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Effect of microwaves pretreatments on extraction yield and quality of mango seed kernel oil

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Abstract

Effect of microwave radiation on mango seed was probed by employing it as a substrate pretreatment prior to oil extraction by soxhlet method. Samples were treated by microwave radiation at a frequency of 2,450 MHz by a household microwave oven. Eighteen microwave pretreatments were established, together combining three potencies (110, 330 and 550 W) and six times of pretreatment (0-150 s). Microwave pretreatment could be applied to mango seed kernel oil extraction prior to soxhlet extraction to decrease the extraction time was generally concluded. Pretreatment at 60 s and at 110 W potency was found as the most appropriate condition of microwave pretreatment since it decreased the extraction time from 150 min to up to 30 min. The major advantage of microwave pretreatment is the reduced time of extraction and energy consumption costs, when is compared to conventional methods. Analysis of oil quality indices (e.g. acid value, peroxide value, oil composition) extracted by microwave pretreatment and non-pretreatment indicated that oils from both processes have comparatively similar properties, thus it was justification of microwaves use as a rapid tool for oil extraction pretreatment.

Introduction

Mango (*Mangifera indica* L.) is one of Thailand's most economically important fruit, particularly so-called Keaw variety which has been used as raw material for many canned fruit products. Only the mango flesh is utilized by these processing factories, causing a vast amount of mango seeds being discarded as waste and burden when disposed.

Mango seed is made of a tenacious material enclosing the kernel. Its seed content of different varieties of mangoes ranges from 9% to 23% of the fruit weight and the kernel content of the seed ranges from 45.7% to 72.8% (Palaniswamy *et al*., 1974). Mango kernel contains nearly 15 wt% oils. Mango kernel oil has long been used in the cosmetics industry as an important ingredient in soaps, shampoos and lotions since it is a plentiful source of phenolic compounds including microelements for examples selenium, copper and zinc (Schiber *et al*., 2003). Additionally, the extracted portion of mango seed kernel demonstrated very high degree of free-radical scavenging and tyrosinase-inhibition activities when compared with methyl gallate and phenolic compounds from the mango seed kernel and methyl gallate in emulsion form affected the stability of the cosmetic emulsion systems.

Traditionally, extraction of oils from oilseeds can be readily performed by pressing or with solvent. Solvent oil extraction is commonly applied to seeds with low content of oil (<20%), like soybean. Pressing method is employed for seeds with a high amount of oil, like rapeseed, but this method is comparatively inefficient and a large portion of the oil is left in the meal (Buenrostro and Lopez-Mungua, 1986). However, residual oil in the meal can be extracted later by solvent. Solvent extraction method is considered one of the most efficient method with less oil left in the meal. Nevertheless, this method has many industrial disadvantages, for instances plant security problems, emissions of volatile organic compounds into atmosphere, high operation costs, rather poor quality products brought about by high processing temperatures, low extraction yield and a quite high number of processing steps (Del Valle and Aguilera, 1999). Among available and currently being-developed methods, microwave pretreatment of seeds a method of choice as it is a simple technique for production of high quality vegetable oil as well as provision of highly nutritional values retention. The new pretreatment permits for better retention and higher availability of desirable nutraceuticals like phytosterols and tocopherols in the extracted oil. Microwave radiation of seeds is receiving lot attention rather than microwave technique (Takagi and Yoshida, 1999 and Uquiche

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et al., 2008). Compared with conventional methods, microwave pretreatment for oil extraction has many advantages e.g. improvement of extracted oil yield and quality, direct extraction capability, lower energy consumption, faster processing time and reduced solvent contents (Ramanadhan, 2005).

There is not much information in the literature in association to application of microwave radiation as a pretreatment for mango seed and its effect on extraction yield and quality of oil. The objective of the present study was to probe the influence of microwave radiation pretreatment before the oil extraction operation by soxhlet extraction upon recovery of oils and oil quality of mango seeds.

