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IDENTIFICATION OF PALM OIL AND ITS FRACTIONS BY HPLC USING TRIACYLGLYCEROL PEAK-AREA RATIOS

Keywords: Triglycerides, Palm Oil, Palm Olein, Palm-mid Fraction, High Performance Liquid Chromatography.

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The concept of peak-area ratios in reversed-phase HPLC of triacylglycerols in palm oil and palm oil fractions was expanded and tested by analysis of numerous authentic samples. Palm oil fractionation changes the tripalmitin and triolein peaks and peak area ratios. To expand the data base, a large number of palm oils, palm oleins and palm stearins of Malaysian origin were investigated and the results compiled. Variability of the peak areas and peak area ratios with changes of solvents is discussed. Peak area ratios were found to be useful in identifying palm oils from different sources as well as in detecting possible admixtures of oils.

INTRODUCTION

Palm oil (PO) is produced in increasingly large quantities in tropical countries with humid climates, mostly in Malaysia, Indonesia and West Africa. Small differences in the characteristics of palm oil from different countries are due to the different planting materials used. Malaysian oil palm is mainly *Dura x Pisifera (DxP)*, or *Tenera*, of *Elaeis guineensis* which produces oil with an iodine value (IV) of 50-54. Sumatran and Brazilian palm oils are slightly more unsaturated (Klagge and Sen Gupta, 1990). A hybrid of *E. guineensis* and *E. oleifera (E.g. x E.o)* which produces an oil similar to olive oil is grown experimentally.

Palm oil is fractionated by different techniques to obtain a more liquid fraction, palm olein (Po-O), and a more solid fraction, palm stearin (Po-S) (Deffense, 1985). Differences in the raw materials and fractionation conditions produce fractions of different properties as shown by the wide range of palm stearins available (IV between 27-45). Furthermore, by multiple fractionation, a middle fraction (palm midfraction, PMF) is obtained which is a valuable raw material for the production of speci-

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ality fats, such as cocoa butter replacers and extenders. The high amount of symmetrical oleodipalmitin (POP) in PMF contributes to its special properties.

Normal palm olein and super olein (IV>60) are used as cooking and frying oils in many countries (Deffense, 1985; Tan, 1989) while palm stearin has numerous applications in a wide range of products such as shortening, margarine, vanaspati and speciality fats (Tan, 1989; Berger, 1981; Kheiri, 1985) and for non-food uses such as soaps and oleochemicals (Kifli and Krishnan, 1987). Blends of palm oil/palm olein with palm stearin in varying proportions are used to tailor make products with specific characteristics for many applications.

In conventional gas chromatography (GC) of triglycerides, the results of fractionation of palm oil are not so easy to interpret as in reversed-phase HPLC of triglycerides (Deffense, 1985). In HPLC systems, the peaks for triolein (OOO) and triplamitin (PPP) can be separated and quantitated (Aitzetmuller *et al.*, 1988). In conventional GC, this is difficult to do because of interference from other C_{54}-triglycerides (SOS, SOO, SLS, SLO, OLO, OLL, *etc.*) in the GC-peak for OOO, and of other C_{48}-triglycerides, notably MOP and MLP, with PPP. It is for this reason that the ratio of OOO:PPP peak-areas, or the ratio of the sum of all triunsaturated peak-areas:sum of all saturated peak-areas - easily obtainable by HPLC - is a good indicator of palm oil fractionation and, in turn, contamination by palm-stearin in palm oil.

Earlier research (Aitzetmuller *et al.*, 1988) has shown that the peak-area ratio of OOO:PPP is usually between 1:1 and 1:2 in genuine palm oils. In order to be confident about contamination, however, a broader data base is first required. For this reason we analysed a number of palm oils and palm oil fractions from known sources in Malaysia.

EXPERIMENTAL

System 1

For the reversed-phase HPLC of palm oils and palm kernel oils the solvents acetonitrile, 2-propanol and hexane were used.

All solvents were of LiChrosolv quality (Merck).

Oils were obtained from commercial sources and from several refining plants and oil companies in Malaysia. Each oil was injected into the HPLC system as a 1.5% solution in 2-propanol (20 µl).

High performance liquid chromatography (HPLC) was carried out with a Merck-Hitachi 655A-12 liquid chromatograph and a L-5000 LC controller equiped with a Rheodyne Model 7125 valve injector (20 µl loop). The column was a 250 x 4 mm i.d. Superspher RP18 end-capped column (Merck) with a Merck type T-6300 column thermostat set at 30°C. The mobile phase was acetonitrile:2-propanol:hexane mixture (65:22:13) set at a flow rate of 0.8 ml/min.

Detectors used included a Waters LC Spectrophotometer Lambda-Max Model 481 at a wavelength of 210 nm and an ERC-7510 ERMA RI detector at a temperature of 35°C. Peak area integration was performed with a Merck-Hitachi D-2500 Chromato-Integrator. A drawback of integrators of this type, however, is that it was not possible to automatically calculate relative retention times based on OOO = 1.000 from the OOO retention time in the same chromatogram.

Warning: Whenever UV- and RI-detection are used in series, the UV detector must always be first because many RI cells cannot withstand the back pressure generated by most UV detectors and their capillary connections.

System 2

High-performance liquid chromatography (HPLC) was performed with a Merck-Hitachi pump L-6000. A Rheodyne (Model 7125) injection valve with a 20 µl loop and two columns in series (250 x 4 mm i.d.) LiChrospher 100 RP 18, 5µm were used.

