and high presence of antioxidants. Mango is an important and popular tropical fruit consumed worldwide and is native to South-east Asia. Apart from direct consumption, mango pulp is used to make mango juice, jam, ice cream, and other dishes like aamras, pies etc. The mango seed also called as mango stone is discarded along with the peel as waste which leads to environmental pollution due to improper disposal. However, by using the seeds to extract oil, this waste can be utilised to obtain a valuable commodity. The oil can be extracted using hydraulic press, solvent extraction, and Soxhlet extraction. This paper focuses on the Soxhlet Extraction of the oil and more importantly the optimisation of the process to get the best yield of the oil. It was found that after optimisation of the parameters - Solvent, Duration, Particle size and Solvent-Solid ratio, 17.3 mL of oil was obtained from 100g of mango seed kernel.**

Keywords— Mango, seed, kernel, edible oil, mango seed butter, solvent, n-hexane, soxhlet extraction.

I. INTRODUCTION

Mango is an edible fruit native to South-East Asia. The Mango plant thrives well in the tropical and sub-tropical regions of Asia and Africa. A sample of mango fruit is shown in Fig. 1.The fruit is sweet to taste with a fruity resinous aroma and is found in hues of yellow, orange, green and red. The fruits have a single inedible, flat, hairy and fibrous seed. They are usually harvested during the months of March and April. The edible pulp of the mango fruit is eaten as such or processed into products such as canned whole or sliced mango pulp in brine or in syrup, mango juice, jam, chutney and pickle.

The annual production of mango is about 50 million tonnes and India produces over 40% of the total every year. This leads to a huge quantity over (10 million tonnes by weight) of discarded seeds and peels which need to be disposed in a proper manner. This waste can be put to use by extraction of mango seed oil from the seeds and then vermicomposting the remains in a proper manner thus, obtaining a useful product and addressing the solid waste issue.

Fig. 1 Mango Fruit

Mango seed oil is extracted from the mango seed kernel or stone and is a golden yellow to brown in colour. It is also called as mango seed butter as it is usually a semi solid in room temperature. Mango seed kernel oil has a melting point of 30 °C, iodine value of 55, 42–44 % unsaturated fatty acids and 52–56 % saturated fatty acids [3]. Stearic Acid and Oleic Acid are the main components of mango seed kernel oil[2]. Mango seed oil also contains a high amount of antioxidants and free radical scavenging compounds [3]. The oil is thus also used as medicine to help to fight with cancer, regulate metabolism and blood sugar levels. The oil is also used in the cosmetic industry in the form of oils, soaps, shampoos and creams to treat dry skin, rashes and dandruff [4]. The oil is edible and is used as such or in confectionary and baking as a substitute to cocoa butter [5]. A sample of mango seeds is shown in Fig. 2.

Fig. 2 Mango Seed Sample

The main objective of this work is to extract mango seed oil from the discarded mango seed kernels using soxhlet apparatus and also optimising the process, thus obtaining valuable product from waste and also preventing the improper disposal of the seeds.

II. MATERIALS AND METHODS

A. Material/Instrument Used:

The materials/instruments used for this work were soxhlet apparatus, water recycling pump, round bottom flask, basket heater, simple distillation unit, thermometer, measuring cylinder, conical flask, filter paper, and funnel.

B. Sample Collection:

The Mango seed samples were collected from local juice parlours in Bangalore city, India.

Preparation of Mango seed sample:

The collected sample of Mango seeds was cleaned thoroughly to remove all dirt and pulp and was washed. The seeds were then manually split open to obtain the kernel within. The mango seeds were then ground and refrigerated until used. The open kernel is shown in Fig. 3.

Fig. 3 Mango Seed split opened

Fig. 4 Cut Seed Kernels

C. Extraction of Oil by Soxhlet Extraction Method:

Soxhlet Extraction was the method chosen to extract oil from mango seed kernels as hydrodistillation method proved to be unsuccessful. The soxhlet apparatus consists of a three necked round bottom flask, the extractor, a vertical condenser, a basket heater, a water recycling pump and a thimble that is inserted into the extractor region of the apparatus. The setup is shown below in Fig. 5.

