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ABSTRACT

Moinuddin M, Ibrahim M, Yeasmin MS, Moktadir M, Rana GMM, Tahmina AC (2021) Evaluation of yield, physicochemical characteristics and fatty acid composition of oil extracted from different size of kernel of oil palm (*Elaeis guineensis*) fruits grown in Bangladesh. *Int. J. Sustain. Crop Prod.* 16(1), 18-23.

Physicochemical characteristics and fatty acid composition of the oil extracted from different size of oil palm kernel were evaluated in this study. Three different size of kernel of oil palm fruits were subjected to determine the oil content (%), their physicochemical properties and fatty acid composition. It was observed that the palm kernel oil grown under the climatic condition of Bangladesh varied with some physicochemical properties depending on the size of seed. The variation in iodine value were 20.1, 17.2 and 16.5 in small, medium and large kernels respectively indicated that there is a correlation between the size of kernel and iodine value of the oil. On the other hand, the fatty acid composition of the oils extracted from three different sizes of kernel also found slight variation in Lauric acid and the values were 46.212, 44.332 and 44.023 in small medium and large respectively. Saturated and unsaturated fatty acids present in the oil were separated and their ratios were found to be varied from 88.2 : 11.8, 89.5 : 10.5 and 89.1 : 10.9 in small medium and large respectively depending on the sizes. The amount of tocols also determined and the values were not significantly different in small, medium and large kernel. The results from the study demonstrated that the small palm kernel oil (SPKO) exhibited good physicochemical properties and could be more suitable for preparing bakery and confectionary food products as well as industrial application than those of medium palm kernel oil (MPKO) and large palm kernel oil (LPKO).

Key words: *palm kernel, fatty acid composition, tocopherol, tocotrinol, lauric acid, iodine value, free fatty acid*

INTRODUCTION

Palm kernel is an oleaginous seed found in *Elaeis guineensis* jack fruits (Wanessa *et al.* 2019) which are grown abundantly in Africa, South America, South East Asia and the South Pacific and on a small scale in other tropical areas. The rapid increase of the production in the last 20 years has made palm oil the most important in the world. Palm oil extracted from meso carp of palm fruits is very popular as a good cooking oil to the people of Bangladesh as well as all over the world. At present Bangladesh is largely dependent on import of edible and non-edible oil for cooking and industrial purposes from different sources to meet her domestic requirement.

The poor income groups of our country can consume palm or palm olein oil conveniently because of its low cost and higher nutritional values compared to other edible oil. So considering the nutritional needs of fat, indigenous production of palm oil through oil palm cultivation in Bangladesh instead of imported has received much attention and attempt has already been taken to plant oil palm as experimental cultivation under the climatic condition of different districts of Bangladesh such as Sylhet, Chottogram, Tangail, Rajshahi, Naogaon etc. The growth of oil palm tree, fruit bearing characteristic and yield of fruits are found very satisfactory.

Our previous study was to evaluate the physicochemical properties and fatty acid composition of crude palm oil extracted from the mesocarp of oil palm fruits grown in Bangladesh **(**Uddin *et al.* 2020**).** After separating the mesocarp, the oil containing hard shell or kernel was remain unused which is a rich source of Lauric acid, a potential industrial raw material. Hence the present study is to evaluate the effect of size of kernel on physicochemical properties and fatty acid composition of palm kernel oil.

Palm kernel oil is extremely important for the oleochemical industry because of its content in short (C_8-C_{10}) and medium chain (C_{12}-C_{14}) fatty acids (Rupilius and Ahmad, 2007). Palm kernel constitutes about 45%-48% by weight of oil which properties a quite different from palm oil rather resembles coconut oil (Gbasouzor *et al.* 2012).

