International Food Research Journal 20(3): 1145-1149 (2013)
Journal homepage: http://www.ifrj.upm.edu.my

Mango seed kernel oil and its physicochemical properties

*Kittiphoom, S. and Sutasinee, S.

Faculty of Agro Industry, Rajamangala University of Technology Srivijaya, Nakhon Si Thammarat, 80240, Thailand

Article history

Received: 6 October 2011
Received in revised form: 3 January 2012
Accepted:3 January 2012

Keywords

Mango seed kernel oil
extraction
fatty acid

Abstract

Mango seed kernel oil was extracted using soxhlet extraction with petroleum ether, ethanol and hexane. The physicochemical properties (acid value, iodine value, peroxide value and saponification value), the fatty acid composition and phenolic contents, of mango seed kernel oil were examined. Oil extracted with hexane has better overall quality. Its acid, peroxide, iodine saponification values and phenolic content were 0.10 mg KOH/g oil, 8.72 mg/g oil, 38.50 mg/100 g oil, 207.5 mg KOH/g oil and 98.7 mg/g, respectively. The main fatty acids found in the mango seed kernel oil were steric acid and oleic acid. The results suggested that mango seed kernel oil is a good source of the unsaturated fatty acid, phenolic compounds and has the potential to be used as nutrient rich food oil or as ingredients for functional or enriched foods.

Introduction

Mangoes (*Mangifera indica* L.) are one of Thailand's most economically important fruit. Particularly the Keaw variety which has been used as raw material for many canned fruit products. Only the mango flesh is utilized by these factories, resulting in a vast amount of mango seeds being discarded as waste. Mango seed consists of a tenacious coat enclosing the kernel. The seed content of different varieties of mangoes ranges from 9% to 23% of the fruit weight (Palaniswamy *et al*., 1974) and the kernel content of the seed ranges from 45.7% to 72.8% (Hemavathy *et al*., 1988). Mango kernel contain almost 15 wt% of oils (Nzikou *et al*., 2010).

Mango kernel oil has been used in the cosmetics industry as an ingredient in soaps, shampoos and lotions because it is a good source of phenolic compounds (Soong and Barlow, 2004) including microelements like selenium, copper and zinc (Schiber *et al*., 2003). In addition, the extract of mango seed kernel exhibited the highest degree of free-radical scavenging and tyrosinase-inhibition activities compared with methyl gallate and phenolic compounds from the mango seed kernel and methyl gallate in emulsion affected the stability of the cosmetic emulsion systems.

Fatty acids are important as nutritional substances and metabolites in living organisms. Many kinds of fatty acids play an important role in the regulation of a variety of physiological and biological functions (Zhao *et al*., 2007). The main fatty acids found in mango kernel oil are about 45% oleic acid and 38% steric acid (Nzikou *et al.*, 2010). Oleic acid is an 18-carbon monounsaturated fatty acid, essential in human nutrition and helps reducing triglycerides, LDL-cholesterol, total cholesterol and glycemic index. Also, the increase in stability over oxidation of vegetable oil is attributed to oleic acid (Abdulkarim *et al*., 2007). Stearic acid, a long C18 straight-chain saturated fatty acid, has been found to bind and plasticize composites (Netravali, 2003), human serum albumin (Bhattacharya *et al.*, 2000) and α-helical sites in bio-molecules (Vila *et al.*, 1998).

The extraction technique used to obtain high aggregate value compounds from natural products is crucial for product quality. Soxhlet extraction is a standard technique. The advantage of conventional soxhlet is the sample is repeatedly brought into contact with the fresh portions of the solvent, thereby helping to displace the transfer equilibrium. There is a wide variety of official methods involving a sample preparation step based on soxhlet extraction. Soxhlet extraction is a general, well-established technique which clearly surpasses in performance other conventional extraction techniques.