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 kernel. The kernel were later ground into a food grinder in order to reduce the particle size to a maximum diameter of up to 500 µm as measured by a sieve, then sealed in a plastic container and stored in a chilled condition until extraction. All microwave tests were carried out with a Toshiba, model ER-D33SC compact microwave oven working at 2.45 GHz with a power of 1,100 W.

Effect of microwave pretreatment and extraction time

For each microwave pretreatment, 15 g of mango seed was arranged in a single layer in Pyrex petri dishes (9-cm diameter). The sample was placed on the external border of the turntable plate of the microwave variable power oven (Model ER-D33SC, Toshiba). Sample was microwave-treated at a frequency of 2,450 MHz and time of radiation was 30 s. Based on preliminary tests, we founded ten treatments with microwave, combining two variables: two levels of potency (0 and 330 W) and six times of extraction (30-180 min). Each one of the twelve treatments was performed in triplicate.

Effect of microwave power and microwave pretreatment times

For microwave power and time of microwave pretreatment tests, we set up eighteen treatments with microwave, combining two variables: three levels of potency (110, 330 and 550 W) and six times of radiation (0-150 s). Each one of the eighteen treatments was done in triplicate. The extraction time used the optimum condition from preliminary tests.

Purification method

Later the samples microwave-treated corresponding to the three replicates were collected and permitted to cool to ambient temperature condition before oil extraction by extraction. Oil content samples were gravimetrically identified by extraction with technical grade hexane to exhaust in a soxhlet apparatus at 70°C. The resultant extracts, obtained by these different methods were separated by evaporating the solvents through a rotary evaporator under reduced pressure and at temperature of 50°C. The obtaining fractions were weighted, and filtered through 0.45 µm membranes afterwards.

Measurement of physical and physicochemical properties of oil

Analysis of the oil samples were determined as describes by AOCS (1993): briefly, specific gravity determination using a 10 mL pycnometer at 25°C, acid value expressed as mg KOH necessary to neutralize free acids in 1 g of oil (Cd 3a–63), peroxide index expressed as milli-equivalents (meq) of peroxide per 1000 g of oil (Cd 8–53), saponification value expressed as mg KOH required to saponify 1 g of oil (Cd 3–25), iodine value by Wijs method, is expressed in terms of the number of g of iodine absorbed per 100 g of oil (Cd 1–25), and unsaponifiable matter expressed in terms of percentage (Ca 6a–40). Fatty acid components were identified by gas chromatography (Model 6850A; Hewlette Packard, USA) equipped with a flame ionization detector.

Statistical analysis

The extractions and all analyses were executed at least in triplicate and data presentation was expressed as means and 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 regarded as significant and merely significant differences were considered unless stated otherwise.

Results and Discussion

Effect of microwave pretreatment and extraction time on oil yield extraction

To examine effect of microwave pretreatment on oil extraction yield by soxhlet extraction, extractions were carried out by using mango seed kernel with microwave pretreatment and untreated samples. Table 1 exhibited oil extraction yield by soxhlet extraction. At the extraction time of 30-180

Table 1. Oil extraction yield from mango seed kernel obtained by different extraction times

Condition	Extraction yield (%)					
	30 min	60 min	90 min	120 min	150 min	180 min
Non-pretreatment	3.50±0.20[a]	4.56±0.25[b]	5.73±0.25[c]	7.17±0.75[d]	8.60±0.38[e]	8.63±0.26[e]
Microwave 330 W	8.60±0.20[ns]	8.50±0.50[ns]	8.57±0.32[ns]	8.47±0.47[ns]	8.47±0.25[ns]	8.43±0.35[ns]

Note: Values are means of three replicates SD. Means followed by different letters are significant different ($p < 0.05$)

Table 2. Oil extraction yield from mango seed kernel obtained by different microwave pretreatment times

