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Optimization and extraction of oil from mango seed kernel (*Mangifera indica*)

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ABSTRACT

Kernels from the stone of mango (*Mangifera indica* L.) were separated from outer leather by decortications and dried to evaluate the oil content. Conditions were optimized for oil extraction from mango seed kernel. The influence of various parameters such as temperature, time, volume of n-hexane (solvent) and particle size on oil yield was investigated. The results revealed that oil yield increased with increase in temperature, time and volume of solvent but decreased with the increase in the particle size. Maximum oil yield of 15.20% was obtained at 1 mm size grinded kernel particles with an extraction time of 90 minutes using 25g of mango kernel seed and 250 mL of n-hexane. The proximate composition and characteristics including the un-saponification matter and fatty acid contents of kernel oil were determined. The major fatty acids present in mango kernel were stearic (58.08%), palmitic acid (1.33%) and oleic (17.99%) and linoleic (2.86%). Mango seed kernel oil contained high un-saponifiable matter which could have good potential to be used in cosmetics.

Key word: Fatty acid, Mango seed kernel, Oil extraction, Oil yield

Mango (*Mangifera indica* L.) fruit is processed into various products, viz. juice, nectar, jam, sauce, chutney, syrup and canned or sliced mango (Singh 1960, Dhingra 1985, Kittiphoom 2012). During the processing of mango for pulp, stone (contributing 15-20 % of total fruit weight) is generated as by-product. Mango kernel is obtained after decortication of mango stone. It contains (on a dry weight average) 6.0% protein, 11% fat, 77% carbohydrate, 2.0% crude fiber and 2.0% ash (Garg *et al.* 2010). It is a good source of polyphenols, phytosterols as campesterol, β-sitosterol and tocopherols. Total lipids (11.6% of dry kernel) consisted of 96.1% neutral and 3.9% polar lipids, which comprised 2.9% glycolipids and 1.0% phospholipids (Hemavathy *et al*, 1988). Rukmini and Vijayaraghan (1984) reported that mango seed kernel fat is promising and a safe source of edible oil. It is so nutritious and non-toxic that it could be substituted for any solid fat without adverse effects. Abdalla *et al*. (2006) reported that the Nigerian mango kernel has a good source of high quality fat. Studies have indicated a wide variation in the fatty acid composition of oil depending on stage of maturity (Garg *et al.* 2010) and varieties of mangoes (Kittiphoom and Sutasinee 2010, Augustin and Ling 1987). Yet, due to the technical feasibility problems, the process of oil extraction from mango kernel has not been explored to desired extent (Nzikou *et al.* 2010).

Hence, the present study was conducted to optimize extraction protocol for maximum oil yield in terms of parameter, viz. particle size, temperature, extraction period, solvent to solid ratio (volume of solvent).

MATERIALS AND METHODS

Mango stones of cv. Dashehari were collected from processing lab of PHM division of Central Institute for Subtropical Horticulture (CISH), Rehmankhera, Kakori, Lucknow and decorticated. The kernels were separated, washed with tap water and dried in hot oven for 7-10 days till constant weight. Seeds were cooled and ground using a grinding machine and sieved through five different laboratory test sieves to obtain the particle sizes of 0.2, 0.5, 1, 2 and 5 mm. The samples were stored in separate air tight containers and labelled properly. Details of optimization parameters is given in Table 1.

The 25g mango kernel powder was taken in a 500 mL capacity round bottom flask and refluxed with n-hexane on a heating mantle. The solution was filtered through a G-1 crucible funnel with the help of vacuum filtration pump. The filtrate containing oil dissolved in n-hexane was distilled to separate solvent from oil. After complete evaporative separation of solvent the quantity of oil was measured by weighing. The recovered solvent was reused

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Table 1 Details of optimization parameters

Optimization parameter	Particle size (mm)	Volume of solvent (mL)	Duration of extraction (min)	Temperature (°C)
Particle size	0.22, 0.5, 1.0, 2.0 and 5.0	250	90	70
Temperature	1	250	90	40, 50, 60, 70 and 80
Duration of extraction	1	250	15, 30, 45, 60, 75, 90, 105 and 120	70
Volume of solvent	1	100, 150, 200, 250, 300, 350 and 400	90	70

for next extraction.