However, there are only few studies on the extraction of mango kernel oil and the fatty acid profile. Therefore, the objectives of this study were to compare the efficiency of the extraction solvents;

*Corresponding author.
Email: *kit_src@yahoo.com*

evaluate the quality of mango kernel oil through the physicochemical properties, fatty acid composition and total phenolic compound that can be used in the extraction of mango kernel oil with soxhlet.

Materials and Methods

Materials

Mango seeds (*Mangifera indica* L.) were harvested from Sam Roi Yot Co., ltd (Thailand). Mango seeds were collected and cracked to obtain the kernels. The kernels were then ground in a food grinder to reduce the particle size to a maximum diameter of 500 mm as measured by a sieve, sealed in a plastic container and stored in a refrigerator until extraction. The storage conditions assured eliminating effects of oxygen and humidity and to avoid oxidation of the dried mango seed powder during storage time. Foline Ciocalteau reagent and NaOH were supplied by Merck. KI, $Na_2S_2O_3$, KOH, phenolphthalein, HCl, starch indicator, I_2, Br_2 were supplied by Ajax Finechem. Gallic acid was supplied by Fluka.

Oil extraction

The soxhlet extractions were performed at least in duplicate, with different solvents: petroleum ether, hexane and ethanol. The solvents chosen for present study are normally used to extract oil from plant kernel. Thirty grams of mango seed kernel were extracted in a soxhlet-extractor with 200 mL solvents for 6 h at 50^{o}C. This mild extraction temperature of 50^{o}C was chosen to avoid thermal degradation on bioactive compounds in the extracts. Also the temperate is in the range of boiling temperature of these solvent. The resulting extracts, obtained by the different methods were separated by evaporating the solvents used in a rotary evaporator under reduced pressure and at temperature of 50^{o}C. The obtaining the fractions were weighted and oil physicochemical properties were determined.

Physicochemical properties of mango kernel oils

The acid value was determined by titration (ASTM D664). Iodine value was determined by titration (AOCS Cd 1b-87). Peroxide value was determined by titration (Cd 8b-90). Saponification value was determined by titration (AOCS T1 1a-64). Fatty acid components were identified by gas chromatography (model 6850A; Hewlette Packard, USA) equipped with a flame ionization detector.

Determination of total phenolic content

The analysis method modified from Brand *et al.*, (1995), the mango kernel oil 0.4 ml were mixed with 2 ml of 10 % Folin Ciocalteau reagent and 1.6 ml of 7.5% Na_2CO_3 and left at room temperature for 30 min. The mixing solution was measured an absorbance at 765 by ultraviolet visible spectrophotometer and calculated as gallic acid equivalent.

Statistical analysis

The extractions and all analyses were carried out at least in triplicate and data were expressed as means ± standard deviation. A one-way analysis of variance (ANOVA) was performed to calculate significant differences in treatment means, and multiple comparisons of means were done by the LSD (least significance difference) test. A probability value of $p < 0.05$ was considered significant and only significant differences were considered unless stated otherwise.

Results and Discussion

Physicochemical properties of oils

The total oil yields are shown in Table 1. Among soxhlet extraction, the solvent of hexane provided highest total oil yield, follow by petroleum ether and ethanol. The interaction between solvent and solutes, both solvent polarity and their boiling temperature may contribute mean factors on the extraction efficacy and yield, as well as composition of mango kernel oil. It can be seen that most of the values fall within the ranges published in the literature (Nzikou *et al.*, 2010 and Saranyu Khammuang and Rakrudee Sarnthima, 2011).

The acidity, iodine, peroxide and saponification values are the major characterization parameters for oil quality. The mango kernel oils were very light yellow in color. The analysis showed that different extraction methods influenced the physicochemical properties of the oils. The acid value was a measure of total acidity of the lipid, involving contributions from all the constituent fatty acids that make up the glyceride molecule (Ekpa and Ekpe, 1995). As shown in Table 1, the acid value was highest in ethanol extract, followed by petroleum ether and the lowest value was found in the hexane extract.