Microwave power	Extraction yield (%)					
	0 s	30 s	60 s	90 s	120 s	150 s
110 W	5.20±0.12[c]	6.77±0.32[b]	9.23±0.31[a]	9.30±0.20[a]	9.30±0.15[a]	9.35±0.32[a]
330 W	5.20±0.12[c]	7.30±0.26[b]	9.10±0. 35[a]	9.20±0.10[a]	*-	-
550 W	5.20±0.12	7.70±0.26	*-	-	-	-

Note: * samples were burned. Values are mean of three replicates SD. Means followed by different letters are significant different ($p < 0.05$)

min, oil extraction yield from mango seed kernel increased when microwave radiation was applied. The most appropriate extraction time for microwave pretreatment was found to be 30 min, as it resulted in the maximum of extraction yield. Thus, a extraction time of 30 min was selected for this study. Untreated (Control) would require 150 min to achieve the same extraction yield compared to when it was produced by microwave pretreatment with a 30 min extraction time. This result was to be expected previously probably due to the fact that microwave pretreatment provides a potential alternative to induce stress reactions in plant systems or oil seeds. By using microwave radiation in oil seeds, a higher extraction yield and an increase in mass transfer coefficients can be obtained because the cell membrane is more severely ruptured. Apart from this, permanent pores were generated as accordingly, this enables the oil to move through permeable cell walls (Azadmard-Damirchi *et al*., 2011).

Effect of microwave power and microwave pretreatment times on oil yield extraction

Comparisons of oil yields of mango seed exposed to three microwave power levels (110, 330 and 550 W) for microwave pretreatment times (0-150 s) were demonstrated in table 2. It was found that oil extraction yield was increased significantly when microwave pretreatment times was increased from 0 to 60 s. However, further increased microwave pretreatment times from 90 -150 s for microwave power 110 W did not show any significant improvement in oil extraction yield and increased microwave pretreatment times higher than 90 s for microwave power 330 W and 30 s for microwave power 550 W, the samples were burned. The effect of microwave power did not show any significant in oil extraction yield at the same time. Therefore, the optimum condition for microwave pretreatment was 110 W of microwave power for 60 s resulted in the highest (9.23%). This result is in good agreement with a report made by Uquiche *et al.* (2008) who employed the optimum condition for pretreated Chilean hazelnut by a pressing extraction was microwave power of 400 W for 240 s. The pretreatment of hazelnuts with microwaves could increase oil extraction yield and increasing of treatment time had a positive effect on oil extraction yield as well. (Uquiche *et al*., 2008) .

Effect of microwave pretreatment on fatty indices and functional components

Physicochemical characteristics of mango seed kernel oil were shown in table 3. Each values represented means of three repetitions. Specific gravity is an important characteristic of vegetable oil and generally corresponds to the ratio of the weight of substance's given volume to weight of an equal volume of water. Specific gravity values were 0.914 for both cases, which fell within the range as reported in the literature for vegetable oils: olive oil (0.910–0.916), rapeseed oil (0.910–0.920) and sunflower seed oil (0.918–0.923) (Nichols and Sanderson, 2003).

Acid value can be used as a purity examination of oil and showed that oil may have already started decomposition reactions. Acid value stayed relatively constant, as can be seen that untreated seeds was 0.56 mg KOH/g oil and microwave pretreatment seeds was 0.72 mg KOH/g oil. Increment in the acid value of oil may be attributed to hydrolysis of triacylglycerols by microwave to produce more amount free fatty acids (Anjum *et al*., 2006).