Oil extracted from mango kernels was tested for antifungal activity against *Aspergillus fumigatus* as per method of Perez *et al.* (1990). One ml of mango kernel oil was spread evenly on Potato Dextrose Agar plates. After 10 minutes, a well (5 mm diameter) was cut where in same sized *A. fumigatus* colony was placed. The plate was incubated at 30°C for 5 days. The growth inhibition of colony diameter of treated plate was compared with that of control (plate not treated with oil).

Acid value, saponification value, iodine value were determined according to the methods prescribed by AOAC (1984). Specific gravity, viscosity, pH, refractive index, flash point, colour and pour point were determined according to the method of AOAC (1990).

Fatty acid methyl esters (FAME) were prepared as per method of Christie (1973). The fatty acid composition was determined by GC using flame ionization detector operated under the following conditions: capillary column Elite FFAP (30 m × 0.25 mm × 0.25 um); Nitrogen flow 40 ml/min; Hydrogen flow 40 ml/min; air flow 400 ml/min; column temperature 100°C hold for 5 minutes then increase at the rate 3 ml/min up to 240°C hold for 15 minutes; injector temperature 210°C and FID temperature 280°C. The fatty acids were identified using authentic standards and reported as a relative percentage.

RESULTS AND DISCUSSION

Effect of particle size on oil yield

The effect of particle size on mango kernel oil yield is shown in Table 2. It was observed that at 1 mm particle size increases or decreases, the size affected on the oil yield. It was observed that oil yield increased from 20 to 50 % as the particle size decreased from 5 to 1 mm but decreased when particle size was further reduced. The negative effect of particle size on oil yield could be attributed to the fact that to smaller particles have larger amount of surface area coupled with increased number of ruptured cells resulting

Table 2 Effect of particle size on mango kernel oil yield

Sample No.	Particle size	Time boil (Min.)	Mango kernel (g)	Hexane (ml)	Recovery oil		Reco-very of hexane (ml)
					Aver-age wt. (g)	Yield (%)	
1	0.22 mm	90	25	250	2.202	8.80	225
2	0.5 mm	90	25	250	2.441	9.76	215
3	1 mm	90	25	250	3.80	15.20	200
4	2 mm	90	25	250	1.832	7.328	190
5	5 mm	90	25	250	1.45	5.8	205

in a high oil concentration at the particle surface and low or little diffusion into the particles surface (Ebewele *et al*. 2010, Sayyar *et al.* 2009). Maximum oil yield of 15.20% was obtained at 1 mm particle size for an extraction time of 90 minutes using 1:10 solid to solvent ratio.

Effect of temperature on oil yield

Oil yield increased with increases in temperature up to 60°C but became constant up to 70°C and decreased further increase in temperature. The oil yield increased from 8.56 % to 15.0% . The maximum oil recovery (15.0 %) was observed at 60 °C for 90 min. Hickox (1953) and Nwabanne (2012) also reported that an increase in oil yield with increase in temperature at 70°C when further temperature increases was not effect on oil yield from cotton seed oil.

Effect of extraction duration on oil yield

Oil yield increased as the extraction time increased up to 90 min and further increase reduced the yield. Oil yield increased from 38.55 to 46.98% as time increased from 15 to 90 min but oil yield deceased when time duration was increased from 90 to 120 min. The same trend was reported by Meziane *et al*. (2006) with oil extracted from olive cake the maximum oil recovery at a fixed extraction time.

Effect of volume of solvent on oil yield

Oil yield increased as the volume of n-hexane (solvent) was increased from 100 to 250 mL. With further increase in volume of n-hexane up to 400 mL, constant oil yield was obtained. Therefore, highest percentage oil yield was obtained with 1:10 ratio of solid and volume of n-hexane (solvent).

Antimicrobial activity

Antifungal activity assay revealed 5 times inhibition in fungal growth in oil treated plate. The increase in colony size was 2 mm (final size) in oil treated plate compared to control where colony further increased 10 mm in size.