A Knauer differential refractometer was used for refractive index detection at room temperature.

The mobile phase was acetone and

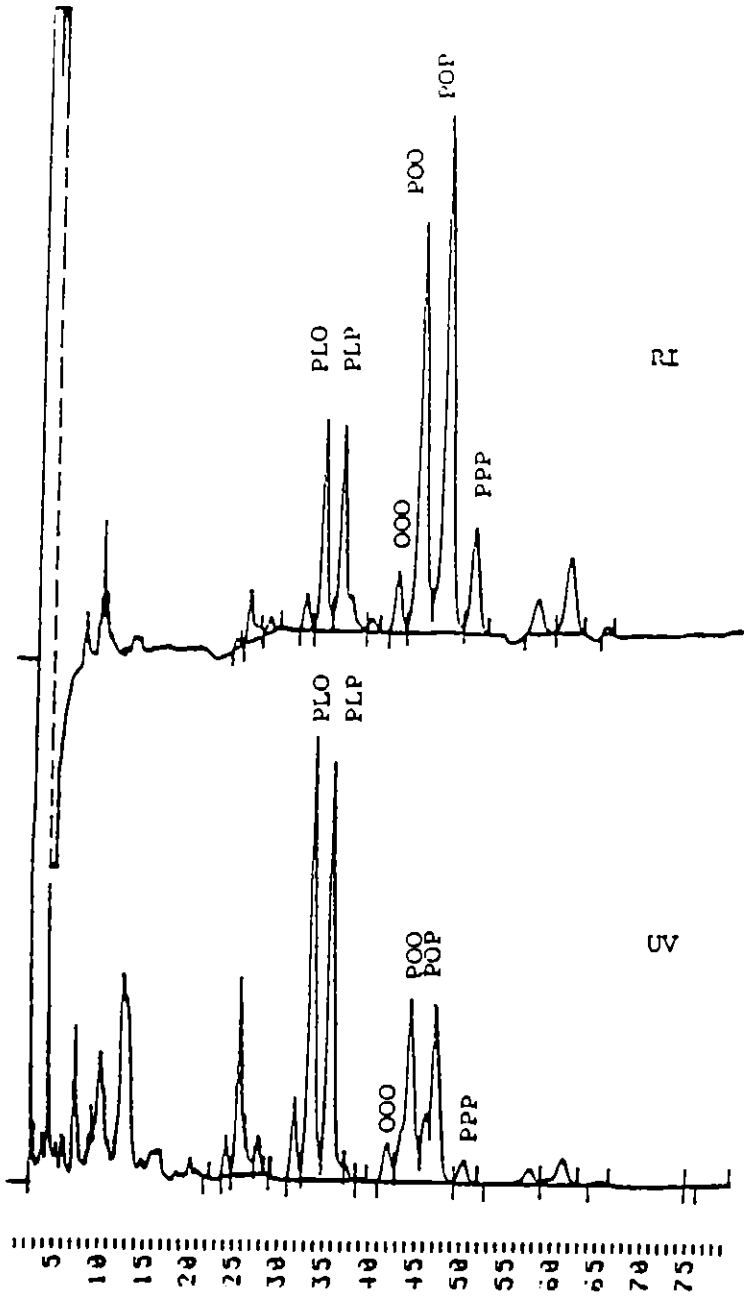

Figure 1(i): HPLC Chromatograms of Palm Oil
Column: 250 x 4 mm Superspher, RP 18 (4μm)
Detector: UV and RI (in series)
Mobile phase: Acetonitrile + 2-Propanol + Hexane
(65) (22) (13)

acetonitrile, often in the ratio of 75:25 at a flow rate of 1 ml/min.

The chromatogram was recorded with the aid of a D-2000 Chromato-Integrator at a chart speed of 1.25 mm/min.