Peroxide value is employed to measure the quantity of peroxides in the oil; these substances are important intermediate product of oxidative reactions since they decompose via transition metal irradiation

Table 3. Physicochemical characteristics of mango seed kernel oil

Properties	Non-pretreatment	Microwave pretreatment
Specific gravity	0.914±0.000	0.914±0.000
Acid value (mg KOH/g oil)	0.56±0.02	0.72±0.03
Peroxide value (meq O_2/kg oil)	8.73±2.4	8.92±2.5
Saponification value (mg KOH/g oil)	188.0±2.6	190.0±3.2
Iodine value (g I/100 g oil)	47.5±4.2	45.4±2.9
Unsaponifiable matter (%)	2.27±0.51	2.78±0.61

and due to elevated temperatures to form free radicals (Decker, 1998). Peroxide values were 8.73 meq O_2/kg oil and 8.92 meq O_2/kg oil for untreated seeds and microwave pretreatment seeds, respectively. Peroxide value has shown good correlation with organoleptic flavor scores. Farag *et al.* (1992) reported acceleration of cottonseed oil oxidation during microwave heating observed by an increase in peroxide value, due to presence of reactive radicals that might be formed by exposure to microwaves.

Saponification value is a measure of the alkali-reactive groups in fats and oils and is useful in predicting the type of glycerides in a sample. Glycerides containing short-chain fatty acids have higher saponification value than those with longer chain fatty acids. Saponification value of the analyzed mango seed kernel oil (Table 3) were 188 and 190 for untreated seeds and microwave pretreatment seeds, consecutively, which fall within the range as reported in the literature for vegetable oils: olive oil (184-196), rapeseed oil (168-181), and sunflower seed oil (188-194) (Nichols and Sanderson, 2003).

Iodine value is a measure of the unsaturation of fats and oils based on the ability of an unsaturated carbon to carbon bond to add halogen atoms and provides a measure of the degree of unsaturation of a lipid iodine value of the analyzed mango seed kernel oil (Table 3) were 47.5 g I/100 g oil and 45.4 g I/100 g oil for untreated seeds and microwave pretreatment seeds respectively, which are within the range reported in the literature for vegetable oils: olive oil (75-94), rapeseed oil (94-120) and sunflower seed oil (118-145) (Nichols and Sanderson, 2003). The reduction of iodine value with microwave pretreatment may be attributable to reductions in the number of unsaturation sites as a result of oxidation, polymerization, or breakage of the long-chain fatty acid (Anjum *et al.*, 2006).

Unsaponifiable matter of the analyzed mango seed kernel oils was 2.27% and 2.78% for untreated seeds and microwave pretreatment seeds, respectively. This oil content containing higher amount of unsaponifiable matter in pretreated pressed seed possibly due to high content of hydrocarbons, sterols, triterpenols, carotenoids and tocopherols (Barnes, 1983).

Table 4. Fatty acids composition in oils from mango seed

Fatty acid		Non-pretreatment	Microwave pretreatment	Nzikou, *et al.* (2010)	Dhingra and Kapoor (1985)
Palmitic acid	C16:0	8.97±0.15	7.35±0.23	6.48	7.18
Steric acid	C18:0	38.50±0.45	39.34±0.78	37.94	38.9
Oleic acid	C18:1	43.45±0.46	40.89±0.84	45.76	42.6
Linoleic acid	C18:2	6.48±0.53	7.87±0.69	7.45	5.7
Linolenic acid	C18:3	0.49±0.09	0.67±0.12	2.37	5.3
Eicosanoic acid	C20:1	2.51±0.18	3.32±0.45	-	-

Fatty acids compositions in oils from mango seed were demonstrated in table 4. Fatty acid composition of mango seed kernel oil is very similar to what can be found in previous reports (Nzikou *et al.*, 2010 and Dhingra and Kapoor 1985). However, differences in the fatty acid composition of mango seed kernel oil are observed between an untreated oil sample and a microwave pretreated sample. Yoshida *et al.* (2003) investigated the effect of microwave treatment on pumpkin seeds. These authors reported a change in the fatty acid composition of vegetable oils through effect of microwave treatment, but they don't inform about changes in extraction yield. Oleic acid was the most abundant fatty acid in mango seed kernel oil, 43.45% and 40.89% for untreated seeds and microwave pretreatment seeds, respectively. Steric acid was the second most abundant fatty acid in the samples and its range was between 38.5% and 39.34%, for untreated seeds and microwave pretreatment, respectively. Results shown in table 4 demonstrated that microwave pretreatment affected the fatty acid compositions of mango seed kernel oil. Changes in the fatty acid composition after microwave pretreatment of oilseeds have been previously reported by Takagi *et al.* (1999).

