

A Survey on the Fatty Acid Composition of Commercial Palm Oil in Thailand

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Abstract: Seven commercially available palm oils in Thailand were studied to evaluate their fatty acid composition using the GC-MS tandem. Seven to eight different fatty acids distributed in varying proportion were identified in each sample. Saturated fatty acids accounted for 24.82 to 44.65% of the total fatty acids. Hexadecanoic acid contributed the highest percentage among the saturated fatty acids identified. This was followed by octanoic acid. Dodecanoic, tetradecanoic and eicosanoic acids were also observed in trace amount. The percentage distribution of unsaturated fatty acids with a range of 55.35-75.18% was determined to be higher than the percentage of saturated fatty acids. 9-Octadecenoic acid largely contributed to the high percentage of unsaturated fatty acids in the palm oil samples. This was followed by 9, 12-octadecadienoic acid. A trace amount of 9,12,15-octadecatatrienoic acid was also detected but only in two palm oil samples.

Keywords: Fatty acids, Palm oil, Transesterification, GC-MS

Introduction

The fatty acid composition of vegetable oils has been of great interest in the past since fatty acids play several useful roles to human health. As constituents of lipids in biological membranes, fatty acids affect fluidity, integrity and the activities of membrane-bound enzymes¹. One of the most significant advances in the understanding of fatty acids is the health benefits derived from the polyunsaturated fatty acids (PUFAs) found in some vegetable or animal-based oil. A diet rich in PUFAs appeared to account for cholesterol lowering which is important in the prevention of cardiovascular diseases². Moreover, the characteristic fatty acid composition of oils has been found useful for evaluating product quality and authenticity³.

Palm oil is an edible vegetable oil obtained from the fruit of the oil palm tree. Through different technological processes it has found great applications in food manufacturing and

in the chemical, cosmetic and pharmaceutical industries. It is used in the manufacture of margarine, cooking oils, soaps and incorporated in various fat blends and a wide variety of food products^{4,6}. In Thailand, palm oil accounts for as much as 62% percent of the vegetable oil market. In fact, a number of palm oil industries are located among the different provinces of Thailand, most of which are in the southern region⁷.

A background on the fatty acid composition of commercial palm oil would greatly benefit consumers who in turn are the end user of this product. Although several studies⁸⁻¹¹ have reported the fatty acid composition of palm oil, none so far have surveyed the fatty acid composition of commercially available palm oil in Thailand. The palm varieties, growth conditions and plantation management in Thailand are different from other countries⁷, thus fatty acid contents may vary. Moreover, fatty acid composition may be influenced by species or strain, regional, climate, degree of ripeness, harvesting, chemical refining processes and others¹². In this study, the fatty acid composition of commercially available palm oil in Thailand was determined using the gas column chromatography- mass spectrometry tandem.

Experimental

A total of seven different brands of palm oil from Tenera variety labeled A-G were obtained from a local market in Chiang Mai, Thailand. Table 1 gives the details for each palm oil sample.

Table 1. Palm oil samples and its respective brand name, company and location of manufacturing company

Sample code	Brand name	Company	Province
A	Waew	P.S. Pacific Co. Ltd.	Petchaburi
B	Yokh	Lumsoong Co. Ltd	Samutprakarn
C	Oline	Oline Co. Ltd.	Bangkok
D	Morakhot	Morakhot Industries Co. Ltd.	Samutprakarn
E	Thip	Wiwat Industries Co. Ltd.	Nonthaburi
F	Reo	Chumporn Palm Oil Industries Co. Ltd.	Chumporn
G	Poisian Flower	Morakhot Industries Co. Ltd.	Samutprakarn

Preparation of fatty acid methyl esters (FAMES)

FAMES were prepared based from the procedure of Pavia *et. al.*¹³ which was modified by Phutdhawong¹⁴ as follows. One gram of the oil sample was weighed accurately in a round bottom flask and 20 mL of methanol and 0.05 g of sodium was added. The solution was left stirred overnight for the transesterification. The solution was transferred to a separatory funnel to which 10 mL of water was added and FAMES were then extracted thrice with 20 mL dichloromethane per extraction. To the dichloromethane layer, anhydrous sodium sulfate was added to remove water. The extract was concentrated in a rotary evaporator until c.a. 1 mL solution which was a mixture of FAMES remained. FAMES were then kept in a refrigerator until analysis in the GC-MS. GC-MS

Analysis

Different GC-MS conditions and dilution ratio of the samples were carried out until the optimum conditions that gave the best separation of FAMES in the sample were achieved. except for sample G which underwent 20-fold dilution, all samples were diluted ten-fold before analyzing in the GC-MS (Agilent 6890-HP5975 model). A 1- μ L diluted FAME sample

was injected in split mode (250:1 split ratio) and GC separation was carried out using helium as the carrier gas maintained at c.a. 16psi and a flow rate of 1.2 mL/min. HP-5MS (5% phenylmethyl siloxane) was used as the capillary column with a nominal diameter of 250 μm , length of 30 m and film thickness of 0.25 μm . The oven temperature was held initially at 150 $^{\circ}\text{C}$ and later ramped at 4 $^{\circ}\text{C}/\text{min}$ to 275 $^{\circ}\text{C}$ and was held isothermally at this point for 30 mins. Chromatograms were obtained in scan mode. The mass spectrometer was operated in electron impact ionization mode. The temperatures of the quadrupole, ionization source and transfer line were 150 $^{\circ}\text{C}$, 230 $^{\circ}\text{C}$ and 280 $^{\circ}\text{C}$ respectively.

