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Physicochemical characteristics of palm oil and sunflower oil blends fractionated at different temperatures

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Abstract

This research was carried out to determine the effect of fractionation temperature on the physicochemical characteristics of refined, bleached and deodorized (RBD) palm oil and sunflower oil blends fractionated at different temperatures. Blends of 20% and 40% sunflower oil with 80% and 60% RBD palm oil, respectively, were fractionated at three different temperatures (15, 18 and 21 °C). The results showed that olein with higher iodine value was obtained at lower fractionation temperature. This was because, at lower fractionation temperature, more of the polyunsaturated fatty acid, namely linoleic acid (C18:2), went into the liquid fraction. On the other hand, more of the saturated fatty acid, namely palmitic acid (C16:0), went into the liquid fraction at higher fractionation temperature. Blending reduced the triacylglycerol composition, namely POP, POS, SOO and PLP, while OLO, PLL, OLL and LLL/LLnO increased. Lower fractionation temperature decreased the composition of monosaturated triacylglycerol and increased the composition of di- and polyunsaturated triacylglycerols. Lower fractionation temperature produced a liquid fraction with lower solid fat content and lower cloud point than did higher fractionation temperature.

Keywords: Blending; Sunflower oil; Palm oil; Fractionation

1. Introduction

Palm oil is widely used in various food products, such as margarines, shortenings, cooking oils, confectionery fats and vanaspati. Its versatility for different food applications is due to its chemical composition. Modern physical and chemical process have enhanced this versatility by modifying the composition of palm oil and hence, its properties. Palm oil is a semi-solid fat at room temperature and can be easily separated into two fractions by partial crystallization in a liquid phase.

To produce a quality edible oil, the refined product is required to undergo fractionation to separate oil into two fractions, namely olein (liquid fraction) and stearin (solid fraction). Fractionation is based on the difference of melting points of triacylglycerides. There are three types of fractionation process, namely dry, solvent and detergent fractionation. The dry fractionation is the simplest and most economical separation technique. In the dry fractionation process, the oil as such is partially crystallized by fractionating the melt in a controlled manner at the desired temperature, after which the remaining liquid is separated from the solid fraction by means of a vacuum filter or membrane filter press.

In temperate countries, palm olein tends to crystallize during winter when temperature is low. It has been

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observed that blending palm olein with vegetables oils with higher degrees of unsaturation, resulted in blends that are more stable (do not crystallize easily) at low temperatures. The blends stay clear for a longer period of time (Nor Aini, Hanirah, Flingoh, & Noraini, 1992; Mahmoud, Rady, & El-Egieul, 1996).

Oils and fats used for commercial frying applications must be stabilized to prevent any changes caused by oxidation, polymerization or hydrolysis during high temperature use. Modifying the fatty acid composition of the oil is the most common method used to stabilize the frying oil. Blending polyunsaturated oil with more saturated or monosaturated oils is an option to adjust fatty acid levels to optimal level, such as combining high-oleic sunflower oil with corn oil or hydrogenated soybean oil with soybean oil (Frankel & Huang, 1994; Moulton, Beal, Warner, & Boundy, 1975) or combining palm-olein with sunflower oil (Nor Aini, Hanirah, & Tang, 1996).

2. Materials and methods

2.1. Oils

Palm oil of iodine value (IV) 53 was obtained from a local refinery. Sunflower oil was supplied by Epic Product Sdn. Bhd. Shah Alam, Selangor Malaysia.

2.2. Fractionation process

Blends (2500 g) were fractionated in the laboratory by a dry fractionation process (Fig. 1). The oil was blended in the following proportions: (A) 80% RBD palm oil with 20% sunflower oil, and (B) 60% RBD palm oil with 40% sunflower oil. The oil blends were heated to 70 °C to destroy any crystals present. The oil blends were agitated at 12.0 ± 0.1 rpm to keep them homogenized and to prevent any settlement at the bottom of the vessel. Three fractionation temperatures were used, namely 15, 18 and 21 °C. Crystals formed as the sample was cooled. The fractionation process was stopped when the respective temperatures were reached. Two fractions were obtained, namely stearin (solid) and olein (liquid). They were separated by vacuum filtration. The liquid fraction was collected in a 500 ml flask for a period of 2 h. Table 1 shows the coding used for the samples and the sample descriptions.

