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Quality Evaluation and Fatty Acid Composition of Palm Oil Cultivated in Two Regions of Pakistan

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Abstract. Mesocarp and kernel oil of palm trees cultivated in two areas of Pakistan, Sindh (Thatta) and Balochistan were analysed for lipid contents, quality parameters and fatty acid profile. Oil content of mesocarp and the kernel of palm trees of Thatta, were found to be 68.23% and 26.4%, respectively, and those of Balochistan 62.7% and 27.79%, respectively. Fatty acid composition revealed the presence of palmitic (42.8%, 37.63%), oleic (34.3%, 43.54%) and linoleic acids (15.38%, 11.12%) as dominant fatty acids in the two mesocarp oils, while lauric acid (45.15%, 44.92%) was found as the most significant fatty acid in palm kernel oil of the two regions, respectively. Physical and chemical parameters such as density, refractive index, melting point, colour, free fatty acids, peroxide value, iodine value, saponification value and unsaponifiable matter of these four oils are also reported.

Keywords: *Elaeis guineensis*, fatty acids, palm fruit mesocarp oil, palm kernel oil

Introduction

The oil palm specie *Elaeis guineensis* is planted commercially in more than a dozen countries all over the world including, west and central Africa, south east Asia, central south America, China and Papua New Guinea (Hui, 1992). The plant is unique as it produces two kinds of oil. The outer fleshy mesocarp of the fruit yields palm oil and the kernel produces palm kernel oil. Physical and chemical characteristics of both the oils are quite different.

Palm oil has been in use for cooking purpose due to its distinctive quality and nutritive importance (tocotriend and carotenoid), in food preparations as margarine, shortening in fat blends and a vast array of food items for 5000 years in more than 100 countries (http://deforestationwatch.org/; Ihekoronye and Ngoddy, 1985). Presence of natural antioxidants and balanced composition of fatty acids make it safe and versatile edible oil with many positive health aspects (http//-wikipedia.org/).

Palm kernel oil is also used in soap and detergent manufacture due to the presence of high amount of lauric acid which contributes good leathering properties (http://-palm oil.com/).

Palm oil is comprised of lipids, vitamin A, vitamin E and other minor constituents. A number of human feeding studies reported that palm oil diet reduces the blood cholesterol from 7-38% (Bonanome and Grundy, 1988; Mattson and Grundy, 1985; Baudet *et al*., 1984; Ahrens *et al*., 1957). Similar study was carried out on fifty one Pakistani adults showing that the consumers of palm oil rich-diet performed better than sunflower oil (Farooq *et al*., 1996). A Malaysian study reported by Ng *et al*. (1991) showed that the diet containing palm oil (olein) and corn oil reduced in humans total cholesterol by 19% and 36%, respectively, while the coconut oil diet raised serum total cholesterol by more than 10%.

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Pakistan imports 70% of oil and fats to meet the edible oil requirement. Oil palm is one of the most important sources of oil, producing 1.700 M/ton oil per acre which is more than any other oil producing crop.

The coastal and riverien belts of Thatta, Badin, Karachi, Hyderabad, Mirpurkhas, and Sangher in Sindh and coastal belt of Hab, Vinder, Uthal, Sonmiani, Pasni, Gawader and Jiwani in Balochistan are suitable for oil palm cultivation. The coastal belt of Sindh is about 300 km in length from Karachi to Badin and that of Balochistan is about 550 km in length from Hub to Jiwani. In Sindh, 500,000 acres and about 2,000,000 acres of land in Balochistan are available for cultivation of oil palm. Plantation of oil palm trees have been carried out in Thatta (Garko) and Balochistan (Vinder).

In the present study, oil content, physicochemical characterization and fatty acid composition of neutral lipids of palm mesocarp and kernel oil of these regions have been investigated. Such type of detailed studies were undertaken for the first time in Pakistan which may be used as a basis for plantation of oil palm in other regions of Sindh and Balochistan as mentioned above.

The aim of present study was to assess the geographical and climatic changes in oil contents, quality and chemical composition of the oils of oil palm grown in Pakistan and compare the results with the published data to explore its potential as an oil source for use for edible and industrial purpose.

Materials and Methods

Product selection. Fresh palm fruit bunches of oil palm, cultivated in Garko and Vinder farms situated in Sindh (Thatta) and Balochistan provinces, respectively, were provided by Oilseed Development Board of Pakistan, Govt. of Pakistan. All the chemicals and fatty acid methyl ester standards were purchased from E. Merck and Sigma Aldrich Company.