RESULTS AND DISCUSSION

System 1

Figures 1(i) and *1(ii)* show typical chromatograms of palm oil and palm olein

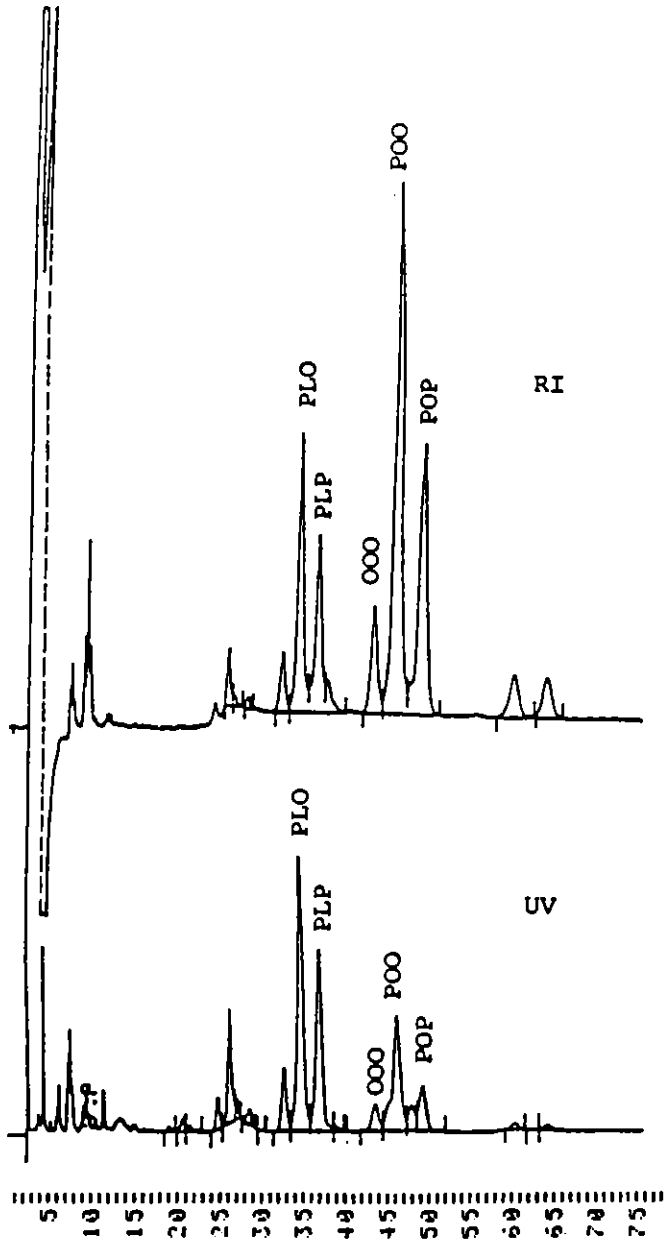

Figure. 1(ii): Chromatograms of High IV Olein
Column: 250 x 4 mm Superspher, RP 18 (4μm)
Detector: UV and RI (in series)
Mobile phase: Acetonitrile + 2-Propanol + Hexane
(65) (22) (13)

using acetone-free solvents with RI and UV detectors in series. One mobile phase was used with RI detection and, in the UV-transparent mobile phase, short-wavelength UV-detection was used in parallel with R1 detection. A tripalmitin peak, although clearly seen in the palm oil sample *(Figure 1(i))*, was absent in the superolein sample *(Figure 1(ii))*. Identification of the peaks was based on the individual triglycerides which were pure triglycerides.

System 2

Figures 2(i), 2(ii), 2(iii) and *2(iv)* show

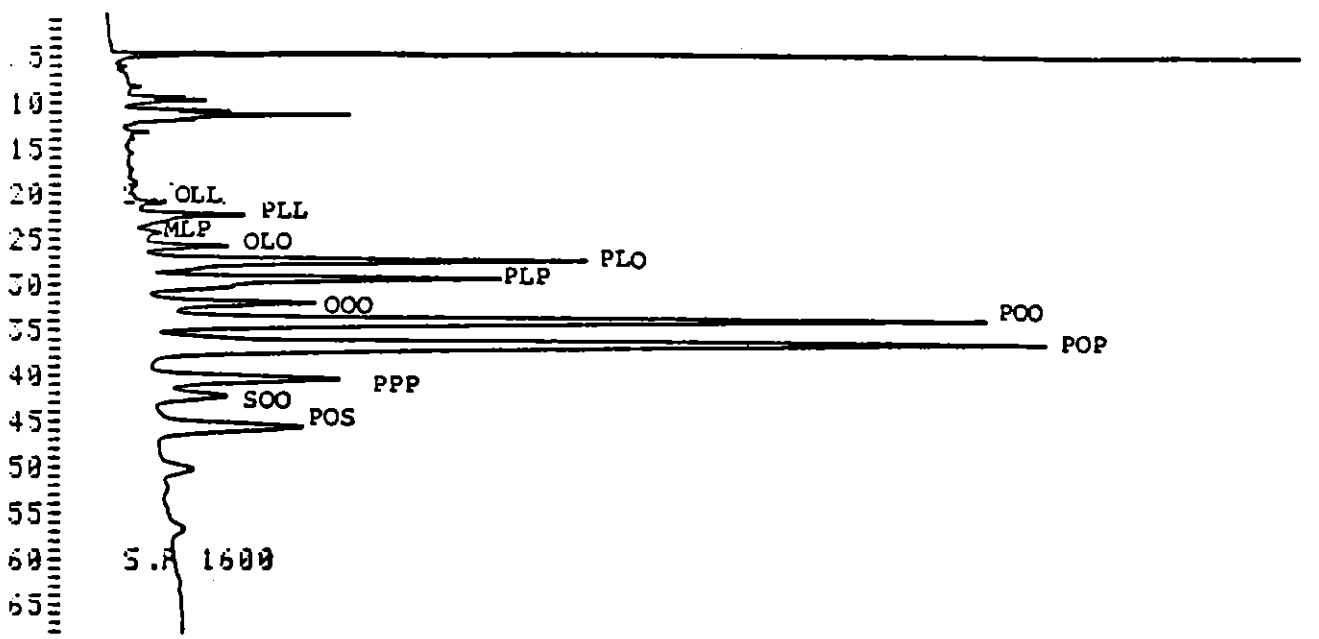

Figure 2 (i): HPLC Chromatogram of Refined Palm Oil
Column: LiChrospher 100 RP 18 (5 μm)
Detector: RI
Mobile phase: Acetone + Acetonitrile
(75) (25)

chromatograms of refined palm oil, palm olein, palm stearin and palm-mid fraction using acetone and acetonitrile (75:25) with RI detector. The peaks corresponded to the individual triglycerides.