Conclusions

In this investigation, effect of microwave pretreatment on extraction oil yield and oil quality from mango seed kernel was investigated. Conclusion reached was that a microwave pretreatment could be applied rather successfully to mango seed kernel oil extraction prior to soxhlet extraction by decreasing its extraction time. Pretreatment at 1 min and 110 W was considered as the most appropriate conditions of microwave pretreatment by decreasing extraction time from 4 h to up to 30 min. The major advantage of microwave pretreatment is the reduced time of extraction and energy consumption costs, when is compared to conventional methods. On the obtained results, microwave extracted oil also show similar characteristics to conventionally extracted oil, indicating that quality of oil (e.g. acid value, peroxide value, oil composition) is not affected by microwave pretreatment.

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References

Anjum. F., Anwar, F., Jamil, A. and Iqbal, M. 2006. Microwave roasting effects on the physico-chemical composition and oxidative stability of sunflower seed oil. Journal of American Oils Chemists Society 83: 777-784.

Azadmard-Damirchi, S., Alirezalu, K. and Fathi Achachlouei, B. 2011. Microwave pretreatment of seeds to extract high quality vegetable oil. World Academy of Science. Engineering and Technology 57: 72-75.

Barnes, P. J. 1983. Non-saponifiable lipids in cereals. In: Barnes PJ (ed) Lipids in cereal technology, p.33-55. New York: Academic Press.

Buenrostro, M. and Lopez-Mungua, C. 1986. Enzymatic extraction of avocado oil. Biotechnology Letters 8: 505–506.

Decker, E. A. 1998. Antioxidant mechanisms. In Akoh, C. C. and Min, D. B. (eds) Food lipids, chemistry, nutrition, and biotechnology, p. 397-401. New York: Marcel Dekker.

Del Valle, J. M. and Aguilera, J. M. 1999. Extracción con CO2 a alta presión. Fundamentosy aplicaciones en la industria de alimentos. Food Science and Technology International 5: 1–24.

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

Farag, R. S., Hewedi, F. M., Abu-Raiia, S. H. and Elbaroty, G. S. 1992. Comparative study on the deterioration of oils by microwave and conventional heating. Journal of Food Protection 55: 722-727.

Nichols, D. S. and Sanderson, K. 2003. The nomenclature, structure, and properties of food lipids. In: Sikorski and Kolakowska (eds) Chemical and functional properties of foods lipids, p.29−59. Boca Raton, FL: CRC Press LLC.

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.

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.

Ramanadhan, B. 2005. Microwave extraction of essential oils (from black pepper and coriander) at 2.46 Ghz, Canada: University of Saskatchewan, MSc thesis.

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.

Takagi, S. and Yoshida, H. 1999. Microwave heating influences on fatty acid distribution of triacylglycerols and phospholipids in hypocotyls of soybeans (*glycine max* L.). Food Chemistry 66: 345–351.

Takagi, S., Ienaga, H., Tsuchiya, C. and Yoshida, H. 1999. Microwave roasting effects on the composition of tocopherols and acyl lipids within each structural part and section of a soya bean. Journal of the Science of Food and Agriculture 79: 1155-1162.

Uquiche, E., Jerez, M. and Ortiz, J. 2008. Effect of pretreatment with microwaves on mechanical extraction yield and quality of vegetable oil from Chilean hazelnuts (*Gevuina avellana Mol*). Innovative Food Science and Emerging Technologies 9: 495–500.

Yoshida, H., Hirakawa, Y., Tomiyama, Y. and Mizushina, Y. 2003. Effects of microwave treatment on the oxidative stability of peanut *(Arachis hypogaea)* oils and the molecular species of their triacylglycerols. European Journal of Lipid Science and Technology 105: 351-358.