The palm kernel oil is highly different from palm oil. The physicochemical properties and fatty acid composition of the two oil extracted from meso carp and seed kernel of same fruits are entirely different. Palm kernel oil is used in manufacturing both edible and non-edible products have a great use both in food industry and non-food industry (Oyinlaha *et al*. 2004). It is high in Lauric acid (Poku 2002). Lauric acid helps in quick lathering (Okeke and Oluka, 2017). Therefore, it is suitable for manufacturing of soaps, washing powders and other personal care products. It can be used alone or in blend with other oil for manufacture of cocoa butter substances, confectionary fats, biscuit dough's, filling cream, cake icing and table margarine (Bredeson 1983). The kernels are various sizes and it was reported that CPKO (crude palm kernel oil) extracted from small kernels have a higher iodine value than large kernels (Siew, 1995). It has been found that the size of palm fruits varied with different factors such as age of oil palm tree, climatic condition, soil texture etc. Hence the present work aimed to evaluate the oil yield (%), physicochemical properties and fatty acid composition of the oil extracted from three different size of palm kernel.

MATERIALS AND METHODS

Seed collection and oil extraction

Ripe and fresh oil palm fruits were collected from Sylhet (Department of forestry), Bangladesh. Seeds were cleaned, shorted out from rotten & spoiled seeds and boiled with water at 100°C for 20-30 min in 3Kg/cm^2 pressure to soften the flesh. Separated the seeds from flesh manually and dried in the sun. Dried seeds were divided into three different catagories as large (>10 mm), medium (7-10 mm) and small (<7 mm) and decorticated the kernels from the hard coat by using an iron mortar and grinded into coarse powder (mesh size 120 µm) and again dried up to the moisture 7%, an ideal moisture content (Ibrahim 2013). The powders of three different kernel sizes were taken in a soxhlet separately for extraction of oil. n-Hexane (40-60°C bp) was used as extracting solvent. Extraction was continued for 6 hrs. Oil was separated from solvent by a rotary vacuum evaporator. Semi solid white oil was thus obtained and taken in three different beakers namely SPKO, MPKO and LPKO.

Analysis of Physicochemical properties

Yield (%) of extracted oil was determined by conventional method. Refractive index and moisture at 38°C were determined by IUPAC (1979) method. Saponification value, unsaponifiable matter, peroxide value and free fatty acid (%) of the oil were determined by standard AOAC method (1995). Iodine value was determined by Hanus method.

Separation of saturated and unsaturated fatty acids present in the oil

Separation of saturated and unsaturated fatty acids was carried out by lead-salt ether method (Das 1989) on about 50gm of oil. The oil was saponified with alcoholic caustic soda to obtain soap solution. A slight excess of lead acetate solution was added to the soap solution to form lead salts of fatty acids which were then separated. Ether was added to the mixture of lead salts and the whole mixture was boiled and then cooled at 0°C for 24 hr. The precipitated lead salts of saturated fatty acids were collected by filtration. The lead salts of the unsaturated fatty acids were obtained by removing the ether from the ethereal solution. Each group of lead salt was suspended in water and treated with sufficient hydrochloric acid from fatty acids and lead chlorides. On evaporating the ether, the fatty acids were obtained in separated groups. Finally masses of saturated and unsaturated fatty acids were obtained by weighing them separately.

Fatty acid composition

Preparation of fatty acid methyl ester (FAMEs):

200 mg (2-3 drops) of sample (Oil/Fat) was taken in a 10 mL Pyrex test tube. Then 3.5 mL of 0.5 M Sodium Methoxide was added to the test tube and heated the test tube using burner before completing the bubbles. Thereafter, 1.5 mL Petroleum Ether was added to the mixture and shaken vigorously. Then around 5 mL deionized water was added to test tube slowly and wait for settle down the layer. Upper layer was taken into the GC vial for GC-MS analysis.

GC-MS Analysis:

The gas chromatographic analysis of the oils were performed on SHIMADZU GC-2010 Plus equipped with auto-sampler (AOC- 20s) and auto-injector (AOC-20i) using SH Rxi 5MS Sill column (30m×0.25mm×0.25 µm). The carrier gas used was helium at 2.00 mL/min flow pressure; oven temperature was programmed from 140.0^{0}C (hold time 10.00 min) and raised at 7^{0}C/min to a final temperature of 250.0^{0}C (hold time 10.00 min). The injector temperature was 250.0^{0}C and injection volume was 1.0 µL at 75:1 split ratio (injection mode was Split). Solvent cut time was 3.40 min and total run time was 35.71 min. The detector used was SHIMADZU GCMS-QP-2020 and detector temperature was 255.0^{0}C.