Table 1 shows the peak area ratios of palm oil and its fractions using RI detector and a mobile phase of acetone and acetonitrile (75:25). The data on palm oil and palm stearin followed the same trend pointed out in an earlier paper

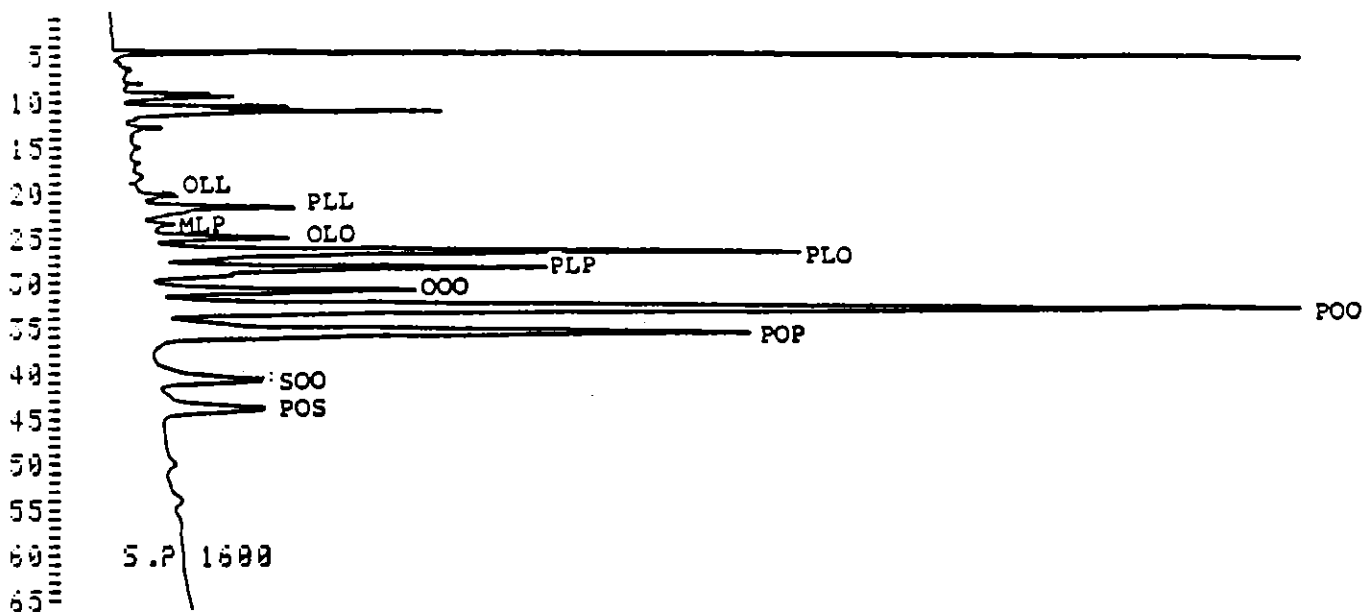

Figure 2(ii): HPLC Chromatogram of Refined Palm Olein
Column: LiChrospher 100 RP 18 (5μm)
Detector: RI
Mobile phase: Acetone + Acetonitrile
(75) (25)

(Aitzetmuller *et al.*, 1988).

The peak area ratios (OOO:PPP) for the palm mid fraction samples were between 1:0.63 and 1:1.53 while the POP:(PPP + OOO) ratios were between 4 to 8 *(Table 1)*. The analytical criterion of palm mid-fraction is defined by a C50/(C48 + C54) minimum value of 4 (Tan *et al.*, 1981). The above two samples would not be considered very good palm mid-fractions as a good cocoa butter substitute has a POP:(PPP + OOO) ratio of 22-35 (Deffense, 1985).

