Fatty acid composition of oil palm (*Elaeis guineensis* Jacq) fruits grown in Bangladesh

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**Abstract**

This study was undertaken to evaluate the fatty acid composition and other physicochemical properties of oil palm (*Elaeis guineensis*) fruits grown in Bangladesh and compared these values with crude palm oil (CPO) imported from Malaysia. Ripe and fresh oil palm (*Elaeis guineensis*) fruits were collected from different districts of Bangladesh and the crude oils were extracted by a screw press machine and was divided into three fractions: crude palm oil (CPO), degummed palm oil (DPO) and degummed bleached palm oil (DBPO). The percent yield, their physico-chemical characteristics, fatty acid composition, β-carotene, tocopherols and tocotrienols of the fractions were determined. Fatty acid composition and other physicochemical properties of Bangladeshi crude palm oil (CPO) were found to be more or less similar to the CPO imported from Malaysia.

**Keywords:** Crude palm oil; β-carotene; Tocopherols; Tocotrienols

**Introduction**

Palm oil is one of the 17 major oils and fats produced and traded in the world today (Koushki et al., 2015). It is extracted from the fleshy orange-red mesocarp of the fruits of the oil palm tree *Elaeis guineensis* which is grown commercially in Africa, South America, South-east Asia and the South pacific and on a small scale in other tropical areas. Although, it is known to the people of the mentioned areas of the world for centuries, it has become the most widely used vegetable oil in the world from last four decades. At present, palm oil is projected to be the world’s largest oil produced, although it is currently occupying second position after soybean oil (CWL et al., 2007). The two largest producers are Malaysia and Indonesia, who together account for roughly 85% of the world palm oil production because of their ideal climatic conditions, sufficient milling and refining technologies, advanced research and development and efficient and adequate management skills (NAa, 2013; USDA, 2005).

Once upon a time, edible oil, mainly mustard oil was available in plenty in Bangladesh and the local production of mustard oil and some other varieties of edible oil could meet domestic need. But the scenario has changed some decades ago when the farmers reduced cultivation of mustard and other indigenous oil seeds and switched over to other crops for their financial benefits. And thus, the country became largely dependent on import of edible oil from various sources to meet domestic requirement, Malaysian palm oil is one of them. At present palm oil, specially the imported palm olein is very popular as a good cooking oil to the people because of its low cost and higher stability during frying compared to other edible oil.

The low income group in Bangladesh can consume the oil conveniently and plays the significant role to meet the nutritional needs of fat, particularly among young children. In this context, indigenous production of palm oil through oil palm cultivation in Bangladesh instead of import of degummed oil(DGO) may have a profound impact to achieve self-sufficiency in edible oil as well as in reducing import.

Although oil palm tree grows well in sandy loom of coastal areas, and heavy rain- fall is necessary for its growth, attempt has been taken to introduce in Bangladesh in the last decades of

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20th century in some areas such as Sylhet, Rajshahi, Naogaon etc. and the growth, fruits bearing characteristics and yield are found very satisfactory.

There were some concern about the nutritional and health impact of palm oil as an edible oil due to its relatively higher saturated fatty acid content, as compared to most of the other vegetable oils, but several recent studies on both human and animals have demonstrated that palm oil does not behave as a saturated fat in its effects on blood cholesterol and blood clotting, as may be predicted from its fatty acid composition (PORIM, 1989). In some studies palm oil has been shown to reduce blood cholesterol levels (Lim et al., 1988) and act as an antithrombotic (Hornstra, 1986). Besides, the high content of β-carotene of the unrefined palm oil can serve as an important source of vitamin A, vitamin E and tocotrienols a unique feature of red palm oil, can act as an antioxidant and antithrombotic, providing several health benefits (Rao, 1992). Red palm oil (RPO) is a highly nutritious premium vegetable oil because of the presence of carotene, vitamin E, ubiquinone and phytosterols (Koushiki et al., 2015).

In this study, we evaluated the oil content of palm fruits grown in Bangladesh, their physicochemical properties and fatty acid composition, which can be conveniently consumed by the people as edible oil instead of imported palm oil and thus the dependence of import can be reduced to a greater extent.

Materials and methods

Ripe fresh fruit bunches of oil palm (Elaeis guineensis) were collected from Sylhet (Department of forestry), Naogaon (Private nursery) and Rajshahi (Roads and highway) districts of Bangladesh. The bunches were preserved at 18°C for about 12 h and then dried at 66.8°C for 12.8 h according to the response surface methodology (RSM) (Tan et al., 2009). Dried fruits were separated from the stalks manually.