Instrument/apparatus. The glassware used for analysis were of Pyrex 'A' category. PFX 995 Lovibond tintometer and Abbe's refractrometer were used to determine colour and refractive index, respectively.

Perkin Elmer's GC chromatograph model Clarus 500, fitted with flame ionization detector, was used for separation of fatty acid in Rtx 2330 column in GC oven.

Extraction of oil. Palm fruits were separated from spikelets using knife and 20-30 fruits were randomly collected depending on size and weight. These fruits were weighed and depericarped to receive mesocarp and kernel/nut. Fresh nuts were dried in a vacuum oven, weighed and grinded in electrical grinder. Similarly wet mesocarp was also dried, weighed and mashed in a kitchen chopper. Minced mesocarp (20 g) and nuts (50 g) were placed in two separate thimbles of soxhlet apparatus and subjected to oil extraction for 8-10 h, using one liter *n*-hexane in each case. Hexane was distilled off, oils were dried over anhydrous sodium sulphate then filtered and weighed. Same procedure was applied for oil extraction from palm fruits of Vinder farms. Red palm oil samples from Garko (Sindh) and Vinder (Balochistan) farms were coded as G-I, V-I and palm kernel oil samples were designated as G-II, V-II, respectively, for further discussion in this paper.

Analysis of palm mesocarp and palm kernel oil. *Physical and chemical parameters*. Density, refractive index, melting point, iodine value, saponification value and unsaponifiable matter of the extracted oils were determined by means of standard analytical methods (Firestone, 2004). Colour was also checked in I inch cell in Lovibond tintometer.

***Fatty acid composition*.** Fatty acid methyl esters were prepared according to the standard method (IUPAC, 1987) and analyzed in gas chromatograph by applying the following test conditions. Initial oven tempe-rature of 70 °C was held for 5 min, then temperature was ramped at the rate of 7 °C/min to 180 °C continuously then ramped at 3 °C /min to final temperature of 220 °C, and held for 10 min. with FID temperature: 275 °C and injector temperature of 250 °C. Oxygen free nitrogen was used as carrier gas at the flow rate of 3.0 mL/min. A sample volume of 0.5 µL was injected and the total run time was 34 min. Fatty acid methyl esters were identified by comparing their retention time with standard fatty acid methyl esters. Fatty acid composition was reported as relative percentage of the total peak area.

Results and Discussion

Oil content of palm mesocarp from Garko farm (G-I; 68.23%) was higher than Vinder (V-I; 62.77%) while the palm kernel oil of Garko farm (G-II; 26.48%) was lower than Vinder farm (V-II; 27.79%) (Table 1). It is interesting to note that the oil content of mesocarp of palm fruits of G-I, V-I were higher and palm kernel oil was lower than the standard values (Pantzaris, 2000; Pritchard, 1991).

Table 1. Physicochemical characteristics of palm oil and palm kernel oil

Characteristics	Present study				Values cited by			
					Malaysian Standard (1994) Pantzaris (2000)		Rossell (1991); Pritchard (1991)	
	Palm oil		Palm kernel oil		Palm oil	Palm kernel oil	Palm oil	Palm kernel oil
	G-I	V-I	G-II	V-II				
Oil content (%)	68.23	62.77	26.48	27.79	49	49	56	48.6(46.4 -50.8)
Density (g/cc@ 50 °C)	0.8910	0.8906	0.9082	0.9086	0.8896-0.891	-	0.891-0.899	0.899-0.914
Refractive index @ 50 °C	1.4659	1.4649	1.460	1.4610	1.4544-1.4550	1.450-1.4518	1.449-1.455	1.448-1.452
Melting point (°C)	36.8	35.9	28.5	27.8	33-39	25.9-28.0	33-40	24-26
Colour in 1"Lovibond cell	7R+70Y	7R+70Y	0.4R+1.0Y	0.1R+0.5Y	-	-	-	-
Free fatty acid (% as P.A.)	13.68	13.59	0.9935 (LA)	0.9899(LA)	5	-	5	6(LA)
Peroxide value(Meq/kg)	2.1097	4.584	0.856	1.448	2	-	3	-
Iodine value	51.52	56.15	13.16	15.98	50.1-54.9	16.2-19.2(17.8)	50-55	14.5-19
Saponification value	205.8	209.35	225.23	226.23	190-202	243-249	190-209	230-254
Unsaponifiable matter (%)	0.71	0.53	0.35	0.28	0.15-0.99	0.1-0.8	0.3-1.2	0.2-0.8

It was observed that the oil content of palm mesocarp and palm kernel were lower than Brazilian palm oil (Bora *et al*., 2003). Oil yield reported by Akubugwo and Ugbogu (2007) in Nigerian palm kernel oil was 28% which is closely related to the Vinder (V-II; 27.79%) kernel oil.

