Chemical and Physical Characteristics of Soap Made from Distilled Fatty Acids of Palm Oil and Palm Kernel Oil

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ABSTRACT: Manufacture of soaps from distilled fatty acids of palm oil (PO) and palm kernel oil (PK) is a well-established technology in Malaysia. Data on quality and characteristics of various blends of PO/PK fatty acid-based (palm-based) soaps made in Malaysia are not available, however. In view of this, the study described in this paper was undertaken. Eleven blends of palm-based bar soaps were made, and their properties were evaluated. There was an increase in the acid value of blended raw materials with increasing amounts of PK fatty acids. The iodine value and titer (°C) of blended raw materials, however, bear an inverse relationship with the amount of PK fatty acids. As expected, the hardness of the soap bars from the various blends increased with increasing PK fatty acid. Total fatty matter ranged from 76–85%, free caustic content was 0.1%, and sodium chloride content was 0.3–0.4%. Characteristics of soap blends made for this study were comparable with those from other countries. Quality of the soap obtained was comparable to those produced commercially.
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KEY WORDS: Foamability, free caustic/acid, hardness, palm base, palm kernel, palm oil, soap, titer, total fatty matter, whiteness.

Soap is the product of the reaction between certain fatty acids and alkali by means of saponification (from oils or fats) or neutralization (from fatty acids) (1). Important fatty acids involved in soapmaking are C_{16}–C_{18} and C_{12}–C_{14}. C_{16}–C_{18} fatty acids contribute to the detergency properties, while C_{12}–C_{14} fatty acids contribute to lathering and washing properties of the soaps. The traditional source of C_{16}–C_{18} fatty acids is tallow, while C_{12}–C_{14} fatty acids come from coconut oil (1,2). Because palm oil (PO) and palm kernel oil (PK) also contain C_{16}–C_{18} and C_{12}–C_{14} fatty acids, respectively, these two types of oil can be used as alternatives to tallow and coconut oil (3,4). In fact, the manufacture of soaps in Malaysia from distilled fatty acids of PO and PK is a well-established technology. Ahmad (5) reviewed the economics of using palm oil and palm stearin as raw materials for soapmaking. Kifli and Krishnan (3) and Ainie and Hamirin (4) discussed properties of palm products, especially palm stearin, and characteristics of soap derived from these distilled fatty acids. Data on quality and characteristics of the various blends of distilled PO/PK fatty acid-based (palm-based) soaps are not available, however. This paper discusses quality and characteristics of soaps made from various blends of distilled PO/PK fatty acids.

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EXPERIMENTAL PROCEDURES

Parameters for fatty acids. Blends of distilled PO and PK fatty acids, obtained from Unichema Malaysia (Selangor, Malaysia), are expressed on a percent w/w basis. Various PO/PK fatty acid blends were evaluated by the following AOCS official methods: acid value (Da 14-48) (6) and titer value (Da 13-48) (6). Iodine value was evaluated according to PORIM methods (7).

Preparation of soap samples. Five kg various distilled PO and PK fatty acid blends (Table 1) were melted in an amalgamator fitted with a hot-water jacket. Half the amount (see Table 1) of total sodium hydroxide (R&M Chemicals, Essex, United Kingdom) was added slowly at the rate of 200 mL 50% sodium hydroxide solution per 15–20 min. The other half of sodium hydroxide was added together with sodium salt of ethylenediaminetetraacetic acid (EDTA) (analytical grade; J.T. Baker, Phillipsburg, NJ) and sodium chloride (Riedel de Haen, Salze, Germany) solution. Sodium chloride was added to reduce viscosity, and EDTA was added to chelate any metal contaminants, if present.

The neat soap was then processed as follows to produce 100-g soap bars: (i) air-drying (fixed room temperature, 30°C) of the wet, neat soap mass to reduce moisture content; (ii) roll-milling of the dried soap mass three times; (iii) plodding and compacting of the milled soap under vacuum (68 cm Hg) at 70°C; (iv) extruding the plodded soap and cutting into 100-g soap bars; and (v) molding and stamping each soap bar.

