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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 Eand 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, vit E, ubiquinone and phytosterols (Koushki *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 *(E.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/cm^2 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 pastel 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 20l 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 1ml/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 50g 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^{0}C (hold time 10 min) and raised at 7^{0}C/min to a final temperature of 250 ^{0}C (hold time 10 min). The injector temperature was 250^{0}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 ^{0}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 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 plam 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.

Table I. Physicochemical properties of Bangladesh grown palm oil

Properties	CPO	DPO	DBPO
Oil yield (%)	37.50	35.9	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) (Total carotenoid)	564.00	304.00	53.00

Table-II. Tocopherol and tocotrienol content (ppm) of Bangladesh grown palm oil

Tocols	CPO	DPO	DBPO
Tocopherols			
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
$C_{14:0}$	3.125	4.157	5.986
$C_{16:0}$	31.329	31.343	29.006
$C_{18:2}$	10.184	17.565	16.839
$C_{18:1}$	43.138	27.209	21.916
$C_{18:1}$	0.730	1.987	8.774
$C_{18:0}$	11.495	17.259	15.821

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

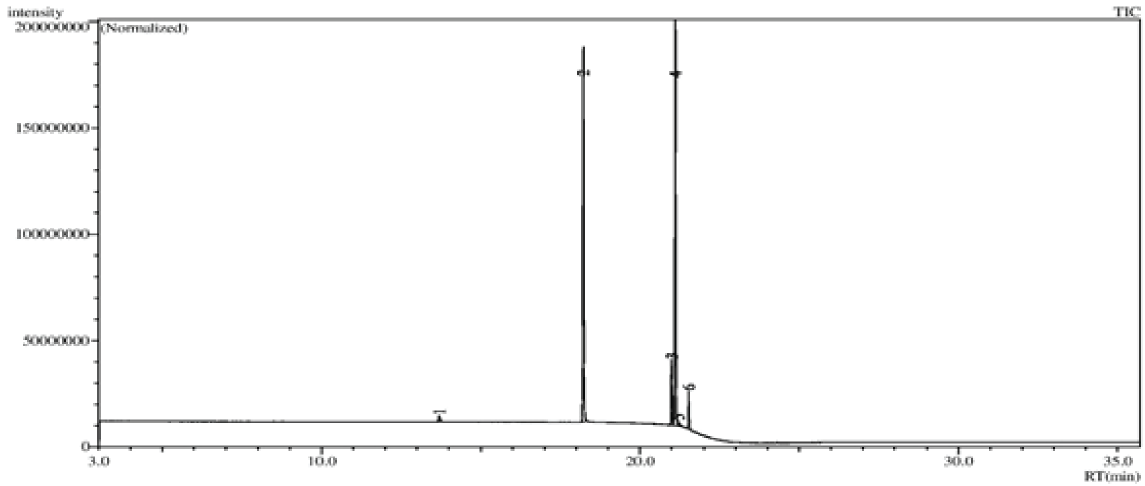

Fig.1. Chromatogram of CPO (Fatty acid composition)

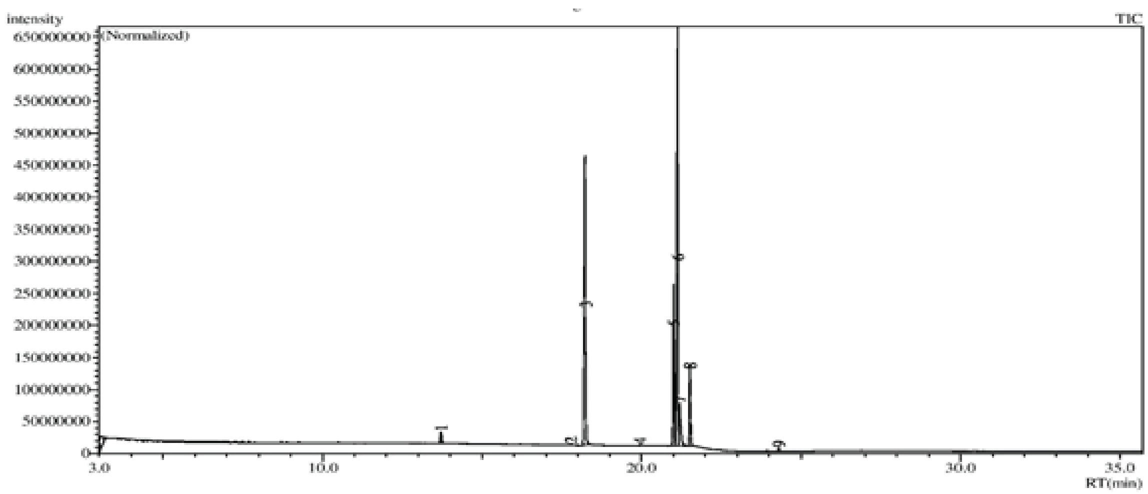

Fig. 2. Chromatogram of DPO (Fatty acid composition)

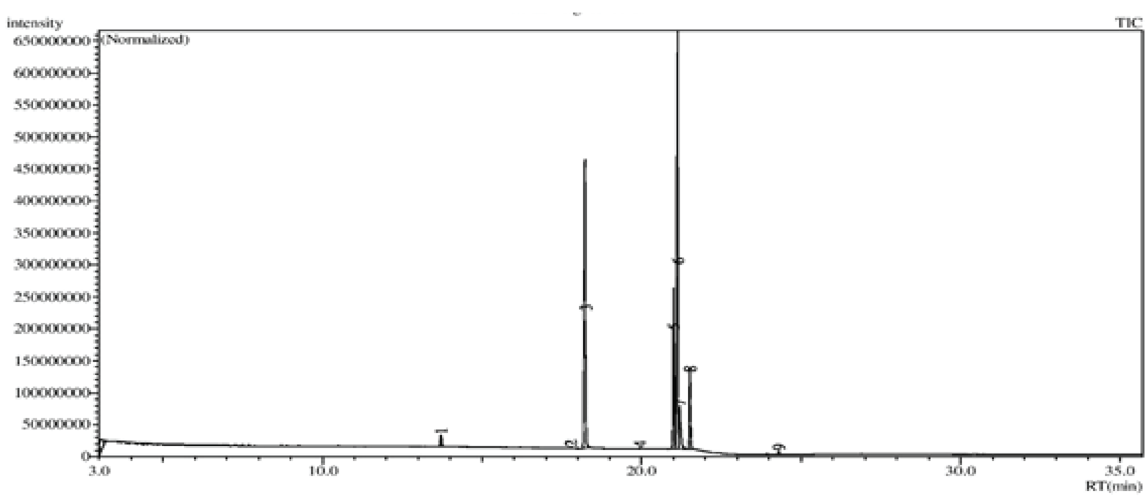

Fig. 3. Chromatogram of DBPO (Fatty acid composition)

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

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 type 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 compunds 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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