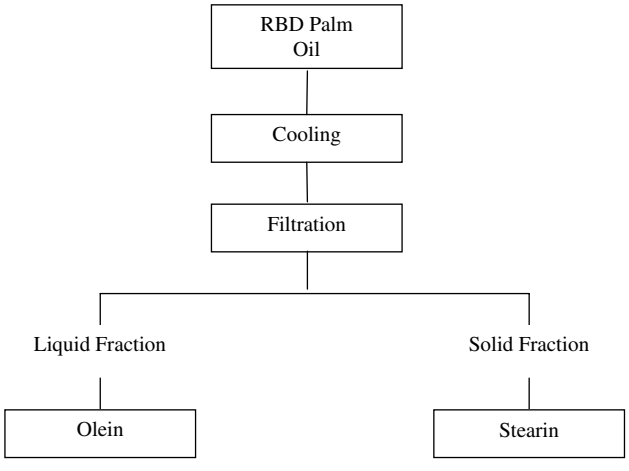

Fig. 1. Flow chart of dry fractionation (*Source*: Thiagarajah, 1992).

2.3. Evaluation and analyses

2.3.1. Iodine value

Iodine value was determined according to the PORIM test method (1995). In this analysis, cyclohexane was used in place of chloroform.

2.3.2. Fatty acid composition

Fatty acid compositions were determined as fatty acid methyl esters (FAME). The oil (0.05 g) was weighed and dissolved in 1 ml of hexane, in a 2 ml screw-capped vial. Sodium methoxide solution (0.2 ml; 2 M $NaOCH_3$ in anhydrous methanol) was added and then mixed for 1 min using a vortex mixer. After sedimentation of sodium glycerolate, 1 μl of the clear supernatant was injected into a SGE-BPX70 polar silica column (60×0.32 μm) and analyzed by using a Shidmazu-17A (Kyoto, Japan) gas chromatograph, equipped with a flame ionization detector (FID) and a C-R6A Chromatopac integrator. The oven temperature was programmed in two stages as follows: first from 50 °C to 180 °C (8 °C/min), and then from 180 °C to 200 °C (5 °C/min). The carrier gas (helium) flow rate was 6.8 ml/min. Correction responses factors were determined by analysis of a RM-5 standard mixture of FAME (Supelco-Cat. No:4 -7024, Tokyo, Japan).

2.3.3. Triacylglycerol composition

The identification of triacylglycerol was achieved using a high performance liquid chromatograph (HPLC), model 510, equipped with differential refractometer, Model 410, as the detector (Millipore Corporation, Milford, MA). The triacylglycerols were separated on a Merck Lichrosphere RP-18 Column (250 mm × 4 mm, particle size 5 μm) (Darmstadt, Germany). During analysis, the column was maintained at 45 °C. The mobile phase was acetone/acetonitrile at a ratio of 70:30 (vol/vol) and a flow rate of 1 ml/min. Triacylglycerols were separated according to their degree of unsaturation and molecular weight. Triacylglycerol peaks were identified by retention times of TAG standards (Sigma Chemical Co. USA).

Table 1
Sample codes at different ratios of blends

Sample code	Sample description	Fractionation temperature (°C)
A-15	80% RBD palm oil + 20% sunflower oil	15
A-18	80% RBD palm oil + 20% sunflower oil	18
A-21	80% RBD palm oil + 20% sunflower oil	21
B-15	60% RBD palm oil + 40% sunflower oil	15
B-18	60% RBD palm oil + 40% sunflower oil	18
B-21	60% RBD palm oil + 40% sunflower oil	21

A-80% RBD palm oil with 20% sunflower oil.
B-80% RBD palm oil with 20% sunflower oil.