Physical and chemical characteristics. Some of the indicators used to characterize palm oil are iodine value (IV) and slip melting point (SMP). The IV measures the degree of unstauration or double bonds in oils and fats. It also indicates the ease of oxidation of oils and fats (Guided Wave Incorporated, 2008). Meanwhile, the SMP is widely used to characterize the melting and solidification properties of oils and fats. It changes with the chain length of fatty acids, unsaturation ratios, *trans* fatty acid content and the position of the fatty acids in the glycerol backbone (Karabulut *et al*., 2004).

Table 1 shows results of physical and chemical parameters including density, refractive index, melting point, colour, free fatty acid, peroxide value, iodine value, saponification value and unsaponifiable matter, of extracted oils which were compatible with specified standards. Density, melting point and unsaponifiable matter of the four oils were in good agreement with the standard values (Malaysian Standard, 1994; Rossell, 1991). Saponification value of palm oil (G-I and V-I) complied with the result of Rossell (1991), but was slightly on higher side than the specified limits of Malaysian Standard (1994). Free fatty acids of the two palm oils were also on higher side because of hydrolytic cleavage of glyceride back bone of palm oil, which was usually produced due to high moisture content present in palm fruit bunches. High FFA content may be minimized by refining of the crude palm oil or any other vegetable oil to a minimum level up to 0.1-0.25%. Some of these parameters of palm oil, collected from different markets of Nigeria were also determined by Udensi and Iroegbu (2007). Peroxide value of palm oil was lower in the present study then that reported by Udensi and Iroegbu (2007). This parameter determines the extent of rancidity of oil and is used as an indication of the quality and stability of fats and oils. Peroxide value of each oil was within the specified limits of Codex Standards for palm oil (Codex Alimentarius, 2001a) and palm kernel oil (Codex Alimentarius, 2001b) in the current study.

In an interlaboratory comparison study of palm oil iodine value and melting point, the consensus values with uncertainties were 52.63±0.14 and 35.6±0.3, respectively, reported by Tarmizi *et al*. (2008a). Iodine value of palm oil ,G-I and melting point of V-I were compatible with Tarmizi *et al.* (2008a). Iodine value of palm oil (G-I and V-I) and refractive index of all the four extracted oils (G-I, V-I, G-II and V-II) were higher than the reported values (Table 1).These differences may be due to variation in the climatic conditions, quality of soil and manure used for growing the oil palm trees.

Fatty acid composition. Oil and fats consist mainly of triglycerides. They are essential nutrients and energy source for human and animal diet (http://iseo.org/food fats and oil, 2006). Functionality of food products depends on physicochemical properties such as fatty acid composition (FAC) which is often used to characterize oil and fats (Gee, 2007). FAC provides information about the total content of saturated and unsaturated fatty acids, which is often used as health indicators. FAC can also be used as one of the indicators to determine the oxidative stability of oil and fats (http://iseo.org/food fats and oil, 2006). Fatty acid composition of palm oil is such that the oil is semisolid at normal room temperature; thus it can be used in margarine and shortening without hydrogenation (Aini, 2000).

Palm mesocarp oil. Elution pattern of fatty acids by gas liquid chromatography is shown in Fig. 1. Fatty acid analysis of neutral lipids of G-I and V-I (Table 2) revealed the presence of significant levels of palmitic acid (42.8% and 37.63%, respectively), oleic acid (34.3% and 43.54%, respectively), and linoleic acid (15.38% and 11.12%, respectively). Palmitic acid and linoleic acid in Garko oil (G-I) were higher than in Vinder oil (V-I), while the oleic acid was higher in Vinder oil than in Garko oil. Other fatty acids like myristic and stearic acid were found to be present in lower amounts.

It is also evident from Table 2 that the quantity of palmitic acid in mesocarp (G-I) oil was slightly higher than the specified limits in Malaysian standards (1994), lower than the Rossell (1991) and within the limit of Codex Alimentarius (2001a), whereas, in case of Vinder mesocarp oil (V-I), palmitic acid was lower in quantity than all of the standard values as mentioned in Table 2.