Tables 2 and *3* give data for the individual

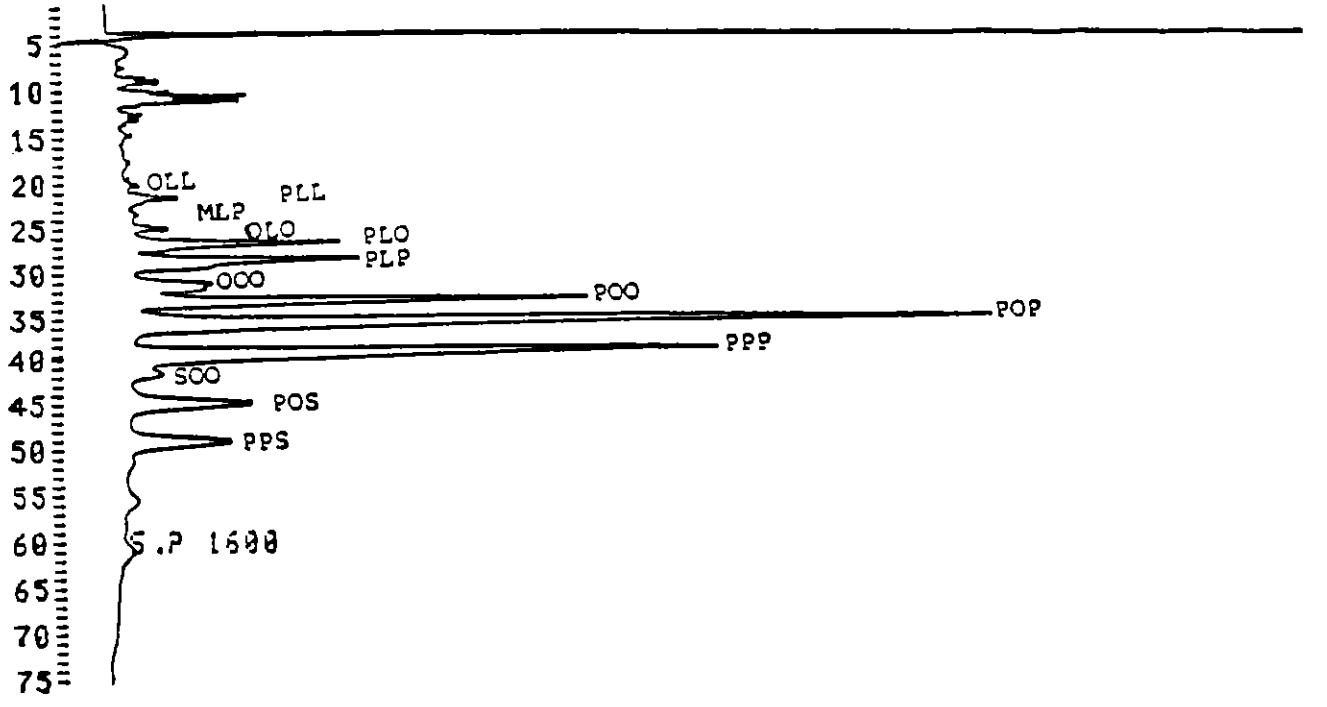

Figure 2(iii): HPLC Chromatogram of Refined Palm Stearin
Column: LiChrospher 100 RP 18 (5μm)
Detector: RI
Mobile phase: Acetone + Acetonitrile
(75) (25)

triglycerides in peak area ratio from the two different isocratic RI-systems. System 2 conformed to the IUPAC HPLC-method for triglycerides (Wolff, 1991). Because the refractive-index depends on the solvent used, there were slight differences in the peak area % between PPP and the highly unsaturated triacylglycerols in the two different RI-systems. The examples shown in *Tables 3* and *4* confirmed this although the differences were small.

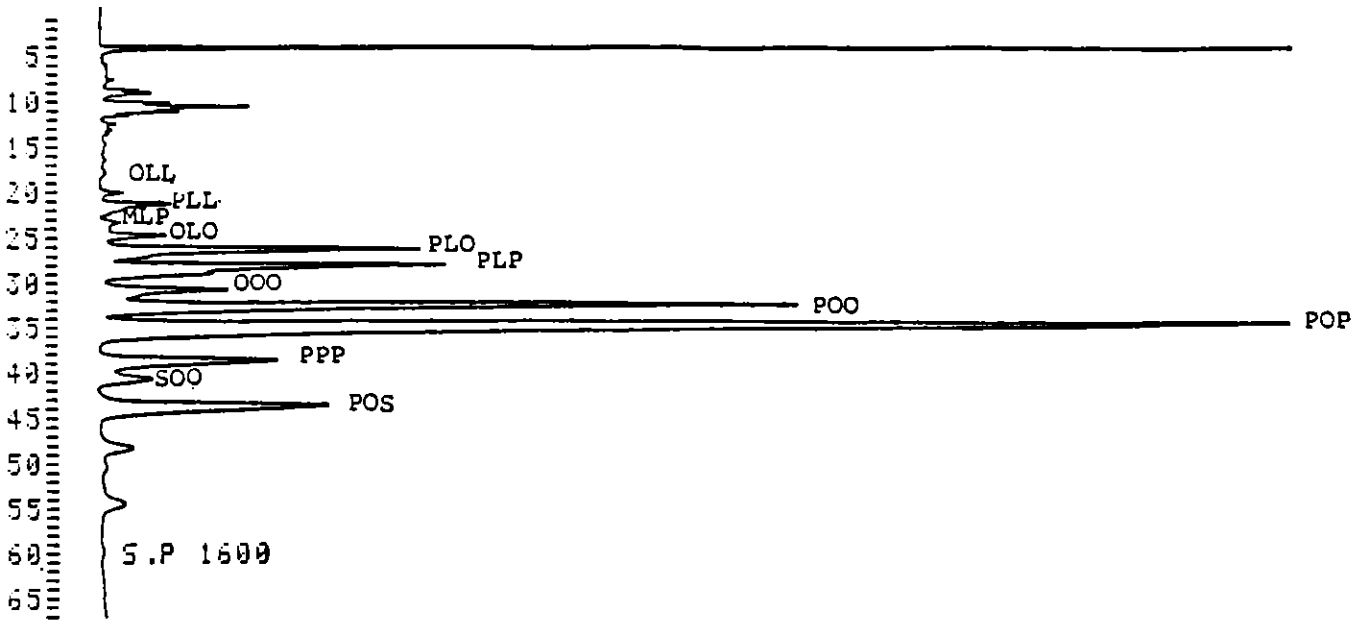

Figure 2(iv): HPLC Chromatogram of Refined Palm-Mid Fraction
Column: LiChrospher 100 RP 18 (5μm)
Detector: RI
Mobile phase: Acetone + Acetonitrile
(75) (25)

TABLE 1. PEAK AREA RATIOS OF TRIGLYCERIDES ON PALM OIL AND ITS FRACTIONS, AND PALM-MID FRACTIONS. SOLVENT SYSTEM: ACETONE + ACETONITRILE (75:25), DETECTOR: RI