Determination of tocopherols and tocotrionols

Two grams of each sample (SPKO, MPKO and LPKO) were dissolved in 10 mL of hexane, 20 μL of the mixture of each sample injected into an HPLC system one by one. The flow rate of mobile phase 0.5% 2-propanol/hexane was set at 1mL/min. The peaks of tocopherols and tocotrionols were determined based on the retention time of standards followed by AOCS method (1993).

RESULTS AND DISCUSSION

The oil yield (%) of three different size of palm kernel were determined and presented in the table 1. The results of table 1 are very close to the reported result of Gbasouzor *et al.* 2012. It is clearly seen that the oil content (43.1, 40.7 & 45.5%) of the kernels are slightly affected by the size of the kernel. It has been found that as the size of fruits decreases tremendously at the last 10 to 20 years of oil palm tree, the total oil yield decreases consequently. Melting point, specific gravity & refractive index of the oil at 38°C are also found more or less same in SPKO, MPKO & LPKO. FFA % of the oil extracted from different sized kernel was found somewhat different depending on the size of kernels (Table 1). The value (3.9%) of MPKO is the highest followed by LPKO (3.5%) and SPKO (3.1%) lowest. The reported range of free fatty acid content of crude palm oil was 2.3-

6.7% according to Saad *et al.* (2006). FFA is one of the most important quality parameters in palm oil industry as it indicates the level of deterioration of oil, Tan *et al.* (2009). Poor & lengthy storage of fruits will lead to a considerable increase in free fatty acids that will affect the quality of oil, Purseglove (1985). Peroxide values are found same in all the three samples. The differences of iodine value in the different size are found significant (Table 1). LPKO (16.5) shows the lowest where SPKO (20.1) the highest which indicates the negative correlation and follow the order of LPKO< MPKO <SPKO. The results are in good agreement with the reported result of Siew (1995). They reported that one of the factors affecting the IV variation in palm kernel oil is its kernel size. Saponification value and unsaponifiable matter (%) presented in the Table 1 shows no markedly variation in three different size. The saponification values determined in this study (263, 260, 262 mg KOH/g) are quite similar in all the sizes and these values are very close to coconut oil of 253 mg KOH/g (Aremu *et al.* 2006). The quality in this oil qualifies its use in soap production (Akimhanmi and Atasie, 2009). The unsaponifiable matters 0.35, 0.36 & 0.36 % in SPKO, MPKO & LPKO respectively and the values are in good agreement with the reported result of Tan *et al.* (2009). The percentage of saturated and unsaturated fatty acids determined by lead salt ether method. The results of table 2 show that the size of kernels did not affect the percentages of saturation and unsaturation. All the sizes are rich in saturated fatty acid (88.2, 89.5 and 89.1%) and the values are almost same in SPKO, MPKO and LPKO. The higher proportion of saturated fatty acids makes the crude palm kernel oil (CPKO) very stable against oxidation (O'Brein 2000). Though the values are almost same in SPKO, MPKO and LPKO, the rate of unsaturation were found to be followed the order SPKO> MPKO>LPKO (11.8, 10.5 and 10.9%). The fatty acid composition of SPKO, MPKO and LPKO were determined by GC-MS and the chromatographic results (Fig-1,2,3) were presented in table 3. From the results of table 3, it was ascertained that all the sizes of kernel contained highest amount of Lauric acid ($C_{12:0}$) 46.212, 44.332 & 44.023% followed by Myristic ($C_{14:0}$) 32.367, 33.014 & 33.345%, Palmitic ($C_{16:0}$) 11.789, 11.951 & 10.993%, Stearic ($C_{18:0}$) 1.434, 1.488 & 1.760% and Oleic ($C_{18:1}$) 8.198, 9.215 & 9.879%. The profile showed that the sizes of kernels do not remarkably affect the predominantly fatty acid (Lauric) present in the oil. The higher Lauric content of the oil (46.212%) agrees with the findings reported by Poku (2002). Palm kernel oil is packed with Lauric fatty acid and therefore suitable for manufacture of soaps, washing powder and other personal care (Okeke and Oluka, 2017).