Peroxide value is one of the most widely used testing for oxidative rancidity in oils. It is a measure of the concentration of peroxides and hydroperoxides formed in the initial stages of lipid oxidation. Generally, the peroxide value should be less than 10 mg/g oil in the fresh oils. The results showed that the peroxide values varied widely in the extracts, ranging from 8.72 ± 3.4 mg/g oil for the hexane extract to 26.35 ± 2.1 mg/g oil for the ethanol extract. Ojeh (1981) reported that oils with high peroxide values are unstable and easily become rancid. The results

Table 1. Physicochemical property of mango seed kernel oils extracted with different solvents (means ± S.D.)

Physicochemical property	Ethanol extract	Hexane extract	Petroleum Ether extract	Nzikou *et al.*, 2010	Saranyu Khammuang and Rakrudee Sarnthima, 2011*
Total oil yield (g/g d.b)	6.96±0.13[a]	8.46±0.01[b]	8.04±0.07[b]	13.0	2.53
Acid value (mg KOH/g oil)	27.55±0.55[b]	0.10±0.012[a]	0.15±0.083[a]	5.35	nr
Peroxide value (mg/g oil)	26.35±2.1[b]	8.72±3.4[a]	8.82±2.8[a]	nr	nr
Iodine value (mg/100g oil)	59.17±2.3[b]	38.50±3.9[a]	37.25±3.0[a]	39.5	nr
Saponification value (mg KOH/g oil)	206.0±13.8[b]	207.5±14.2[b]	190.2±12.8[a]	207.5	nr
Total phenolic content (mg GAE/g)	53.5±7.5[a]	98.7±8.8[c]	77.0±7.4[b]	117	118.1±0.2

Note: nr not reported * The Keaw variety
a-b Means within the same row not followed by the same letter differ significantly ($p < 0.05$). Each experiment was performed in triplicates.

suggested that the mango kernel oils extracted with hexane and petroleum ether could be stored with less deterioration than the oil extracted with ethanol. The acid and peroxide values were good indices for the stability of the oil.

The iodine value is used to determine the unsaturation of oils and in assessing the stability of oil in industrial applications (Xu *et al*., 2007). The oil extracted with petroleum ether had the lowest iodine value, which reflected its characteristics such as higher resistance to oxidation, longer shelf life and higher quality. The differences in iodine values between oil samples maybe were due to the different fatty acid compositions.

Saponification value was highest in the hexane extract, followed by the ethanol extract while the lowest value was in petroleum ether extract. The saponification value is a useful tool for the evaluation of the chain length (molecular weight) of fatty acids occurring in the triacylglycerols in oil. The lower saponification value indicates a very high content of low molecular weight triacylglycerols. The results suggested that the oils extracted with petroleum ether had the higher fatty acid contents.

Total phenolic content

The phenolic compounds are the main component responsible for antioxidant activity, is mainly due to their redox properties, which can play an important role in absorbing and neutralizing free radicals, quenching singlet and triplet oxygen, or decomposing peroxides (Osawa, 1994). The determination of total phenolic content through the method of Folin-Ciocalteau represents a good estimative of antioxidant potential of food samples.

The total phenolic contents of kernel meal and oil by different solvent extractions are presented in Table 1. The oils extracted with solvents resulted in high phenolic contents (98.7 ± 8.8 mg GAE/g), indicating that only parts of the phenolic content were transferred to oils.

The total phenolic content varies considerably from one kind of fruit to another. Phenolic content of seeds of avocado, jackfruit, longan, mango and tamarind were shown in Table 2. Mango seed kernel had the highest phenolic content, followed by the seeds of tamarind, avocado, longan and jackfruit. This suggests that the fruit seeds should be further utilized rather than just discarded as waste.