Sample	Code	Peak Area Ratio								
		POP:PPP	POP:OOO	POP:(PPP+OOO)	POP:POO	OOO:PPP	OOO:PLO	PLO:PLP	POP / (PPP+OOO)	2 x PLP / OOO+PLO
Refined	4	1:0.00	1:0.24	1:0.24	1:1.46	1:0.00	1:2.89	1:0.79	4.25	1.19
Palm	5	1:0.00	1:0.24	1:0.24	1:1.37	1:0.00	1:2.59	1:0.73	4.18	1.06
Olein	6	1:0.00	1:0.37	1:0.37	1:1.03	1:0.00	1:2.62	1:0.66	2.70	0.96
IV > 60	7	1:0.00	1:0.31	1:0.31	1:1.70	1:0.00	1:2.48	1:0.69	3.28	0.98
	8	1:0.00	1:0.27	1:0.27	1:1.54	1:0.00	1:2.54	1:0.74	3.68	1.06
	9	1:0.00	1:0.36	1:0.36	1:1.95	1:0.00	1:2.54	1:0.65	2.77	0.94
	11	1:0.00	1:0.19	1:0.19	1:1.18	1:0.00	1:2.72	1:0.79	5.24	1.16
	12	1:0.00	1:0.21	1:0.21	1:1.26	1:0.00	1:2.66	1:0.76	4.79	1.11
	14	1:0.00	1:0.23	1:0.23	1:1.40	1:0.00	1:2.77	1:0.78	4.32	1.14
	15	1:0.00	1:0.22	1:0.22	1:1.28	1:0.00	1:2.45	1:0.94	4.43	1.09
	16	1:0.00	1:0.22	1:0.23	1:1.28	1:0.05	1:2.21	1:0.99	4.63	1.08
	17	1:0.00	1:0.42	1:0.42	1:1.13	1:0.00	1:2.18	1:0.75	2.89	0.89
	18	1:0.00	1:0.19	1:0.19	1:1.19	1:0.00	1:2.71	1:1.02	5.15	1.16
	19	1:0.00	1:0.12	1:0.13	1:1.86	1:0.00	1:2.37	1:1.13	7.01	1.29
	20	1:0.00	1:0.32	1:0.32	1:1.17	1:0.00	1:2.21	1:0.85	3.16	0.97
Average		1:0.00	1.0.26	1:0.26	1:1.39	1:0.03	1:2.52	1:0.82	4.16	1.07
Min		1:0.00	1:0.12	1:0.13	1:1.03	1:0.00	1:2.18	1:0.65	2.70	0.89
Max		1:0.00	1:0.42	1:0.42	1:1.70	1:0.05	1:2.89	1:1.13	5.24	1.29
Palm-Mid	1	1:0.10	1:0.08	1:0.21	1:1.40	1:1.53	1:2.08	1:1.34	4.79	1.81
Fraction	2	1:0.10	1:0.08	1:0.12	1:1.41	1:0.63	1:2.29	1:1.40	8.09	1.77
Average		1:0.10	1.0.08	1:0.16	1:1.41	1:1.08	1:2.18	1:1.37	6.44	1.79
Min		1:0.10	1:0.08	1:0.12	1:1.40	1:1.53	1:2.08	1:1.34	4.79	1.77
Max		1:0.10	1:0:08	1:0.21	1:1.41	1:0.63	1:2.29	1:1.40	9.09	1.81

Cont.

TABLE 1 (Continued)

Sample	Code	Peak Area Ratio								
		POP:PPP	POP:OOO	POP:(PPP+OOO)	POP:POO	OOO:PPP	OOO:PLO	PLO:PLP	$\frac{POP}{(PPP+OOO)}$	$\frac{2 \times PLP}{OOO+PLO}$
Refined	60	1:0.82	1:0.12	1:0.94	1:1.35	1:6.89	1:1.28	1:1.51	1.06	1.69
Palm	61	1:0.71	1:0.14	1:0.85	1:1.51	1:5.18	1:1.58	1:1.19	1.18	1.46
Stearin	62	1:0.85	1:0.12	1:0.97	1:1.44	1:6.99	1:1.53	1:1.35	1.03	1.63
	64	1:0.69	1:0.14	1:0.82	1:1.44	1:5.08	1:1.49	1:1.33	1.22	1.59
	65	1:0.53	1:0.13	1:0.66	1:1.49	1:4.09	1:1.78	1:1.22	1.51	0.85
Average		1:0.75	1.0.13	1:0.84	1:1.45	1:5.65	1:1.53	1:1.32	1.2	1.44
Min		1:0.53	1:0.12	1:0.66	1:1.35	1:5.08	1:1.28	1:1.19	1.03	0.85
Max		1:0.85	1:0:14	1:0.97	1:1.51	1:6.99	1:1.78	1:1.51	1.51	1.69
Refined	55	1:0.19	1:0.15	1:0.34	1:1.78	1:1.31	1:2.37	1:0.93	2.91	1.32
Palm	56	1:0.21	1:0.12	1:0.33	1:1.77	1:1.76	1:2.76	1:0.98	3.02	1.44
Oil	57	1:0.20	1:0.12	1:0.33	1:1.74	1:1.62	1:2.65	1:0.97	3.07	1.40
	58	1:0.19	1:0.12	1:0.31	1:1.75	1:1.52	1:2.87	1:0.95	3.18	1.41
	59	1:0.18	1:0.11	1:0.29	1:1.74	1:1.66	1:2.95	1:0.97	3.39	1.45
Average		1:0.19	1.0.12	1:0.32	1:1.76	1:1.57	1:2.72	1:0.96	3.11	1.40
Min		1:0.18	1:0.11	1:0.29	1:1.74	1:1.31	1:2.37	1:0.93	2.91	1.32
Max		1:0.21	1:0:15	1:0.34	1:1.78	1:1.76	1:2.95	1:0.98	3.39	1.45

P,O,L refers to palmitic, oleic, linoleic acids respectively. The triglyceride symbols refer to the sum of all the triglycerides with the three acyl groups (*i.e.* 3 positional isomers or 6 stereo isomers).