Determination of properties of soap bars. Free caustic or free acid content of the soap was determined by AOCS official method Da 4a-48 (6), moisture content with a moisture balance (Mettler LP 15, Greifensee, Switzerland), total fatty matter (TFM) by Kenyan standard method (8), Hunter whiteness with a color and color difference meter (Ogawa Seiki

TABLE 1
Composition (% w/w) of Soap Blends Made from Distilled PO and PK Fatty Acids[a]

	Soap blends										
	1	2	3	4	5	6	7	8	9	10	11
Raw material	100 PO 0 PK	90 PO 10 PK	80 PO 20 PK	70 PO 30 PK	60 PO 40 PK	50 PO 50 PK	40 PO 60 PK	30 PO 70 PK	20 PO 80 PK	10 PO 90 PK	0 PO 100 PK
Distilled PO FA (g)	5,000	4,500	4,000	3,500	3,000	2,500	2,000	1,500	1,000	500	0
Distilled PK FA (g)	0	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
Sodium hydroxide (g)	761.4	776.4	799.2	803.9	834.7	852.6	871.4	883.9	905.3	929.3	981.4
Distilled water (2 × wt NaOH) (g)	1,520	1,550	1,600	1,610	1,670	1,710	1,740	1,770	1,810	1,860	1,960
Sodium chloride 0.25% (g)	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
EDTA 0.1% (g)	5	5	5	5	5	5	5	5	5	5	5

[a]PO, palm oil; PK, palm kernel oil; FA, fatty acid; EDTA, ethylenediaminetetraacetic acid.

Nippon Denshoku, Tokyo, Japan) (9), sodium chloride content by AOCS official method Da 9-48 (6), and hardness with a PNR 6 penetrometer (SUR, Berlin, Germany) with a reading at 1/10-mm penetration depth. Foamability testing was carried out by measuring the volume of foam formed from a 0.1% soap solution in a measuring cylinder. The measurement was made after agitation (30 strokes) with a perforated paddle stirrer. The volume of foam was again measured after 5 min.

RESULTS AND DISCUSSION

Quality of the fatty acids. Figure 1 shows titer, iodine, and acid values of blended PO/PK fatty acids. Titre and iodine values decrease with decreasing amounts of PO fatty acid, while the acid value increases with increasing amounts of PK fatty acid. This is further illustrated in Figure 2, which shows the relationship between fatty acid content (FAC) and titer, and iodine and acid values of PO/PK fatty acid blends.

From FAC analysis, the PO fatty acid sample contained palmitic acid (C_{16}), stearic acid (C_{18}), oleic acid ($C_{18:1}$), linoleic acid ($C_{18:2}$), and trace amounts of other fatty acids. Lauric acid (C_{12}) and myristic acid (C_{14}) were the main fatty acids present in the PK fatty acid used for making soaps. Titer increases with increasing amounts of C_{16}–C_{18} fatty acids in the blends. It decreases, however, with increase in C_{12}–C_{14} FAC (Fig. 2).

The iodine value of PO fatty acids was higher than that of PK fatty acids. This is because of the high content of $C_{18:1}$ acid and the presence of a small amount of $C_{18:2}$ fatty acid (Fig. 2). With increasing amounts of oleic acid in the raw material blends, the iodine value increases, and vice versa. The acid value increases with increasing amounts of C_{12}–C_{14} fatty acids in the blends. It decreases, however, with increasing C_{16}–C_{18} FAC of the blends (Fig. 2).

Properties of the soap samples. Table 2 shows properties of the soap samples. The degree of whiteness of soaps obtained from various blends was high, ranging from 83–90%. The soap with the highest whiteness was 100% PK soap. This is attributed to the high degree of whiteness of distilled PK fatty acid. These whiteness values are acceptable based on a