Oil extraction

About 1.0 kg dried and fresh palm fruits were taken in a stainless steel container and boiled with water at 100°C for 20-30 min in 3 kg/cm² vacuum pressure until the mesocarp became soft to remove from kernel. The boiled fruits were then transferred in a mortar and smashed so carefully with pestle that the kernels were not broken. The separated pulp was then taken in an electric oven and kept at 80°C for 6 h for removing moisture. Dried fleshes were then taken in a screw press machine and oil extraction was carried out at 40°C. Crude palm oil (CPO) of dark red color was thus obtained and preserved at 25°C. One fraction of CPO was degummed and another fraction was degummed and bleached simultaneously using 0.06% phosphoric acid and acid activated bleaching earth (0.1%) according to the method of Wei et al. (2004). The obtained oil was thus divided into three categories namely crude palm oil (CPO), degummed palm oil (DPO) and degummed bleached palm oil (DBPO) and subjected to analysis of the physicochemical and nutritional properties.

Physicochemical analysis of extracted oil

The percent yield (%) of oil was determined by conventional method, specific gravity of the oil was calculated at 38°C with the help of a Pycnometer, refractive index and moisture at 38°C were determined by IUPAC (1979) method. The percentages of free fatty acid (%FFA), saponification value, peroxide value and unsaponifiable matters were determined by the standard AOAC method (1995). Hanus method was followed to determine the iodine value and carotene contents were measured by using UV-visible spectrophotometer.

Determination of tocopherols and tocotrienols

Two grams of each sample (CPO, DPO and DBPO) were dissolved in 10 ml of hexane, the hexane portion were filtered through 0.45 µm filter paper and 201 of the filtered hexane portion of each sample injected into an HPLC system individually. The flow rate of mobile phase 0.5% 2-propanol/hexane was set at 1 ml/min. The peaks of tocopherols and tocotrienols were determined based on the retention time of standards, as described by AOCS method (1993).

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 as described by Das (1989). About 50 g oil was saponified with alcoholic caustic soda to obtain soap solution. Then lead acetate solution was added to the soap solution to form lead salts of fatty acids, then ether was added to the mixture of lead salts and the whole mixture was boiled and then cooled at 0°C for 24 h. 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 ether solution. Each group of lead salt was suspended in water and treated with sufficient hydrochloric acid to form 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)**

Approximately, 200 mg (2-3 drop) of sample (oil/fat) was taken in a 10 ml Pyrex test tube and 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 of petroleum ether was added to the mixture and shaken vigorously and after that 5 ml of deionized water was added to test tube slowly and wait until the layer was settled down. Upper layer was taken into the Gas Chromatography (GC) vial for GC-MS analysis.

**GC-MS Analysis**

The gas chromatographic analysis of the oil was performed by SHIMADZU GC-2010 Plus equipped with auto-sampler (AOC- 20s) and auto-injector (AOC-20i) using SH RXi 5MS steel column (30m×0.25mm×0.25 µm). The carrier gas used was helium at 2 ml/min flow pressure; oven temperature was programmed from 140°C (hold time 10 min) and raised at 7°C/min to a final temperature of 250°C (hold time 10 min). The injector temperature was 250°C and injection volume was 1 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°C.

**Results and discussion**

Physicochemical characterization of different fractions of Bangladesh grown palm oil (CPO, DPO and DBPO) were determined and the values were depicted in Table I. Results showed that the crude palm oil (CPO) yield was 37.5%, and

| Properties                      | CPO  | DPO  | DBPO |
|---------------------------------|------|------|------|
| Oil yield (%)                   | 37.50| 35.90| 35.50|
| Moisture content (%)            | 0.90 | 0.85 | 0.75 |
| Specific gravity at 38°C        | 0.92 | 0.90 | 0.89 |
| Refractive index at 38°C        | 1.45 | 1.43 | 1.42 |
| FFA (%)                         | 1.90 | 1.00 | 0.90 |
| PV (meq/kg oil)                 | 1.50 | 0.50 | 0.45 |
| IV                              | 50.50| 51.50| 52.40|
| Unsaponifiable matters (mg KOH)| 0.49 | 0.24 | 0.15 |
| Carotene content (ppm)          | 564.00| 304.00| 53.00|

slightly decreased after degumming (DPO) 35.9% and further decreased after degumming- bleaching 35.5% (DBPO) were recorded. However, the CPO content of mesocarps of Asian palm was about 39% according to literature (Bockisch1998), the decreased oil content of Bangladesh grown palm oil might be due to the impact of processing parameters including extraction time, pressure and temperature (Baryeh, 2001). Moisture content of the oil was found below 1.0 %, indicating the proper drying of the mesocarp (80°C for 6 hrs). In addition, the specific gravity and refractive index of Bangladesh grown oils are found similar to all good quality edible oil.