Tocopherols & tocotrinols were determined by HPLC system equipped with a UV detector according to AOCS method (AOCS 1993). The amounts of tocols (Table 4) among three samples were found to be 230, 260 & 235 ppm. From the result of table 4 it is seen that the kernel oil of all sizes are riched in gamma tocopherol and the value was the highest in MPKO (131 ppm). The total contents (230, 260 & 235 ppm) are in good agreement with the reported result of Ibrahim.N.A.2013.

Table 1. Physicochemical properties of different size palm kernel oil

Properties	**SPKO**[a]	**MPKO**[b]	**LPKO**[c]
Oil yield (%)	43.1 ± 1.03	40.7 ± 1.17	45.5 ± 1.58
Melting point (°C)	36.4 ± 0.12	36.8 ± 0.36	36.6 ± 0.18
Conjeal point (°C)	17.6 ± 0.31	18.4 ± 0.46	18.8 ± 0.14
Specific gravity (at 38°C)	0.93 ± 0.09	0.93 ± 0.05	0.92 ± 0.02
Refractive index (38°C)	1.44 ± 0.17	1.41 ± 0.26	1.46 ±0.13
FFA (%, at palmitic)	3.1 ± 0.05	3.9 ± 0.02	3.5 ± 0.08
PV (meqv/kg oil)	8.5 ± 0.62	8.0 ± 0.42	8.2 ± 0.71
IV	20.1 ± 0.86	17.2 ± 0.95	16.5 ± 0.83
Saponification value	263 ± 5.58	260 ± 8.90	262 ± 6.87
Unsaponifiable matter (%)	0.35 ± 0.03	0.36 ± 0.09	0.36 ± 0.06

Mean ± Standard Deviation (n=3)

a) Small palm kernel oil, b) Medium palm kernel oil & c) Large palm kernel oil
FFA= Free Fatty Acid, PV= Peroxide Value, IV= Iodine Value

Table 2. Percentage of saturated and unsaturated fatty acids

Size of kernel	**Saturated**	**Unsaturated**
SPKO	88.2	11.8
MPKO	89.5	10.5
LPKO	89.1	10.9

Table 3. Fatty acid composition (%) of different size palm kernel oil

Fatty acids	**SPKO**	**MPKO**	**LPKO**
$C_{12}:_0$	46.212	44.332	44.023
$C_{14}:_0$	32.367	33.014	33.345
$C_{16}:_0$	11.789	11.951	10.993
$C_{18}:_0$	1.434	1.488	1.760
$C_{18}:_1$	8.198	9.215	9.879

Table 4. Tocopherol and Tocotrionol (ppm) of different size of palm kernel oil

Tocols	SPKO	MPKO	LPKO
α-tocopherol	10	12	12
β-tocopherol	60	72	72
γ-tocopherol	110	131	110
Tocotrinol	50	45	41
Total	**230**	**260**	**235**