2.3.4. Solid fat content

The solid fat contents of the samples were measured using a Bruker Minispec pNMR Analyzer Model No.120 (Rheinstetten, Germany). The non-stabilized procedure was applied according to the PORIM test method (1995). The sample in the NMR tube was melted at 70–80 °C for 30 min and then chilled at 0 °C for 90 min before being held at each measuring temperature for 30 min, prior to being measured (0, 5, 10 and 15 °C).

2.3.5. Cloud point

Cloud point was determined according to AOCS test method, Cc 6-25 (1989).

3. Results and discussion

Fig. 2 shows iodine values (IV) of the liquid fractions obtained after fractionating blends of 80% RBD palm oil with 20% sunflower oil and 60% RBD palm oil with 40% sunflower oil at three different temperatures (15, 18 and 21 °C). The iodine value is a measure of the

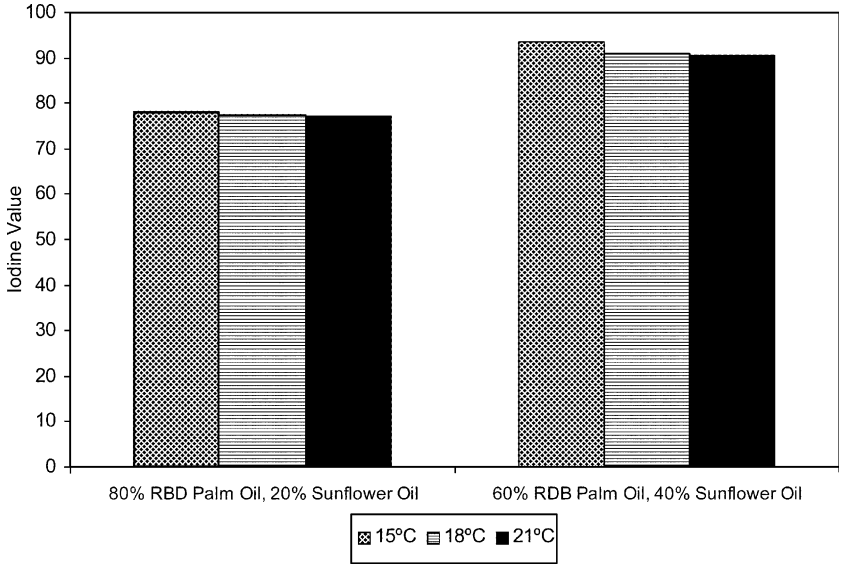

Fig. 2. Iodine values of the liquid fraction obtained after fractioning blends of RBD palm oil and sunflower oil at 15, 18 and 21 °C.

Table 2
Fatty acid compositions of the liquid fraction obtained after fractioning blends of RBD palm oil and sunflower oil at 15, 18 and 21 °C

Fatty acid composition	Fractionation temperature (°C)					
	SFA[a]			SFB[a]		
	15	18	21	15	18	21
C12:0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0
C14:0	0.8 ± 0.0	0.8 ± 0.0	0.8 ± 0.0	0.6 ± 0.0	0.6 ± 0.0	0.6 ± 0.0
C16:0	30.6 ± 0.1	31.1 ± 0.2	32.0 ± 0.1	23.7 ± 0.2	24.8 ± 0.1	25.1 ± 0.1
C16:1	0.2 ± 0.0	0.8 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	0.1 ± 0.0
C18:0	3.8 ± 0.0	3.8 ± 0.0	3.8 ± 0.0	3.6 ± 0.0	3.7 ± 0.0	3.7 ± 0.0
C18:1	38.4 ± 0.1	38.2 ± 0.3	38.1 ± 0.1	34.4 ± 0.2	34.4 ± 0.1	34.4 ± 0.2
C18:2	24.9 ± 0.2	24.6 ± 0.1	23.8 ± 0.0	36.2 ± 0.1	35.1 ± 0.2	34.8 ± 0.2
C18:3	0.8 ± 0.0	0.8 ± 0.1	0.7 ± 0.0	0.9 ± 0.0	0.8 ± 0.0	0.9 ± 0.0
C20:0	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0

[a] Means of duplicate samples.