The FFA values are one of the most important quality parameters of edible oil. The results showed that the FFA value of CPO is slightly higher than DPO and DBPO but all the values were less than 2.0, which were very close to the value (3.0%) of Malaysian crude palm oil (Corley and Tinker, 2003) (Table I). However, the reported range of free fatty acid

| Table-II. Tocopherol and tocotrienol content (ppm) of Bangladesh grown palm oil |
|---------------------------------|------|------|------|
| **Tocols**                      | CPO  | DPO  | DBPO |
| α. Tocopherol                   | 220  | 50   | 20   |
| β. Tocopherol                   | 80   | 10   | 5    |
| γ. Tocopherol                   | 40   | 5    | 5    |
| Total                           | 340  | 65   | 30   |
| **Tocotrienols**                |      |      |      |
| α. Tocotrienol                  | 240  | 80   | 30   |
| γ. Tocotrienol                  | 280  | 60   | 15   |
| δ. Tocotrienol                  | 190  | 30   | 10   |
| Total                           | 710  | 170  | 55   |

| Table-III. Fatty acid composition (%)of Bangladesh grown palm oil |
|---------------------------------|------|------|------|
| Fatty acids                     | CPO  | DPO  | DBPO |
| C14:0                           | 3.125| 4.157| 5.986|
| C16:0                           | 31.329| 31.343| 29.006|
| C18:1                           | 10.184| 17.565| 16.839|
| C18:2                           | 43.138| 27.209| 21.916|
| C18:3                           | 0.730| 1.987| 8.774|
| C18:0                           | 11.495| 17.259| 15.821|
but the scenario has changed some decades ago. It is currently occupying the second position after soybean oil in the world from last four decades. At present, palm oil is known to the people of the mentioned areas of the world for its nutritional needs of fat, particularly among young children. Although oil palm tree grows well in sandy loam of coastal areas and Indonesia, who together account for roughly 85% of the world palm oil production because of their ideal climatic conditions, sufficient milling and refining technologies, and local production of edible oil through oil palm cultivation in Bangladesh instead of import of degummed oil (DGO) may have a profound impact on the nutritional needs of fat, particularly among young children.

Palm oil contains a large amount of unsaturated fatty acids, which make it an ideal substitute for animal fat in the diet. It is rich in low molecular weight free fatty acids, especially lauric acid (12:0), myristic acid (14:0), palmitic acid (16:0), oleic acid (18:1ω9), stearic acid (18:0), and linoleic acid (18:2ω6). The fatty acid composition of palm oil is not the same in all regions, and it mainly depends on the variety of palm oil. The genetic difference is very large. The total content of unsaturated fatty acids in palm oil is higher than the total content of saturated fatty acids. The ratio of unsaturated fatty acids to saturated fatty acids is about 1.82 in red palm oil (RPO). On the one hand, the unsaturated fatty acids in palm oil can lower blood cholesterol. On the other hand, it is also an important source of essential fatty acids. Palm oil is also an important source of fat that can provide energy. The high content of lauric acid is also a characteristic feature of palm oil, and studies have shown that it has a certain antifungal effect. Palm oil has more health effects than animal fat, such as beverage fat, oil, or fish oil.

The composition of fatty acids in different palm oil fractions was investigated. The fatty acid composition of oil palm (Elaeis guineensis) grown in Bangladesh and the other areas of the world was compared. The fatty acid composition of oil palm (CPO) was evaluated during the normal refining process which is associated with degumming and bleaching. The results showed that the crude palm oil (CPO) yield was 37.5%, and slightly decreased after degumming (DPO) 35.9% and further decreased after degumming and bleaching (DBPO) 35.3%.