Physico-chemical properties of extracted mango kernel powder oil

Physical property: The oil was found to be yellow in

Table 3 Physicochemical properties of mango kernel oil

Physicochemical properties	Value
pH	5.9
Refractive index	1.476
Density/specific	0.911g/cm^3/0.9111
Viscosity value	119cp
Pour point	32°C
Acid value	4.77 mg NaOH/g
Saponification value	162.69 mg KOH/g
iodine value	123.83 mg/100g
Oil content	6 – 15.20 %

Table 4 Fatty acid composition (% w/w) of oils extracted from mango kernel

Fatty acid	% (w/w)
Stearic acid	58.08
Oleic acid	17.99
Palmitic acid	1.33
Palmitoleic acid	0.30
Linoleic acid	2.86
Myristic acid	0.17
Myristate acid	0.15
Octadecanoate acid	0.50

colour and had non-offensive odour. The pH, refractive index and density/specific gravity of the kernel oil was obtained to be 5.9, 1.476 and 0.911g/cm^3/0.911, respectively (Table 3). Refractive index of oils depends on the density of the oil (Ajayi and Oderinde 2002). In general, the refractive index and relative density/specific gravity values of edible vegetable oils are physical measures of adulteration of vegetable oils, since different oils have characteristic density/specific gravity and refractive index (Olutoye and Garba 2008). The viscosity value of 119cp as determined reflects the resistance of the oil to shear stress. The value of the pour point is 32°C and oil ceases to flow on increased temperature.

Chemical properties: The chemical analysis showed that the oil obtained had an acid value of 4.77 mg NaOH/g, saponification value of 162.69 mg KOH/g and iodine value of 123.83 mg/100g. The acid value gives an indication of the amount of free fatty acids present in the oil at the time of the test. It is an indicator for edibility and suitability for its use in industry like soap production and in making other cosmetic products such as shampoo. Kittiphoom and Sutasinee (2010) have reported acid value (mg KOH/g oil) 27.55±0.55, iodine value (mg/100g oil) 59.17±2.3, saponification value (mg KOH/g oil) 206.0±13.8 in mango kernel oil using ethanol solvent. The high saponification value recorded for the oil is an indicative that they have potential for use in the industry (Bastic *et al.* 1978, Amoo *et al*. 2004, Kittiphoom and Sutasinee 2010). Iodine value measures the degree of unsaturation of a particular vegetable oil and studies have shown that as the degree of unsaturation increases, iodine value increases and the liability of the vegetable oil to become rancid by oxidation increases (Cocks and Rede 1966, Eka 1980).

Fatty acid composition

The total fatty acid composition of the oil extracts of mango kernel from cultivation of Dashehari obtained in this study was determined by GCFID and is shown in Table 4. The major saturated fatty acids found were stearic acid (58.08%), palmitic acid (1.33%), myristic acid (1.17%), arachidic acid (1.10%) and margaric acid (0.15%) while some unsaturated fatty acids were oleic acid (17.99%), linoleic acid (2.86%), linolenic acid (1.48%) and palmitoleic acid (0.30%). Trace amount of eicosa-11-enoate, lignocerate, tridecanoate, myristoleate, heptadenoate and lauric acid were also found. Nzikou *et al*. (2010) reported stearic (37.73%), oleic (46.22%), palmitic (6.43%), linoleic (7.33%) and linolenic (2.30%) acids in mango kernel oil. Akinyemi *et al.* (2015) reported stearic (37.57–38.80 mg/kg) and oleic (43.71–44.91 mg/kg) acids in mango seed kernel flour. Fahimdanesh and Bahrami (2013) also reported saturated fatty acids in mango seed kernel oil as stearic (37.73%) and palmitic (6.43%) acids while oleic (46.22%), linoleic (7.33%) and linolenic (2.30%) acids to be the main unsaturated fatty acids. The proportion of unsaturated fatty acids was greater than the saturated fatty acids. The comparison of the composition in fatty acids of mango seed kernel oil with that of vegetable oils indicates that it is richer in stearic and oleic acids. Therefore, mango seed kernel oil is more stable than many other vegetable oils rich in unsaturated fatty acids.

Maximum oil yield of 15.2% was obtained at 1 mm size with 1:10 solid to solvent ratio and an extraction time of 90 min at the temperature 60°C. This study has optimized parameters, viz temperature, time and volume of solvent and particle size for higher oil yield. Mango seed kernels oil is rich in stearic and oleic acid as the principal fatty acids and proportion of unsaturated fatty acids was greater than saturated fatty acids. Mango seed kernel oil contains high unsaponifiable matter which could provide it a good potential to be used in cosmetics.

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