Table 3
Triacylglycerol compositions of the liquid fraction obtained after fractioning blends of (A) 80% RBD palm oil with 20% sunflower oil and (B) 80% RBD palm oil with 20% sunflower oil at 15, 18 and 21 °C

Sample	Iodine value	Trisaturated		Monounsaturated			Diunsaturated			Polyunsaturated							
		PPP	PPS	POP	POS	SOS	POO	SOO	MLP	PLP	OOO	PLO	OLO	PLL	OLL	LLnP	LLL/ LLnO	LLnL
Palm oil	52.0	5.39	0.93	31.4	5.24	0.40	23.7	2.38	2.57	10.43	4.17	10.4	1.61	0.50	0.36	–	–	–
A-15	78.2	–	–	21.7	3.82	0.51	22.7	2.57	0.40	8.70	4.15	12.2	4.35	4.99	7.05	0.31	6.27	0.52
A-18	77.5	0.04	–	22.5	3.83	0.47	22.3	2.60	0.41	8.73	4.10	12.1	4.28	4.94	6.96	0.31	6.19	0.51
A-21	77.2	0.33	–	23.9	4.07	0.78	22.0	2.56	0.41	8.80	4.07	11.7	4.09	4.70	6.52	0.28	5.77	0.47
B-15	93.6	0.28	–	15.3	2.74	0.62	17.1	2.20	0.28	6.36	4.02	11.9	6.69	6.52	13.2	0.40	12.0	0.78
B-18	90.7	0.31	–	17.3	3.08	0.77	16.8	2.03	0.27	6.37	3.91	11.5	6.53	6.20	13.0	0.32	11.6	0.62
B-21	90.6	0.48	–	17.5	3.12	0.24	16.7	2.13	0.29	6.51	3.90	11.5	6.36	6.30	12.6	0.40	11.5	0.77

A-80% RBD palm oil with 20% sunflower oil.
B-80% RBD palm oil with 20% sunflower oil.

unsaturation of fats and oils. It is one of the parameters used to measure the quality of the olein (Haryati, Che Man, Ghazali, Asbi, & Buana, 1998). This study showed that the liquid fraction, obtained after fractionating a blend of 60% RBD palm oil with 40% sunflower oil, had higher IV than the other liquid fraction obtained after fractionating a blend of 80% RBD palm oil with 20% sunflower oil. The olein fraction obtained by fractionation at lower temperatures contained more unsaturated fatty acids which contributed to its higher IV than the one fractionated at higher temperature.

Fractionation produced olein containing less saturated fatty acids than unsaturated fatty acids. Saturated fatty acids consisted of five types of fatty acids, namely lauric (C12:0), myristic (C14:0), palmitic (C16:0), stearic (C18:0) and arachidonic (C20:0) acids, while unsaturated fatty acids consisted of three major fatty acids, namely oleic (C18:1), linoleic (C18:2), and linolenic (C18:3) acids. Other fatty acids were also present but in small amounts. Lower fractionation temperature resulted in the olein having less of the saturated fatty acids and more of the unsaturated fatty acids than at higher fractionation temperatures.

At a fractionation temperature of 15 °C, the major fatty acids in olein obtained after fractionating a blend of 80% RBD palm oil with 20% sunflower oil were palmitic (30.6%), oleic (38.4%) and linoleic (24.9%). At 18 °C, there was an increase in palmitic acid (31.1%), while oleic and linoleic acids were reduced to 38.2–24.6%, respectively. Olein fractionated at 21 °C contained the highest amount of palmitic acid (32.0%). There were decreases in the amounts of oleic acid (38.1%) and linoleic acid (23.8%) (Table 2). Oleins obtained after fractioning a blend of 60% RBD palm oil with 40% sunflower oil contained less saturated fatty acids, namely palmitic and stearic acids. On the other hand, they contained more of the monounsaturated fatty aid (oleic) and polyunsaturated fatty acid (linoleic) than did the former sample.