Identification

FAMES were positively identified by matching their mass spectra with literature data derived from two databases: NIST (National Institutes of Standards and Technology) and Wiley.

Results and Discussion

The transesterification of commercial palm oil produced no emulsion. FAMES extracted are pale yellow and the percentage yield of fatty acids from the commercial palm oil ranged from 90.70-96.60%.

The results of the GC-MS analysis are summarized in Table 2 and a typical chromatogram of the commercial palm oil is shown in Figure 1. Seven to eight fatty acids distributed in varying amounts were determined in each palm oil samples. A similarity in the pattern of chromatograms was also observed in all the samples. All showed four prominent peaks that correspond to the methyl esters of hexadecanoic acid (peak 3), 9,12-octadecadienoic acid (peak 4), 9-octadecenoic acid (peak 5) and octanoic acid (peak 7). Minor peaks labeled as 1, 2, 6 and 8 corresponds to the methyl esters of dodecanoic ($\text{C}_{12:0}$), tetradecanoic ($\text{C}_{14:0}$), 9,12,15-octadecatrienoic($\text{C}_{18:3}$) and eicosanoic ($\text{C}_{20:0}$) acids respectively.

Table 2. Summary of the GC-MS analysis of the commercial palm oils in Thailand.

Compounds ^a	Sample code/brand name						
	RT ^b	A (Waew)			B(Yokh)		
		RA% ^c	Quality ^d	RT ^b	RA% ^c	Quality ^d	
Dodecanoic acid methyl ester	4.58	0.20	96	4.57	0.46	96	
Tetradecanoic acid methyl ester	7.58	0.78	99	7.57	0.68	98	
Hexadecanoic acid methyl ester	11.51	36.96	98	11.48	28.58	98	
9,12-Octadecadienoic acid methyl ester	14.99	10.15	99	14.99	23.91	99	
9-Octadecenoic acid methyl ester	15.16	45.75	99	15.14	39.76	99	
9,12,15-Octadecatrienoic acid methyl ester	--	--	--	15.40	0.35	97	
Octadecanoic acid methyl ester	15.63	4.68	99	15.62	4.62	99	
Eicosanoic acid methyl ester	19.74	0.18	97	19.73	0.21	96	
		C (Oline)			D (Morakhot)		
Dodecanoic acid methyl ester	4.56	0.19	96	4.57	0.35	97	
Tetradecanoic acid methyl ester	7.56	0.56	99	7.57	0.94	98	
Hexadecanoic acid methyl ester	11.49	26.60	98	11.52	36.25	99	
9,12-Octadecadienoic acid methyl ester	15.01	23.99	99	14.99	11.07	99	
9-Octadecenoic acid methyl ester	15.17	37.59	99	15.19	45.05	99	

Contd...

9,12,15-Octadecatrienoic acid methyl ester	--	--	--	--	--	--
Octadecanoic acid methyl ester	15.63	4.67	99	15.63	4.76	99
Eicosanoic acid methyl ester	19.73	0.28	99	19.72	0.33	99
	E (Thip)			F (Reo)		
Dodecanoic acid methyl ester	--	0.08	--	4.58	3.04	96
Tetradecanoic acid methyl ester	7.58	0.31	98	7.58	1.69	99
Hexadecanoic acid methyl ester	11.49	18.95	98	11.52	31.37	99
9,12-Octadecadienoic acid methyl ester	15.05	41.55	99	14.99	8.36	99
9-Octadecenoic acid methyl ester	15.18	31.94	99	15.18	41.91	99
9,12,15-Octadecatrienoic acid methyl ester	15.42	1.18	99	--	--	--
Octadecanoic acid methyl ester	15.65	5.42	99	15.64	4.32	99
Eicosanoic acid methyl ester	19.74	0.49	99	19.75	0.13	97
	G (Poisian Flower)					
Dodecanoic acid methyl ester	4.57	0.24	93			
Tetradecanoic acid methyl ester	7.57	0.69	98			
Hexadecanoic acid methyl ester	11.47	38.04	98			
9,12-Octadecadienoic acid methyl ester	14.96	9.38	99			
9-Octadecenoic acid methyl ester	15.12	46.25	99			
9,12,15-Octadecatrienoic acid methyl ester	--	--	--			
Octadecanoic acid methyl ester	15.61	4.26	99			
Eicosanoic acid methyl ester	--	--	--			