100g of the pre-treated mango seed kernel was taken in a thimble that was placed in the extractor of the apparatus. Suitable solvent was taken in measure amounts in the round bottom flask and the heat is supplied to the apparatus from the basket heater and cold water is fed into the condenser using a pump.

Fig. 5 Soxhlet Apparatus Setup

As the round bottom flask heats, the solvent evaporates and passes into the extraction region where it is condensed into hot liquid which collects in the extractor region, making contact with the ground seed kernels, thus extracting oils from the solid. As the liquid level in the extractor rises with time, it siphons into the round bottom flask when level of liquid in the extractor exceeds that in the siphon tube. This process is allowed to repeat numerous times. The liquid mixture in the round bottom flask is collected and distilled in order to separate the solvent from the oil. The oil is then collected in vials and sent for Gas Chromatography – Mass Spectroscopy testing.

Fig. 6 Mango Seed Kernel Butter

Parameters such as Solvent used, Condition of raw material, duration of extraction, particle size of raw material and solvent-solid ratio were optimized to obtain maximum possible yield. The mango seed butter collected is shown in Fig. 6.

III. RESULTS AND DISCUSSIONS

A. Optimizing solvent used for extraction:

Solvents such as Hexane, n-Hexane, Light petroleum Ether and Heavy petroleum Ether were used to extract oil from the mango seed kernel in different trials under the same conditions.

The results obtained from the trials are shown below in Table 1.

Table 1. Optimization of Solvent used for Extraction

Solvent used	Light petrol Ether	Heavy Petrol Ether	n-Hexane	Hexane
Solvent vol.	250 mL	250 mL	250 mL	250 mL
Solids used	100 g	100 g	100 g	100 g
Oil obtained	**2.3 mL**	**1.2 mL**	**3.3 ml**	**2.8 ml**

It is observed in Table 1. That n-Hexane solvent gives the best yield. The comparison is shown in Fig.7.This was the chosen solvent for further trials.

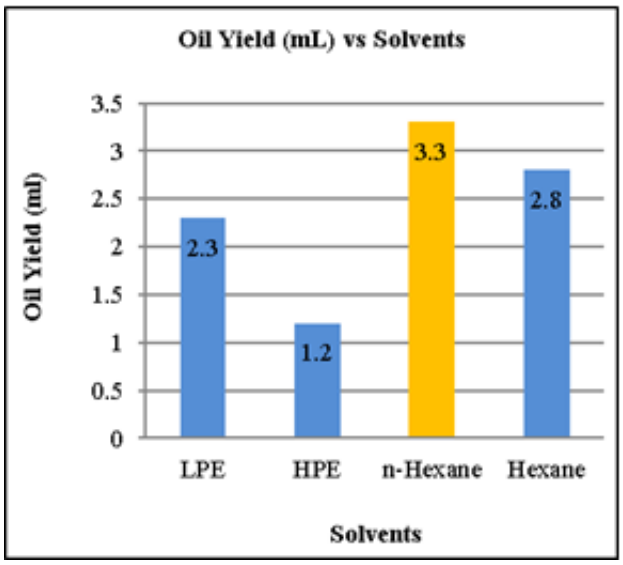

Fig. 7 Comparison of different solvents for extraction

Optimizing Duration of Extraction and nature of raw material

Mango seed kernels were ground and used as raw material in the soxhlet extraction method with 100g of kernel and 300mL n-Hexane (at 67 °C) as the solvent for different durations of time.

This was repeated with sun dried mango seed kernels and the results are shown below in Table 2.

Table 2. Optimization of Extraction Duration and Kernel Condition.

Sr. No.	**Time (Hrs.)**	**Oil Obtained Wet Solids (mL)**	**Oil Obtained Dried Solids (mL)**
1	1	0.3	0.5
2	2	0.7	1.3
3	3	1.1	1.7
4	4	1.7	2.3
5	5	2.1	2.8
6	**6**	**2.8**	**3.4**
7	7	2.8	3.4

From Table 2. We see that mango seed kernels in the dry condition gave better oil yield. It is also observed that the yield of mango seed oil increases with increase in the duration of extraction. This is shown in Fig.8. The optimum duration of 6 hours was chosen for further trials.