RBD palm oil contained high amounts of POP (31.4%) and POO (23.7%) triacylglycerols. It contained considerable amounts of PLP (10.4%), PLO (10.4%) and POS (5.24%). The amounts of OLO, PLL and OLL triacylglycerols were low in the RBD palm oil. Blending RBD palm oil with sunflower oil, followed by fractionation of the mixture, resulted in decreases in the amounts of POP, POS and PLP in the liquid fractions. On the other hand, the amounts of PLO, OLO, PLL and OLL in the liquid fractions increased. After fractionation, the blend containing 80% RBD palm oil and 20% sunflower oil produced liquid fractions which were richer in POP (21.7–23.9%), POS (3.82–4.07%), POO (22.7–22%), PLP (8.70–8.80%) than was the blend containing 60% RBD palm oil with 40% sunflower oil (Table 3). The study also showed that lower fractionation temperature resulted in lower

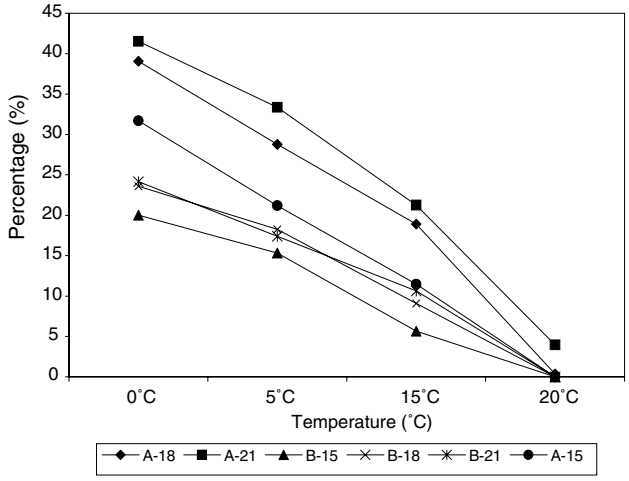

Fig. 3. Solid fat content of the liquid fraction obtained after fractioning blends of (A) 80% RBD palm oil with 20% sunflower oil and (B) 80% RBD palm oil with 20% sunflower oil at 15, 18 and 21 °C.

amounts of saturated triacylglycerols and of the di- as well as polyunsaturated triacylglycerols in the liquid fractions (Table 3).

Mohd Zaki, Nik Meriam, and Sivaruby (1997) reported that the higher content of unsaturated triacylglycerols, such as POO, would improve the resistance to clouding of the liquid fraction (olein). They also reported that the absence of PPS and MPP triacylglycerols also helped protect the olein against clouding.

Fig. 3 shows the solid fat of samples fractionated at three different fractionation temperatures. The solid fat content can be used as a useful tool to compare the resistance of the olein against crystallization at lower temperature. Products with lower solid fat content at sub-ambient temperature (such as 5 °C or lower) will have better cold stability than those with higher solid fat content at the same temperature. Fractionation at 15 °C produced olein with lower solid fat content than at 18 and 21 °C. This was due to the fact that, at lower fractionation temperature, more stearins would be formed in the slurry and this would reduce the content of saturated triacylglycerols in the olein. The amounts of crystals formed at different temperatures were related to the iodine value of the oil.

The cloud point is a typical physical parameter. It is applied to oleins in order to determine the resistance against crystallisation and hence to get a quick estimation of their cold stability (Kellens, 1993). Table 4 shows the cloud points and they ranged from 2.9 to 5.7 °C. Hasmadi, NorAini, and Mamot (2002) reported that cloud points of palm olein obtained by fractionating 100% RBD palm oil at 15, 18 and 21 °C ranged from 7.8 to 8.9 °C. In this study, results showed that blending RBD palm oil with sunflower oil, followed by fractionation, improved the cloud point of the liquid fraction.