^aAll the compounds listed were identified from the two databases: NIST and Wiley, ^bRT, retention times, ^cRA%, relative area, (peak area relative to total peak area), ^dMass spectral quality comparison with the database of Wiley, -- not detected in the sample

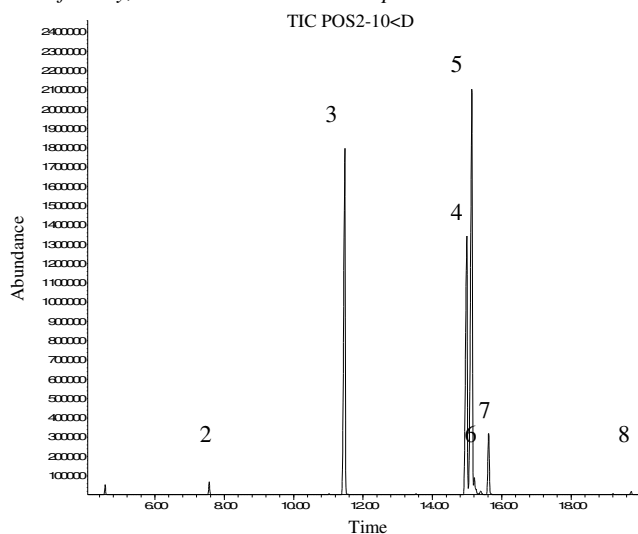


Figure 1. A typical chromatogram of commercial palm oil in Thailand

The only monounsaturated fatty acid identified in the palm oil samples was 9-octadecenoic acid ($C_{18:1}$). This acid also contributed the highest percentage in the total fatty acids of all the palm oil samples except with sample E. The concentration of $C_{18:1}$ ranged from 31.94 to 46.25%, the highest being observed in palm oil sample F. The higher concentration of $C_{18:1}$ over the other fatty acids conforms to the findings of Bora *et. al.*¹⁵ with the Brazilian oil palm. However, other monounsaturated fatty acids present in the Brazilian oil palm such as $C_{14:1}$, $C_{15:1}$, $C_{16:1}$, $C_{20:1}$ and $C_{22:1}$ were not detected. The absence of these monounsaturated fatty acids in the commercially available palm oil may be attributed to several factors as mentioned earlier.

Among the saturated fatty acids determined in the palm oil samples, hexadecanoic acid ($C_{16:0}$), gave the highest concentration with a range of 18.95 - 38.04%. The highest concentration of $C_{16:0}$ was observed in sample G and lowest in sample E. The amount of $C_{18:0}$ ranged from 4.32 - 5.42%. Other saturated fatty acids such as $C_{12:0}$, $C_{14:0}$, and $C_{20:0}$ were also present in small quantities with a concentration of not more than 1% of the total fatty acids in the palm oil sample. Not included however is sample F whose percentage of $C_{12:0}$ and $C_{14:0}$ is 3.04 and 1.69% respectively.

Similar with the palm oil analyses of Bora *et. al.*¹⁵ and Rezanka and Rezanková¹⁶, only two polyunsaturated fatty acids were detected in the palm oil samples. These were the 9,12-octadecadienoic acid ($C_{18:2}$) and 9,12,15-octadecatrienoic acid ($C_{18:3}$). The concentration of $C_{18:2}$ ranged from 8.36% to 41.55%. Although palm oil sample E gave the lowest amount of $C_{18:1}$, it exhibited the highest concentration of $C_{18:2}$. A trace amount of $C_{18:3}$ was observed only in palm oil samples B and E with a concentration of 0.35 and 1.18% respectively.

Overall, the percentage of saturated fatty acids in the seven palm oil samples have a range of 24.82 - 44.65% while unsaturated fatty acids have a range of 55.35-75.18%. The high percentage of unsaturated fatty acids is largely attributed to $C_{18:1}$ except for sample E where $C_{18:2}$ was the most predominant fatty acid. Monounsaturated fatty acids have also been reported to be as effective as PUFAs in the reduction of low density lipoprotein cholesterol in humans¹⁷.

Conclusion

GC-MS analysis of the 7 commercially available palm oil samples in Thailand revealed seven to eight different fatty acids distributed in varying proportion. The saturated fatty acids identified were $C_{12:0}$, $C_{14:0}$, $C_{16:0}$ and $C_{20:0}$. Unsaturated fatty acids include the monounsaturated $C_{18:1}$ and the polyunsaturated $C_{18:2}$ and $C_{18:3}$. The percentage distribution of unsaturated fatty acids was observed to be higher than the saturated fatty acids. The monounsaturated $C_{18:1}$ largely contributed to the high percentage of unsaturated fatty acids in the palm oil samples.

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