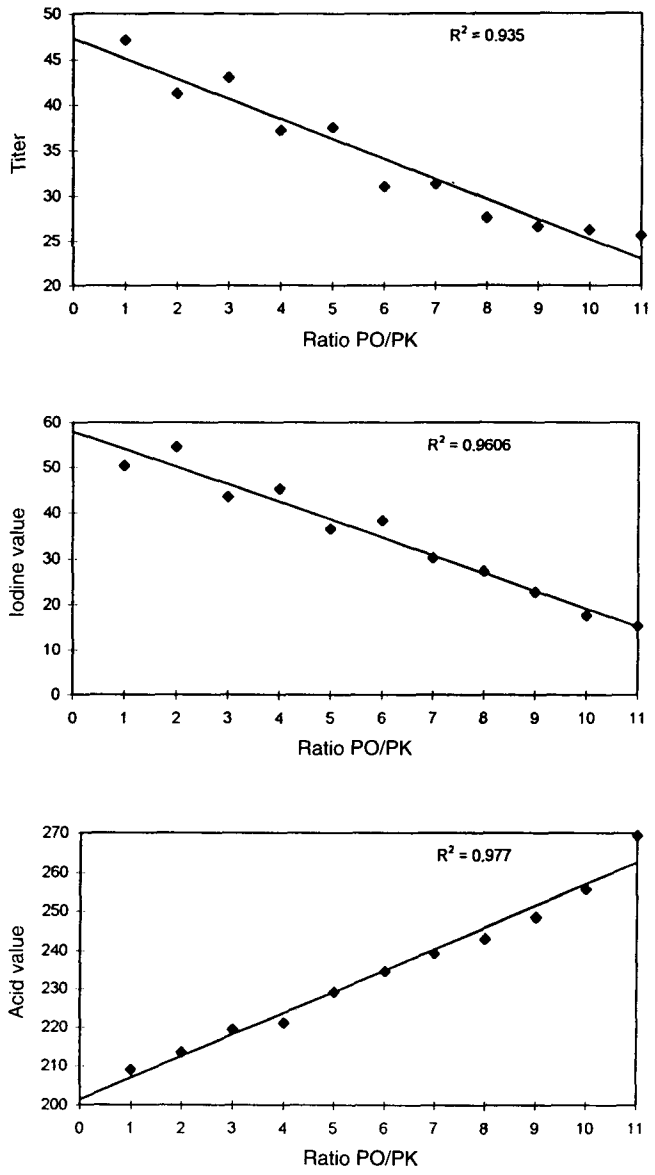

FIG. 1. Characteristics of various distilled palm oil/palm kernel oil (PO/PK) fatty acid blends.