The gas chromatographic analysis of the oil was performed to test tube slowly and wait until the layer was settled down. Approximately, 200 mg (2-3 drop) of sample (oil/fat) was added to the test tube. Methyl ester of fatty acids of three fractions were investigated by the standard AOAC method (1995). Hanus method was used to determine the amount of carotene in the palm oil. The results of Table I showed that the amount of carotene in CPO was compared to the reported range in conventional oil palm. Degumming and bleaching play roles in the refining solution. Each group of lead salt was suspended in water and heated the test tube. The detector used was SHIMADZU.

The carotenoids (β-carotene) in different palm oil fractions were investigated by the standard AOAC method (1995). The results showed that the content of β-carotene of the unrefined palm oil can serve as a source of antioxidant (Hornstra, 1986). Besides, the high content of lauric acid is also a characteristic feature of palm oil, and studies have shown that it has a certain antifungal effect. Palm oil has more health effects than animal fat, such as beverage fat, oil, or fish oil.
content of CPO was 2.3-6.7% according to Saad et al. (2006). Harvesting and lengthy storage of palm fruits will lead to a considerable increase in free fatty acid (Purseglove, 1985).

The peroxide value (PV) and unsaponifiable matter were determined and the values of CPO, DPO and DBPO were found almost similar (Table I). The amount of carotene of the different fractions of extracted palm oil (CPO, DPO and DBPO) were determined and the amount of total carotene (α + β) present in CPO, DPO and DBPO were 564, 304 and 53 ppm respectively (Table II). The amount 564 ppm present in CPO was compared to the reported range in conventional CPO (500-700 ppm) of carotenoids (Chong, 1994). In cases of DPO and DBPO the amount of β-carotene were decreased remarkably due to use of degumming and bleaching agents. Both β-carotene (56%) and α-carotene (35%) are destroyed during the normal refining process which is associated with degumming and bleaching (Koushki et al., 2015). The total tocopherols and total tocotrienols content in CPO were 340 ppm and 710 ppm respectively, which was remarkably higher than DPO and DBPO (Table II). The results of Table II are in good agreement with the reported results of Tan et al. (2009). It has been reported that the amount of Vit-E reduced greatly during refining (Sambanthammurthi et al., 2000). However, many studies reported the effects of degum and its strength and/or bleaching reagents are very important on the chemical and physical characteristics of edible oil (Chinyere et al., 1996). The refining process removes not only undesirable compounds but also some beneficial compounds such as tocopherols (Kim and Choe, 2005). Degumming and bleaching play roles in the refining of palm oil to obtain a refined edible oil (Wei et al., 2004).

Methyl ester of fatty acids of three fractions were investigated by GC-MS and the results are presented in Table-III and Figs. 1, 2 and 3. It was observed that the major saturated fatty acids in CPO were palmitic (C_{16:0}) 31.329% followed by stearic (C_{18:0}) 11.495% acids on the contrary, the main unsaturated fatty acids were found to be oleic (C_{18:1}) 43.138% acid followed by linoleic (C_{18:2}) 10.184% acid. The palmitic acid contents in CPO, DPO and DBPO were found more or less similar but the oleic acids contents were found different in Bangladesh grown palm oil. It was also observed that the oleic acid (43.868%) content was higher in CPO, however, DPO and DBPO contain comparatively lower oleic acid 29.196% and 30.690% respectively. In addition, although the oleic acid varied slightly, but the ratio of saturated and unsaturated fatty acids was almost similar in CPO, DPO and DBPO (Table IV). This variation may be due to the degumming and bleaching step. Thus, the ratio of saturated/unsaturated fatty acids of CPO remains almost unchanged during degumming and bleaching but the amount of individual fatty acid like oleic acid may be changed. The compositions and slight variation of fatty acids are in good agreement with the reported results of Clegg (1973).

**Conclusion**

The results of this study concluded that the oil yield, physicochemical characteristics and fatty acid composition of the oil extracted from oil palm fruits grown in the soil and climatic condition of Bangladesh are almost similar to the imported Malaysian palm oil. Nevertheless, since it was found that the soil and climate of Bangladesh fits to grow oil palm tree, a large-scale field level study is needed to evaluate the reproducibility of the results obtained in this study.

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**References**

AOCS (1993), Determination of tocopherols and tocotrienols in vegetable oils and fats by HPLC, pp-8-89.