TABLE 2. PEAK AREA % OF INDIVIDUAL TRIGLYCERIDES IN PALM OLEIN AND PALM MID-FRACTIONS USING R1 DETECTOR SOLVENT USED: ACETONITRILE + 2-PROPONAL + HEXANE (65:22:13)

Sample	Code	OLL	PLL	MLP	OLO	PLO	PLP	OOO	POO	POP	PPP	SOO	POS	Others
Refined Palm Olein	4	1.18	3.74	0.89	2.29	14.10	12.31	5.05	31.99	21.70	-	3.02	3.72	0.01
IV > 60	5	1.21	4.06	1.21	2.43	12.70	12.20	5.29	30.75	22.39	-	3.39	4.35	0.02
	6	0.80	4.40	1.13	3.74	14.84	11.85	5.92	35.20	16.56	-	3.75	2.81	nil
	7	0.55	2.87	0.57	2.67	14.81	11.26	5.93	34.62	19.34	-	3.89	3.50	nil
	8	0.72	3.70	0.90	2.31	13.18	11.74	5.70	33.75	20.80	-	3.57	3.53	nil
	9	0.78	3.92	1.07	2.52	14.80	11.55	6.28	35.29	18.09	-	3.14	2.56	nil
	11	0.90	2.77	0.76	1.72	11.58	11.55	4.79	30.77	25.87	0.25	3.85	5.17	0.02
	12	0.85	3.26	0.53	2.24	12.97	11.08	5.03	31.53	25.67	-	2.99	3.86	0.08
	13	1.87	3.73	0.90	2.57	10.15	10.82	5.60	27.81	30.13	-	2.52	3.91	nil
	14	1.67	3.95	1.11	2.17	13.93	10.79	5.14	32.22	22.07	-	3.42	3.53	nil
	15	0.93	2.96	0.55	2.34	12.92	12.20	5.28	30.97	24.23	-	2.62	3.82	1.18
	16	0.75	2.31	0.88	2.19	12.23	12.09	5.53	31.56	24.74	0.25	2.95	4.05	0.47
	17	0.81	5.11	0.61	2.96	14.76	11.00	6.77	34.68	16.31	-	3.67	2.32	1.0
	18	0.45	3.88	0.90	2.13	12.71	12.97	4.69	30.14	25.24	-	2.69	4.20	nil
	19	0.38	2.35	0.76	1.78	10.34	11.64	4.36	28.04	32.51	-	2.72	5.51	nil
	20	0.58	2.13	0.39	2.7	13.94	11.89	6.31	35.22	19.93	-	3.96	3.51	nil
Average		0.90	3.45	0.82	2.42	13.12	11.68	5.48	32.16	22.85	0.25	3.26	3.77	0.17
Min		0.38	2.13	0.39	1.72	10.15	10.79	4.36	27.81	16.31	-	2.62	2.32	0.01
Max		1.87	5.11	1.21	3.74	14.84	12.97	6.77	35.29	32.51	-	3.96	5.51	1.18
Palm-Mid Fraction	2	0.35	1.73	0.41	1.05	6.12	9.42	2.69	17.24	46.76	2.32	1.87	8.36	1.68
	1	0.63	3.06	1.12	1.14	6.31	10.51	2.72	16.75	42.42	4.42	1.68	7.80	1.44
Average		0.49	2.39	0.77	1.09	6.21	9.96	2.70	17.00	44.59	3.37	1.76	8.08	1.56
Min		0.35	1.73	0.41	1.05	6.12	9.42	2.69	16.75	42.42	2.32	1.68	7.80	1.44
Max		0.63	3.06	1.12	1.14	6.31	10.51	2.72	17.24	46.76	4.42	1.87	8.36	1.68

TABLE 3. PEAK AREA % OF INDIVIDUAL TRIGLYCERIDES IN PALM OIL AND ITS FRACTIONS USING R1 DETECTOR
SOLVENT USED: ACETONE + ACETONITRILE (75:25)