Oleic acid was lower in mesocarp (G-I) oil than all of the standard values (Malaysian Standard, 1994, Rossell, 1991; Codex Alimentarius, 2001a, b), while it was higher in mesocarp (V-I) oil than the Malaysian Standard (1994) and Rossell (1991) but complying with Codex Alimentarius standard. It has been found from the fatty acid profile of palm mesocarp oil that normally the neutral lipid is a 50:50 combination of saturated and unsaturated fatty acids (Sundram *et al*., 2003) (Table 3). Saturated fatty acids in palm oil, stearic and palmitic acids, do not raise the blood cholesterol level in people whose blood cholesterol level is in normal range (Hayes *et al*., 1995; 1991; Khosla and Hayes, 1994; 1992).

In the present study, it is interesting to note that palm mesocarp oil, (G-I), is composed of approximately 50:50 mixture of saturated and unsaturated fatty acids but in the other case

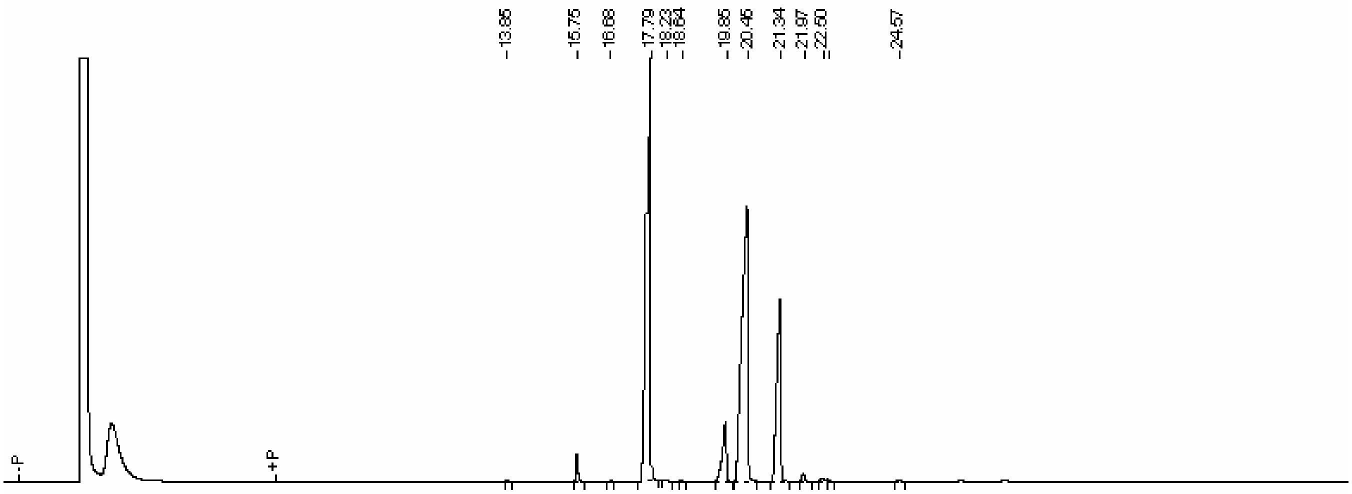

Fig. 1. Palm fruit mesocarp oil chromatogram.

Table 2. Fatty acid composition of palm oil and palm kernel oil (present study and other standards)

Fatty acid composition (wt %)	Present Study				Malaysian standard (1994)		Rossell (1991)		Codex Alimentarius (2001a, b)	
	Palm oil		Palm kernel oil		Palm oil	Palm kernel oil*	Palm oil (mean)	Palm kernel oil (mean)	Palm oil (Stan. 125-1981)	Palm kernel oil (Stan. 126-1981)
	G-I	V-I	G-II	V-II						
Caproic acid (C6:0)	-	-	-	-	-	0.1-0.5 (0.5)	-	ND-0.8 (0.3)	-	< 0.8
Caprylic acid (C8:0)	-	-	2.71	1.93	-	3.4-5.9 (4.4)	-	2.5-4.7 (3.3)	-	2.4-6.2
Capric acid (C10:0)	-	-	2.74	2.48	-	(3.3-4.4) (3.7)	-	2.8-4.5 (3.5)	-	2.6-5.0
Lauric acid (C12:0)	-	-	45.15	44.92	0.1-0.4	46.3-51.1 (48.3)	ND-0.2 (0.1)	43.6-51.4 (47.5)	< 0.4	41-55
Myristic acid (C14:0)	1.13	0.56	15.96	17.21	1.0-1.4	14.3-16.8 (15.6)	0.8-1.3 (1.0)	15.3-17.2 (16.4)	0.5-2.0	14 - 18
Palmitic acid (C16:0)	42.8	37.63	9.64	9.72	40.9-40.7	6.5-8.9 (7.8)	43.1-46.3 (44.3)	7.2-10 (8.5)	41-47	6.5- 10
Stearic acid (C18:0)	4.58	5.07	2.08	2.38	3.8-4.8	1.6-2.6 (2.0)	4.0-5.5 (4.6)	1.9-3.0 (2.4)	3.5-6.0	1.3-3.0
Oleic acid (C18:1)	34.3	43.54	16.32	18.05	36.4-41.2	13.2-16.4 (15.1)	36.7-40.8 (38.7)	11.9-18.5 (15.3)	36.0-44	12-19
Linoleic acid (C18:2)	15.38	11.12	4.69	2.93	9.2-11.6	2.2-3.4 (2.7)	9.4 -11.9 (10.5)	1.4 -3.3 (2.4)	6.5-12.0	1.0-3.5
Linolenic acid (C18:3)	0.26	0.21	0.25	0.10	0-0.5	-	0.1- 0.4 (0.3)	Tr -0.7 (0.1)	< 0.5	< 1