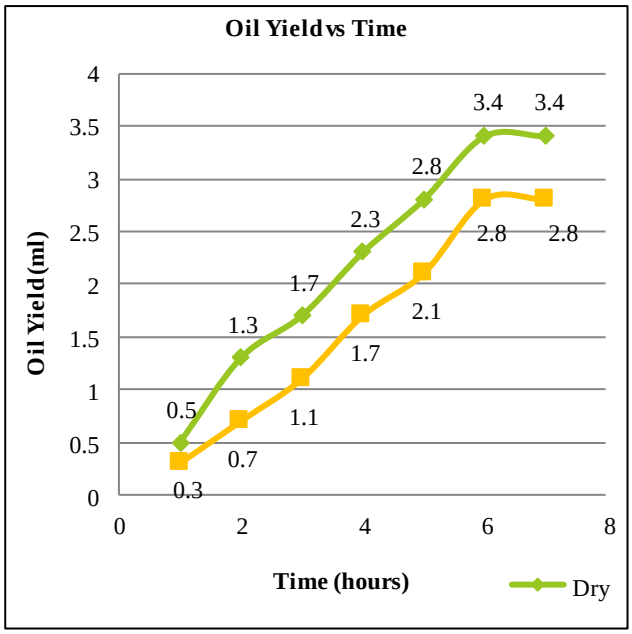

Fig. 8 Effect of duration of extraction and nature of raw material on oil yield

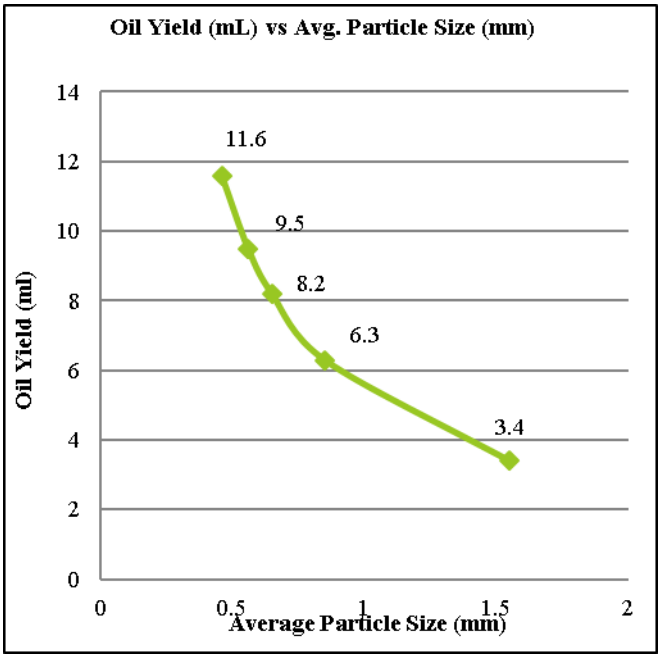

Fig. 9 Effect of Avg. Particle Size on Oil Yield

B. Optimizing the Particle Size of the raw material

Dry mango seed kernel was ground and the particles were separated to different particle sizes using a series of sieve trays. The various particle size samples were used for extraction of oil from 100g of dry kernel using 300mL n-Hexane and duration of 6 hours at 67 °C. The results are shown in Table 3.

Table 3. Optimization of Average Particle Size

Sr. No	Average Particle Size (mm)	Oil Extracted (ml)
1	1.55	3.4
2	0.85	6.3
3	0.65	8.2
4	0.56	9.5
5	**0.46**	**11.6**

From Table 3. it is observed that the yield of oil from the soxhlet extraction increases with reduction in the particle size of the kernel. This is due the better contact due to increased surface area with reduction in particle size. Average particle size of 0.46 mm was found to be the optimum and was used for all further trials. The trend is shown in Fig. 9.

C. Optimizing the Solvent – Solid Ratio

Series of trials were carried out to find the optimum solvent to solid ratio for maximum extraction of oil. The solvent used was n-Hexane and the solids were taken in dry condition with average particle size of 0.46mm and extraction was done for duration of 6 hours at 67 °C. The results are tabulated in Table 4.

It is observed from Table 4. that the yield of the oil increases with increase in solvent per gram of solid. 15:1 ratio was the optimum ratio and resulted in extraction of 17.3 mL of mango seed oil. Further increase in the solvent to solid ration has no significant affect in oil yield. The trend is shown in Fig. 10.