Table 4
Cloud point of the liquid fraction obtained after fractioning blends of (A) 80% RBD palm oil with 20% sunflower oil and (B) 80% RBD palm oil with 20% sunflower oil at 15, 18 and 21 °C

Samples	Cloud point[a] (°C)
A-15	5.7 ± 0.1
A-18	6.2 ± 0.1
A-21	6.6 ± 0.1
B-15	2.9 ± 0.0
B-18	3.5 ± 0.1
B-21	3.7 ± 0.1

[a] Means of duplicate samples.

4. Conclusion

The study has shown that lower fractionation temperature produced a liquid fraction (olein) with higher iodine value, due to reduction in the amount of palmitic acid (C16:0) and increases in the amounts of oleic acid (C18:1) and linoleic acid (C18:2). Blending RBD palm oil with sunflower oil changed the triacylglycerol compositions and resulted in lower amounts of monounsaturated triacylglycerols, namely POP and POS, as well as SOO and PLP. On the other hand, amounts of di- and polyunsaturated triacylglycerols, namely OLO, PLL, OLL and LLL/LLnO, increased. The changes in the chemical compositions influenced physical characteristics of the oleins such as their solid fat contents and cloud points.

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References

AOCS (1989). In R. E. Walker (Ed.), *Official methods and recommended practices of the American Oil Chemist's Society*. (4th ed.). American Oil Chemist's Society Champaign.

Frankel, E. N., & Huang, S. W. (1994). Improving the oxidative stability of polyunsaturated vegetables oils by blending with high-oleic sunflower oil. *Journal of American Oil Chemists' Society, 71*, 255–259.

Haryati, T., Che Man, Y. B., Ghazali, H. M., Asbi, B. A., & Buana, L. (1998). Determination of iodine value of palm oil based on triglyceride composition. *Journal of American Oil Chemists' Society, 75*, 789–792.

Hasmadi, M., NorAini, I., & Mamot, S. (2002). The effect of different types of stirrer and fractionation temperatures during fractionation on the yield, characteristics and quality of oleins. *Journal of Food Lipids, 9*(4), 295–307.

Kellens, M. (1993). *New developments in the fractionation of palm oil. 1993 PORIM international palm oil congress – update and vision*

(Chemistry & Technology). Malaysia: Ministry of Primary Industries, pp. 335–345.

Mahmoud, M. M., Rady, A. H., Faried A., & El-Egieul, A. (1996). Blending of palm olein with cottonseed oil. In *Proceedings of the 1996 PORIM international palm oil Congress (Chemistry & Technology)* (pp. 286–300).

Mohd Zaki, S., Nik Meriam, S., & Sivaruby, K. (1997). Triacylglycerols responsible for the onset of nucleation during clouding of palm olein. *Journal of American Oil Chemists' Society, 74*, 1553–1558.

Moulton, K. J., Beal, R. E, Warner, K., & Boundy, B. K. (1975). Flavor evaluation of cooper-nickel hydrogenated soybean oil and blends with unhydrogenated oil. *Journal of American Oil Chemists' Society, 52*, 469–472.

Nor Aini, I., Hanirah, H., Flingoh, C. H. O., & Noraini, S. (1992). Resistance to crystallization of blends of palm olein with soybean oil stored at various temperatures. *Journal of American Oil Chemists' Society, 69*(12), 1206–1209.

Nor Aini, I., Hanirah, H., & Tang, T. S. (1996). Clarity and chemical composition of palm olein–sunflower and palm olein–safflower oil blends. *ELAEIS, 7*(1), 64–86.

PORIM. (1995). *PORIM test methods*. Malaysia: Palm Oil Research Institute of Malaysia, Ministry of Primary Industries.

Thiagarajah, T. (1992). *Refining of palm and palm kernel oils. Selected readings on palm oil for participants of palm oil familiarization programme PORIM*. Malaysia: Ministry of Primary Industries.