Sample	Code	OLL	PLL	MLP	OLO	PLO	PLP	OOO	POO	POP	PPP	SOO	POS	Others
Refined Palm Olein	4	0.61	3.61	0.73	2.26	14.61	11.67	5.05	31.26	21.43	-	3.34	3.88	1.55
IV > 60	5	0.70	3.27	0.37	2.33	14.15	10.40	5.46	31.18	22.81	-	3.73	4.52	1.08
	6	0.80	3.98	0.59	3.19	16.04	10.64	6.13	33.68	16.53	-	4.24	3.17	1.01
	7	0.70	3.56	0.85	2.80	14.88	10.27	6.00	33.40	19.66	-	3.48	3.76	0.64
	8	0.65	3.31	0.50	2.42	14.50	10.66	5.70	32.34	20.97	-	4.00	3.83	1.12
	9	0.91	3.86	0.60	3.16	15.98	10.44	6.30	34.06	17.38	-	3.96	2.64	0.79
	11	0.53	3.82	0.50	2.07	13.02	10.32	4.78	29.45	25.02	-	4.43	5.20	1.86
	12	0.45	2.16	0.75	2.23	13.59	10.41	5.11	30.91	24.45	-	3.83	4.42	1.69
	14	0.55	3.47	0.78	2.32	14.27	11.11	5.15	31.12	22.23	-	3.65	4.34	1.01
	15	0.78	3.26	0.49	2.47	13.90	10.43	5.25	30.25	23.25	-	3.81	4.28	1.83
	16	0.64	2.30	0.85	2.49	13.62	10.21	5.31	30.97	24.60	-	3.57	4.10	1.34
	17	1.28	4.27	0.49	3.12	16.11	9.80	5.89	34.42	16.98	-	4.20	2.80	0.64
	19	0.37	2.19	0.37	1.76	11.37	10.21	4.43	27.44	31.06	-	3.86	5.89	1.05
	20	0.61	3.27	0.53	2.90	14.70	10.03	6.07	33.58	19.14	-	4.35	3.92	0.90
	21	0.60	3.31	0.55	2.44	14.50	10.34	6.22	34.42	19.32	-	3.91	3.36	1.03
Average		0.68	3.31	0.60	2.53	14.35	10.46	5.52	31.90	21.65	-	3.89	4.01	1.17
Min		0.37	2.16	0.37	1.76	11.37	9.80	4.43	27.44	17.38	-	3.34	2.64	0.64
Max		1.28	4.27	0.85	3.19	16.11	11.67	6.30	34.42	31.06	-	4.43	5.89	1.89
Palm-Mid Fraction	1	0.32	1.75	0.57	1.36	7.64	10.71	3.33	18.00	44.24	2.13	1.80	7.84	0.31
	2	0.24	1.51	0.32	1.22	7.18	9.61	3.46	16.91	42.01	5.31	1.81	7.90	2.52
Average		0.28	1.63	0.45	1.29	7.41	10.16	3.40	17.46	43.13	3.72	1.81	7.87	1.42
Min		0.24	1.51	0.32	1.22	7.18	9.61	3.33	16.91	42.01	2.13	1.80	7.84	0.31
Max		1.32	1.75	0.57	1.36	7.64	10.71	3.46	18.00	44.24	5.31	1.81	7.90	2.52
Refined Palm Oil	55	0.44	3.51	0.60	1.75	10.64	9.94	4.49	23.57	30.14	5.86	2.46	5.36	2.24
	56	0.42	2.46	0.13	1.62	10.06	9.82	3.64	23.45	30.31	6.39	2.85	5.79	3.06
	57	0.41	2.33	0.40	1.62	10.20	9.86	3.85	23.00	30.97	6.24	2.41	5.71	3.00
	58	0.63	2.66	0.42	1.91	10.76	10.20	3.75	22.67	30.08	5.72	2.61	5.83	2.76
	59	0.52	2.52	0.33	1.41	10.27	9.95	3.48	23.42	31.46	5.78	2.51	5.78	2.57
Average		0.48	2.70	0.38	1.66	10.39	9.95	3.84	23.22	30.59	6.00	2.57	5.79	2.73
Min		0.41	2.33	0.13	1.41	10.06	9.82	3.48	22.67	30.08	5.72	2.41	5.36	2.24
Max		0.63	3.51	0.60	1.91	10.76	10.20	4.49	23.57	31.46	6.39	2.85	5.83	3.06

Of course, area % data cannot be used in short wavelength UV-detection. The usefulness of UV detection is seen in the samples with unsaturated triglycerides (PLO, PLP) where the peaks with a UV detector were three times higher than the peaks shown by the RI detector. This sensitivity of UV detection of unsaturated triglycerides is useful in the identification of peak components of a sample.

It was noted, however, that high IV olein differed from normal olein in having a OOO : PPP area peak ratio of 1:0 compared to 1:0.09-1:0.35 (Aitzetmuller *et al.*, 1988). This indicated that tripalmitin had been completely removed from the oleins by fractionation.

Peak area ratios between triglycerides were also useful for identifying samples contaminated with other oils. We attempted to detect an admixture of 5% stearin in palm oil *(Table 4)*. Although only a few samples were done, the experiment showed promising results as the OOO:PPP ratios of the admixtures were out of the range for palm oil, being 10 times higher than those of the palm oil samples. Peak area ratios of PLP with PLO and OOO in the admixtures were 9 times higher.

Such results can be obtained quickly by HPLC, and can be used to characterize palm oil and its fractions. Sample preparation is minimal - the oils are diluted in 2-propanol and, if the solution is not clear, filtration may be required.

TABLE 4. PEAK AREA RATIOS OF REFINED PALM OIL WITH 5% PALM STEARIN SOLVENT: ACETONE + ACETONITRILE (75:25)

Sample	Code	Ratio OOO:PPP	Ratio POP / PPP + OOO	Ratio 2 x PLP / OOO + PLO
Refined palm oil + 5% refined palm stearin	66	1:1.80	3.03	1.41
	67	1:1.91	2.85	1.43
	68	1:1.97	2.94	1.43
	69	1:1.99	2.78	1.39

TABLE 5. PEAK AREA RATIOS OF REFINED PALM OIL SOLVENT SYSTEM: ACETONE + ACETONITRILE (75:25)

Sample	Code	Ratio OOO:PPP	Ratio POP / PPP + OOO	Ratio 2 x PLP / OOO + PLO
Refined palm oil	55	1:0.19	2.91	0.66
	56	1:0.21	3.02	0.72
	57	1:0.20	3.07	0.70
	58	1:0.19	3.18	0.70
	59	1:0.18	3.40	0.72

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