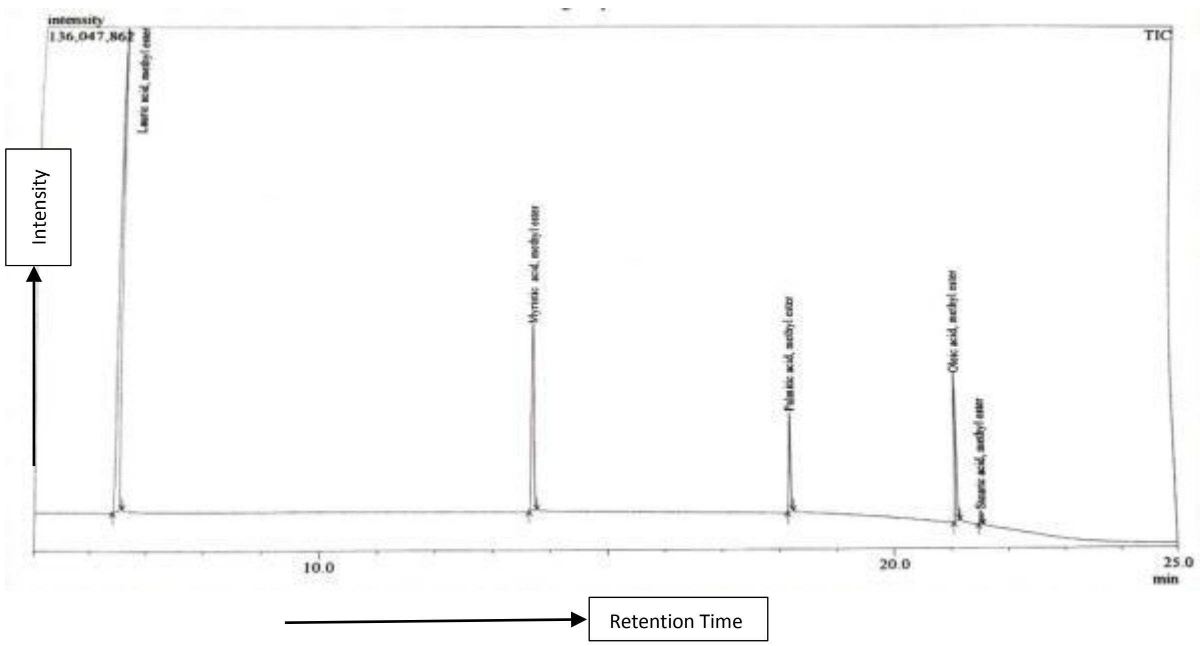

Fig. 1. Chromatogram of SPKO (Fatty acid composition)