ND = not detected; * = Pantzaris (2000).

(V-I) this ratio was not the same. The percentage composition of saturated fatty acids and unsaturated fatty acids present in mesocarp oil of V-I were 43.26 and 54.87, respectively. The presence of excess amount of unsaturated fatty acid was also confirmed by iodine value and melting points of both the extracted oils (G-I and V-I) (Table 1), i.e., 51.52, 36.8 °C and 56.15, 35.9 °C, respectively. The difference in fatty acid profile of the two oils cultivated in different areas of Pakistan showed that the oil of Vinder farm was comparatively a better source of mono- and poly- unsaturated fatty acids. Fatty acid content of palm oil and palm kernel oil found in the current study may also be compatible with the findings of other scientists (Table 3) (Tarmizi *et al.*, 2008b; Bora *et al.*, 2003; Sundram *et al.*, 2003; palmoil.com, html doc; http//en.wikipedia).

Table 3. Fatty acid compositions of palm and palm kernel oil (reported values)

Fatty acid composition (wt %)	Present study				Literature/Journal values							
	Palm oil (PO)		Palm kernel oil (PKO)		Sundram *et al.* (2003)	Bora *et al.* (2003)		Tarmizi *et al.* (2008)	Palmoil. com (htm.doc)		Palmoil en.wikipedia (htm.com)	
	G-I	V-I	G-II	V-II	PO	PO	PKO	PO	PO	PKO	PO	PKO
Caproic acid (C6:0)	-	-	-	-	-	-	-	-	-	-	-	-
Caprylic acid (C8:0)	-	-	2.71	1.93	-	-	-	-	-	-	-	3.3
Capric acid (C10:0)	-	-	2.74	2.48	-	-	-	-	-	-	-	3.4
Lauric acid (C12:0)	-	-	45.15	44.92	0.3	-	53.3	0.2	-	48	10.5	48.2
Myristic acid (C14:0)	1.13	0.56	15.96	17.21	1.1	-	-	1.66	-	16	1.0	16.2
Palmitic acid (C16:0)	42.8	37.63	9.64	9.72	43.5	36.9	-	43.39	44	-	44.3	8.4
Stearic acid (C18:0)	4.58	5.07	2.08	2.38	4.3	-	-	3.9	-	-	4.6	2.5
Oleic acid (C18:1)	34.3	43.54	16.32	18.05	39.8	45.29	5.5	40.95	39	15	36.7	15.3
Linoleic acid (C18:2)	15.38	11.12	4.69	2.93	10.2	-	-	9.68	11	-	10.5	2.3
Linolenic acid (C18:3)	0.26	0.21	0.25	0.10	0.3	-	-	-	-	-	others/ 0.9	others/ 0.4

PO = palm oil; PKO = palm kernel oil.

Palm kernel oil. Elution pattern of fatty acids by gas liquid chromatography is shown in Fig. 2 and fatty acid composition of palm kernel oil is summarized in Table 2. It shows that the level of saturated fatty acids was higher than the unsaturated fatty acids in the two oils (G-II, 78.28% and V-II, 78.64%). Lauric acid was found to be the most dominant fatty acid and forms 45% of the total fatty acids. In the present study, it was lower than the prescribed Malaysian Standard (1994) and conforms with the other standards (Codex Alimentarius, 2001a,b; Rosselle, 1991). Fatty acid composition of palm kernel oil cited in the literature is presented in Table 3 for reference purpose. It also resembles the coconut oil in fatty acid composition and physicochemical characteristics, (Table 4).