Table 2. The total antioxidant activity and phenolic contents of seed of mango, tamarind, longan, avocado and jackfruit

Item	Phenolic content (mg/g)
Mango kernel (This research)	98.7 ± 8.8
Mango kernel	117 ± 13.5
Tamarind seed	94.5 ± 4.9
Longan seed	62.6 ± 3.2
Avocado seed	88.2 ± 2.2
Jackfruit seed	27.7 ± 3.4

(Source: Soong and Barlow, 2006)

Profile of fatty acid composition in mango seed kernel oil extract

The total fatty acid composition of the extracts obtained in this study was determined by GC and was shown in Table 3. The fatty acid profile is a main determinant of the oil quality. The extracted oil contained major fatty acid compounds were oleic acid and steric acid. It can be seen that most of the values fall within the ranges published in the literature (Nzikou *et al*., 2010; Dhingra and Kapoor, 1985).

All oil samples had high amounts of the unsaturated fatty acid that primarily were oleic and linoleic acids. The unsaturated fatty acids are very important for the stability of oils because of the chemical reactions occurring at the double bonds.

Table 3. Fatty acid composition (%w/w) of oils extracted with different solvents (means ± S.D.)

Fatty acid	Ethanol extract	Hexane extract	Petroleum ether extract	Nzikou *et al.*, 2010	Dhingra and Kapoor, 1985
Palmitic acid (16:0)	8.50 ± 0.26[a]	8.97 ± 0.15[b]	8.73 ± 0.15[ab]	6.48	7.18
Steric acid (18:0)	38.50 ± 0.45[b]	37.37 ± 0.23[a]	37.7 ± 0.16[a]	37.94	38.90
Oleic acid (18:1)	43.45 ± 0.46[a]	43.77 ± 0.37[a]	44.75 ± 0.40[b]	45.76	42.60
Linoleic acid (18:2)	6.48 ± 0.53[b]	6.78 ± 0.25[b]	5.67 ± 0.31[a]	7.45	5.70
Linolenic acid (18:3)	0.49 ± 0.09[a]	0.79 ± 0.18[b]	0.59 ± 0.19[a]	2.37	5.3
Eicosanoic acid (20:1)	2.51 ± 0.18[b]	2.19 ± 0.19[a]	2.48 ± 0.16[b]	-	-

a-b Means within the same row not followed by the same letter differ significantly ($p < 0.05$). Each experiment was performed in triplicates.

The rates of those oxidation reactions depend on the number of double bonds in the carbon chain. Therefore oils with a high proportion of oleic acid are more stable than others. Oleic acid is less susceptible to the oxidation than polyunsaturated fatty acid from the n-6 series (linoleic acid).

The linoleic acid as an essential fatty acid contributes health benefits for human body and it is preferred by industries when oil hydrogenation is required. Based on the results of physicochemical properties and fatty acid profile of the mango kernel oil, it can be concluded that the mango kernels can become valuable resource to produce high value essential oil products. The high quality and nutritional value of mango kernel oil has potential application in human foods. The results suggested that the best method to produce high extraction yield and total phenolic content for mango seed kernel oil is soxhlet extraction with hexane as solvent.

Conclusions

Mango seed kernel oils were extracted by organic solvents (petroleum ether, ethanol and hexane) and evaluated for their characterization and quality analysis. According to the analysis of physicochemical properties, fatty acid profile and total phenols, the results showed that these oils are rich in oleic acid and steric acid, indicating that they are stable and tolerant to rancidity. The effects of different extraction solvents significantly influenced the physicochemical properties of oil, and the phenolic composition and antioxidant properties of the meals and extracted oils. The results suggested that the oil extracted with hexane has better quality. Hexane has been widely used for extraction in food industry due to it is easily be evaporated from extracts. This oil may be considered as an important source of unsaturated fatty acid and has the potential to be used as nutrient rich food oil. Furthermore, the results also verified that mango seed kernel oil contained high amounts of total phenolic, enabling their application as ingredients of functional or enriched foods. The results of present study provide useful information for essential oil and food industry. Due to its special composition, rich in polyunsaturated fatty acids, including linoleic and oleic acids, and in antioxidant compounds.