Table 4. Optimization of Solvent – Solid Ratio

Sr. No.	Solvent to solids ratio (ml/g)	Oil yield(ml)
1	3:1	11.6
2	5:1	12.1
3	10:1	14.7
4	**15:1**	**17.3**
5	20:1	17.5

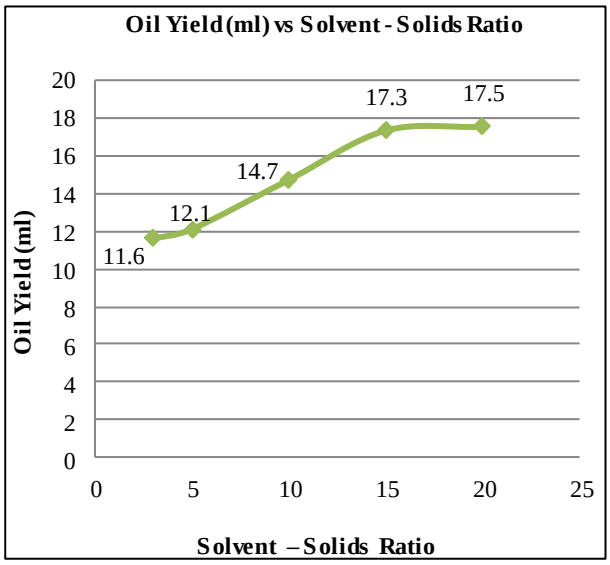

Fig. 10 Effect of Solvent – Solid Ratio on Oil Yield

The Gas Chromatography – Mass Spectroscopy result of the fatty acid composition test of mango seed kernel oil sample is shown below in Fig. 11 and Table 5.

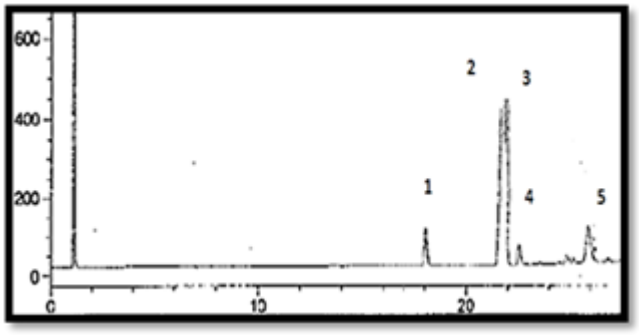

Fig. 11 Gas Chromatography Standard Graph

Table 5 Gas Chromatography Results

Peak No.	Fatty Acid	Retention Time(min)	Peak Height
1	Palmitic Acid	18.034	93.97
2	Stearic Acid	21.656	395.47
3	Oleic Acid	21.905	415.13
4	Linoleic Acid	22.557	50.52
5	Arachidonic Acid	25.851	93.11

CONCLUSION

Mango Seed oil was successfully extracted using soxhlet extraction method. The process was also optimized for maximum yield of oil. The maximum yield of 17.3mL of mango seed kernel oil can be extracted using soxhlet extraction method with n-Hexane solvent and kernels in sun dried condition with average particle size of 0.46mm for an optimum duration of extraction of 6 hours and solvent to solid ratio of 15mL/g of raw material. Gas Chromatography of the oil shows that Stearic Acid and Oleic Acid content is 43.32% and 42.25% respectively. The residual solids are then properly disposed for composting, thus tackling the solid waste issue while being able to extract valuable product from the same waste.

IV. ACKNOWLEDGEMENT

We thankfully acknowledge the help from Dr. Ravishankar R, Prof. G.K. Mahadevraju, Dr. B.R Veena, Prof. M.R. Rajani, Prof. Pradeep H.N., Prof. B.S. Thirumalesh, Prof. Karthik K.V, Department of Chemical Engineering, DSCE, Bengaluru. We would also like to thank Dr. D. Hemachandra Sagar, Chairman, Dr. D. Premachandra Sagar, Vice-Chairman, Sri Galiswamy, Secretary and C.P.S. Prakash, Principal, Dayananda Sagar College of Engineering, Bengaluru, for their encouragement and help rendered.

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