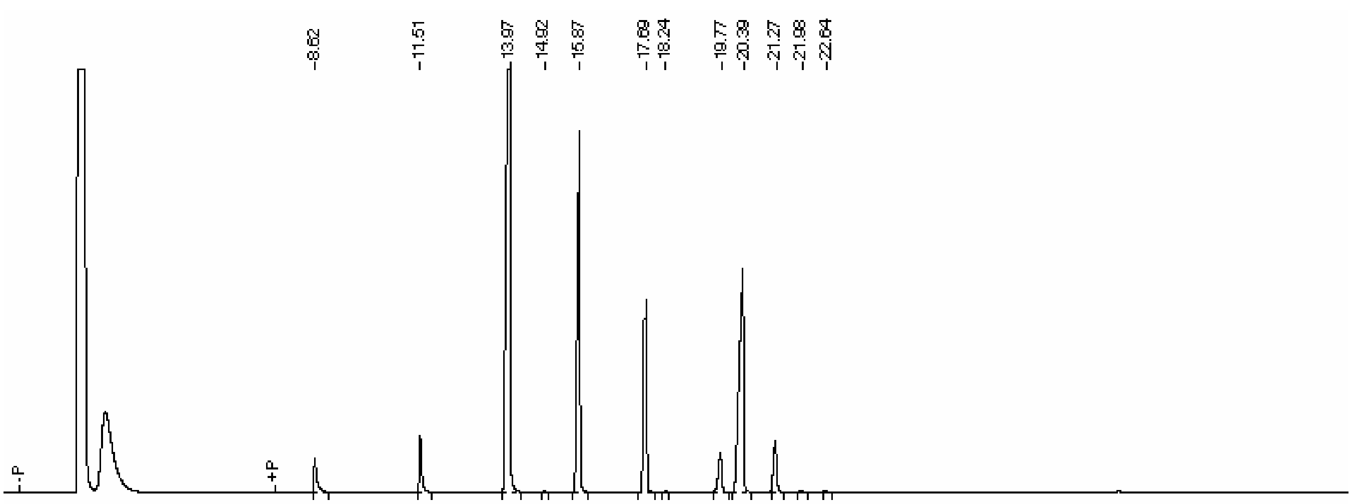

Fig. 2. Palm kernel oil chromatogram.

Table 4. Physical and chemical characteristics of coconut oil and palm kernel oil

Characteristics	Coconut oil (Rossell, 1991)	Palm kernel oil (present study)	
		G-II	V-II
Refractive index	1.448-1.450	1.460	1.4610
Melting point (°C)	23-26	28.5	27.8
Colour in 1"Lovibond cell	-	0.4R+1.0Y	0.1R+0.5Y
Iodine value	6-11	13.16	15.98
Saponification value	248-265	225.23	226.23
Unsaponifiable matter (%)	0-0.5	0.35	0.28
Fatty acid composition (wt%)			
Caproic acid (C6:0)	0.4-0.6 (0.5)	-	-
Caprylic acid (C8:0)	6.9-9.4 (7.8)	2.71	1.93
Capric acid (C10:0)	(6.2-7.8) (6.7)	2.74	2.48
Lauric acid (C12:0)	(45.9-50.3) (47.5)	45.15	44.92
Myristic acid (C14:0)	16.8-19.0 (18.1)	15.96	17.21
Palmitic acid (C16:0)	(7.7-9.7) (8.8)	9.64	9.72
Stearic acid (C18:0)	2.5-3.2 (2.65)	2.08	2.38
Oleic acid (C18:1)	5.4-7.4 (6.2)	16.32	18.05
Linoleic acid (C18:2)	(1.3-2.1) (1.6)	4.69	2.93
Linolenic acid (C18:3)	-	0.25	0.10

Conclusion

It is concluded that the cultivation of oil palm in Pakistan yields healthy palm fruit bunches possessing good quantity and quality of palm mesocarp oil and palm kernel oil which may be successfully used for edible purpose, (after refining), as well as non-edible purpose. Efforts should be made to promote the plantation of oil palm in coastal belt of Pakistan which is about 850 km in length. This will beautify the barren land and minimize the environmental pollution as well. Besides, the country can save billions of foreign exchange each year being spent on the import of edible oil from abroad to meet the domestic requirements.

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