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**Table-IV. Saturated and unsaturated fatty acids (%) of Bangladesh grown palm oil**

| Name of sample | Saturated fatty acids | Unsaturated fatty acids |
|----------------|-----------------------|-------------------------|
| CPO            | 45.910                | 54.090                  |
| DPO            | 52.759                | 47.241                  |
| DBPO           | 52.471                | 47.529                  |
AOAC (1995), Official Methods of Analysis, 8th Ed. Washington.

Baryeh EA (2001), Effects of palm oil processing parameters on yield, Journal of Food Engineering 48: 1-6.

Bockisch M (1998), Fats and oils handbook, USA: AOCS Press, pp 1-31, 110-121.

Corley RHV and Tinker PB (2003), The oil palm, USA: Blackwell, pp 450–471.

Chong CL (1994), Chemical and physical properties of palm oil and palm kernel oil In: Selected readings on palm oil and its uses, Eds. Ariffin A, Ahmad MJ, Ghazali R and Mahidin MR, Palm Oil Research Institute of Malaysia, pp 60–67.

Clegg AJ (1973), Composition and related nutritional and organoleptic aspects of palm oil, Journal of the American Oil Chemists Society 50: 321–324.

Chinyere I, Iwuoha CNU, Rophina C, Ugwo, Ngozi and Okereke U (1996), Chemical and physical characteristics of palm, palm kernel and groundnut oils as affected by degumming, Food Chemistry 55(1): 29-34. DOI: 10.1016/0308-8146(95)00067-4

CWL SB, Jab SM, Lim PB, Ali MSA, Wai TW and Saleh IM (2007), Determination of free fatty acids in palm oil samples using nonaqueous flow injection titrimetric method, Analytical, Nutritional and Clinical Methods 102: 1407–14.

Das KR (1989), Industrial Chemistry, Part-2, Kalyani Publishers, New Delhi, India, p 279

Hornstra G (1986), Beneficial effects of palm oil on arterial thrombosis (rat) and atherosclerosis (rabbit), Palm Oil Research Institute, Malaysia.

IUPAC (International Union of Pure and Applied Chemistry) (1979), Standard Methods for the Analysis of Oils, Fats and Derivatives, 6th Ed., Pargamon Press.

Kim I and Choe E (2005), Effects of bleaching on the properties of roasted sesame oil, Journal of Food Science 70: 48-52, DOI: 10.1111/j.1365-2621.2005.tb09019.x

Koushki M, Nahidi M and Cheraghal F (2015), Physico-chemical properties, fatty acid profile and nutrition in palm oil, Journal of Paramedical Sciences (JPS) 6(3): 117-134. DOI: 10.22037/jps.v6i3.9772

Lim JB, Ng TKW, Hassan K, Lye MS and Ishak R (1988), Hypcholesterolemic effect of a palm oil diet on human volunteers, Presented at the National Conference on on Palm/Palm Oil 1: 11-15.

NAa SF (2013), The Oil Palm Wastes in Malaysia, INTECH, 3rd Ed., Official and tentative methods of the American oil chemists society (1980), (I and II),

Purseglove JW (1985), Tropical crops–monocotyledons, Longman, London.

PORIM (1989), Palm oil, a compilation of documented facts on nutritional effects of palm oil, PORIM, Kuala Lumpur, Malaysia.

Rao NSB (1992), Palm Oil As An Edible Oil In India And Its Role In Meeting The Nutritional Needs Of Its Population, Nutrition Research 12(1): 3-21. DOI: 10.1016/S0165-2621(00)00015-1

Saad B, Ling CW, Jab MS, Lim BP, Ali ASM and Wai WT (2006), Determination of free fatty acids in palm oil samples using non-aqueous flow injection titrimetric method, Food Chemistry 102: 1407-1414. DOI: 10.1016/j.foodchem.2006.05.051

Sambanthamurthi R, Sundram K and Tan YA (2000), Chemistry and biochemistry of palm oil, Progress in lipid research 39: 507-558. DOI: 10.1016/S0163-7827(00)00015-1

Tan HC, Ghazali MH, Kuntom A, Tan PC and Ariffin AA (2009), Extraction and physicochemical properties of low free fatty acid crude palm oil, Food Chemistry 113: 645-650.

USDA (2005), Growing Industrial Use of Vegetable Oil Expected to Impact EU Oilseeds and Products Trade, Foreign Agricultural Service, Oil Seeds Circular, October.

Wei CP, May YC, Ngan AM and Hock CC (2004), Degumming and Bleaching Effect On Selected Constituents of Palm Oil, Journal of Oil Palm Research 16(2): 57-63