Acknowledgements

This work supported from Faculty of Agro Industry, Rajamangala University of Technology Srivijaya,Nakhon Si Thammarat (Thailand).

References

Abdulkarim, S.M., Long, K., Muhammad, S.K.S. and Ghazali, H.M. 2007. Frying quality and stability of high-oleic *Moringa oleifera* seed oil in comparison with other vegetable oils. Food Chemistry 105: 1382-1389.

Bhattacharya, A.A., Grune, T. and Curry, S. 2000. Crystallographic analysis reveals common modes of binding of medium and long-chain fatty acids to human serum albumin. Journal of Molecular Biology 303: 721–732.

Brand, W.W., Cuvelier, M.E., and Berset, C. 1995. Use of a free radical method to evaluate antioxidant activity. Food Science and Technology 28: 25-30.

Dhingra, S. and Kapoor, A.C. 1985. Nutritive value of mango seed kernel. Journal of the Science of Food and Agriculture 6: 752-756.

Ekpa, O.D. and Ekpe, U.J. 1995. The effects of coconut oil concentration and air exposure to the total acidity of palm oil. Global Journal of Pure and Applied Sciences 11: 51-58.

Hemavathy, J., Prabhakar, J.V. and Sen, D.P. 1988. Drying and storage behavior of mango (*Mangifera indica*) seeds and composition of kernel fat. Asean Food Journal 4(2): 59-65.

Khammuang S. and Sarnthima R. 2011. Antioxidant and antibacterial activities of selected varieties of thai mango seed extract. Pakistan Journal of Pharmaceutical Sciences 24(1): 37-42.

Netravali, A., 2003. “Green” Composites from Cellulose Fabrics & Soy Protein Resins. National Textile Center Project F01-CR01 Annual Report. Cornell University. Downloaded from *http://www.human.cornell.edu/units/txa/research/ntc/F01-CR01-A3.pdf.* on 3/6/2012.

Nzikou, J.M., Kimbonguila, A., Matos, L., Loumouamou, B., Pambou-Tobi, N. P.G., Ndangui, C.B., Abena, A.A., Silou, Th., Scher, J. and Desobry, S. 2010. Extraction and characteristics of seed kernel oil from mango (*Mangifera indica*). Research Journal of Environmental and Earth Sciences 2(1): 31-35.

Ojeh, O. 1981. Effects of refining on the physical and chemical properties of cashew kernel oil. Journal of Fats and Oils Technology 16: 513-517.

Osawa, T. 1994. Novel natural antioxidants for utilization in food and biological systems. Postharvest Biochemistry of Plant Food-Materials in the Tropics 241-251.

Palaniswamy, K.P., Muthukrishna, C.R. and Shanmugavelu, K.G. 1974. Physicochemical characteristics of some varieties of mango. Indian Food Packer 28(5): 12-18.

Schiber, A., Berardini, N. and Carle, R. 2003. Identification of flavonol and xanthol glycosides from mango peels by HPLC. Journal of Agricultural and Food Chemistry 51: 5006-5011.

Soong, Y.Y. and Barlow, P.J. 2006. Quantification of gallic acid and ellagic acid from longan (*Dimocarpus longan* Lour.) seed and mango (*Mangifera indica* L.) kernel and their effects on antioxidant activity. Food Chemistry 97(3): 524-530.

Vila, J.A., Ripoll, D.R.,Villegas, M.E.,Vorobjev,Y.N. and Scheraga, H.A. 1998. Role of hydrophobicity and solvent-mediated charge–charge interactions in stabilizing α-helices. Biophysical Journal 75: 2637-2646.

Xu, Y.X., Hanna, M.A. and Josiah, S.J. 2007. Hybrid hazelnut oil characteristics and its potential oleochemical application. Industrial Crops and Products 26: 69-76.

Zhao, X., Wang, H., You, J. and Suo, Y. 2007. Determination of free fatty acids in bryophyte plants and soil by HPLC with fluorescence detection and identification by online MS. Chromatographia 66: 197-206.