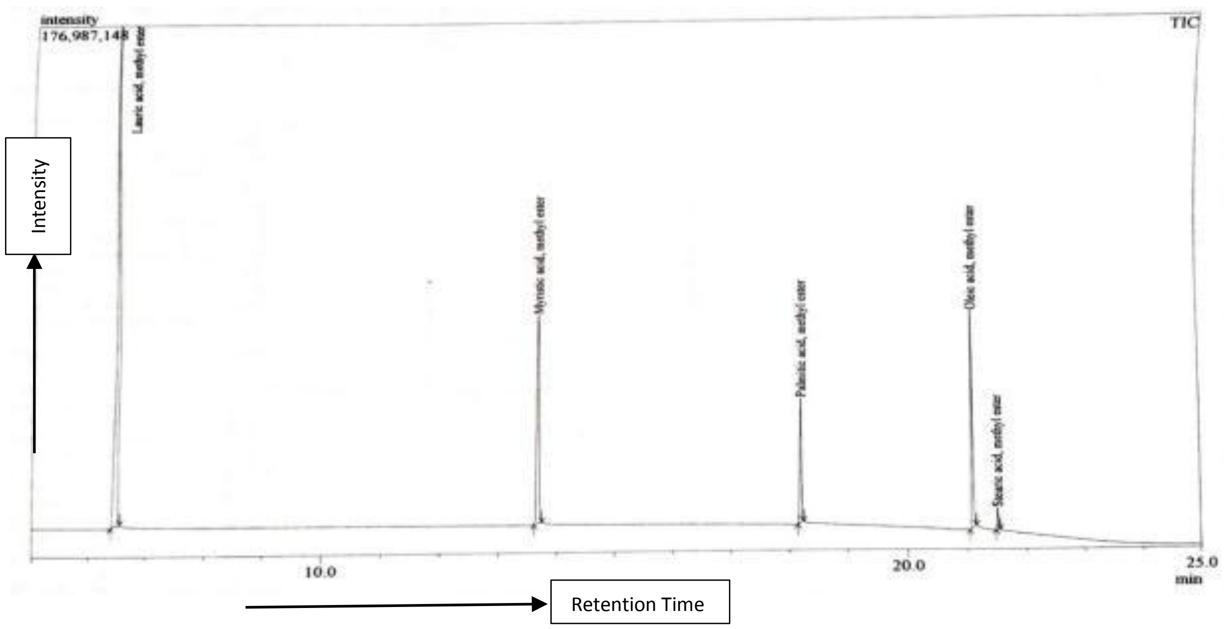

Fig. 2. Chromatogram of MPKO (Fatty acid composition)

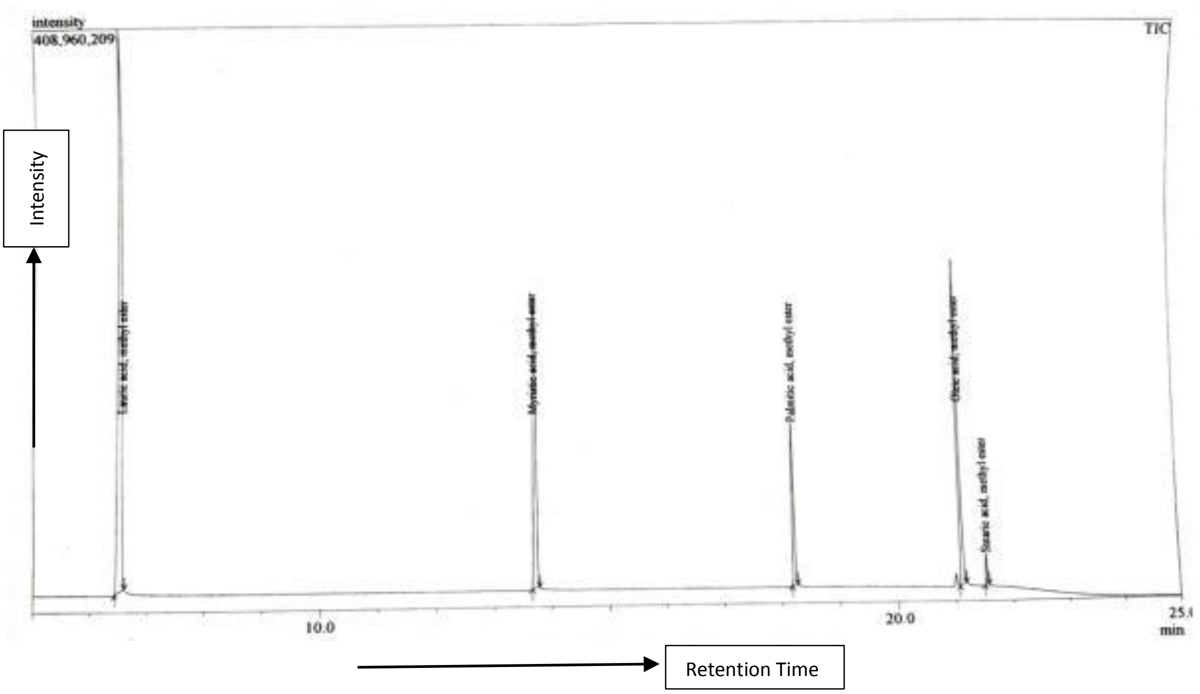

Fig. 3. Chromatogram of LPKO (Fatty acid composition)

CONCLUSION

The study concludes that crude palm kernel oil extracted from small kernels have a higher iodine value (IV) than large kernels which is an important parameter to obtain desired quality oil which may be used in cooking or manufacturing cosmetics and other industrial products. All the sizes are riched in lauric acid and thier saponification values are also high. So it may also be concluded that the oil extracted from kernels of all sizes grown in Bangladesh are suitable for use in formulation of both food and non-food products for its higher shelf life. But considering the degree of unsaturation, the small palm kernel oil is more suitable for preparing bakery and confectionery food products which may be a good substitute of butter (a hydrogenated trans fat).

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