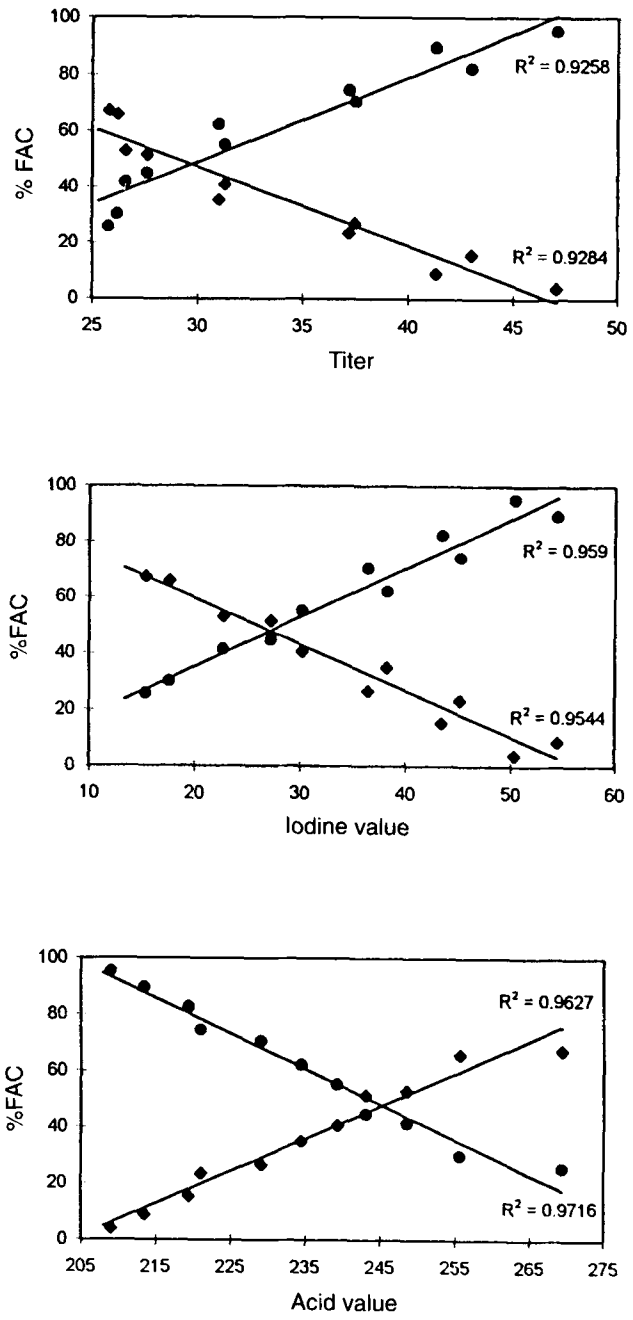

FIG. 2. Relationship between fatty acid content (FAC) of PO/PK fatty acid blends with titer, iodine, and acid values: ◆, C_{12}–C_{14}; ●, C_{16}–C_{18}. Abbreviations as in Figure 1.

minimum of 80% for a good pure-white soap. The whiteness of soaps made from PO/PK blends was comparable to that of commercial samples.

Free caustic content was less than 0.1% and ranged from 0.01–0.09% (Table 2). TFM of soap blends was greater than 80%, except for blend 11. TFM of soap made from blend 11 PO/PK fatty acids was 76%. Sodium chloride content was 0.3–0.4% (<1%). Moisture content was 8–14%, whereas most commercial soaps have moisture contents of 6–9% (after being on the shelf for some time). These properties were also comparable to the commercial toilet-soap samples.

Figure 3 shows the foamability, or lathering property, of soaps made from eleven blends of distilled PO/PK fatty acids. All soap samples derived from blends produced lather volumes greater than 500 mL, except for soap produced from blend 1 (100 PO/0 PK). Soap made from blend-1 fatty acids had a foamability of 495 mL, and this volume of lather was reduced to 335 mL after 5 min. Soaps with high contents of C_{12}–C_{14} fatty acids, such as blends 10 and 11, gave more lather compared to soaps made from blend-1 fatty acids, which is a special cut of C_{16}–C_{18} fatty acids. The reduction of foam or lather volume after 5 min was the same for all samples made from the eleven blends. The average foam-volume reduction was 162

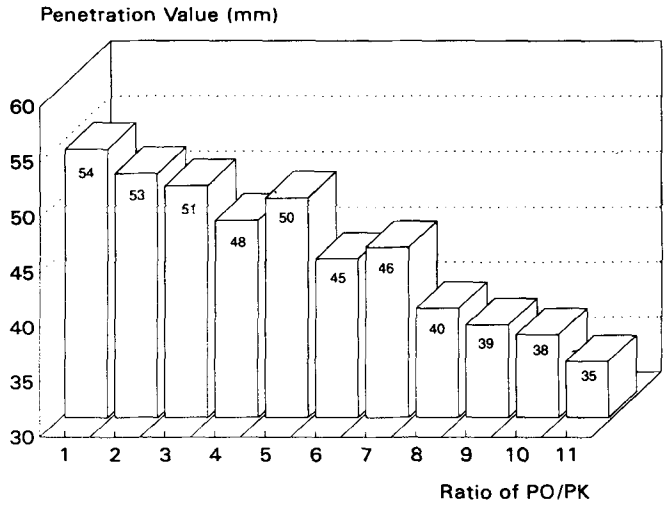

FIG. 3. Foamability of blends of PO/PK soap base: ruled bar, initial; open bar, after 5 min. Abbreviations as in Figure 1.

TABLE 2
Properties of Blends of Distilled PO/PK Soap-Base Samples[a]

	Soap blends										
	1	2	3	4	5	6	7	8	9	10	11
Property	100 PO 0 PK	90 PO 10 PK	80 PO 20 PK	70 PO 30 PK	60 PO 40 PK	50 PO 50 PK	40 PO 60 PK	30 PO 70 PK	20 PO 80 PK	10PO 90 PK	0 PO 100 PK
Free caustic content (%)	0.03	0.09	0.01	0.06	0.03	0.06	0.02	0.09	0.03	0.09	0.02
Moisture (%)	10	10	10	8	11	11	10	10	11	10	14
Total fatty matter (%)	83	84	81	85	80	82	80	82	80	82	76
Hunter whiteness (%)	85	85	86	83	87	85	87	88	88	87	90
NaCl content (%)	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3

[a]Abbreviations as in Table 1.

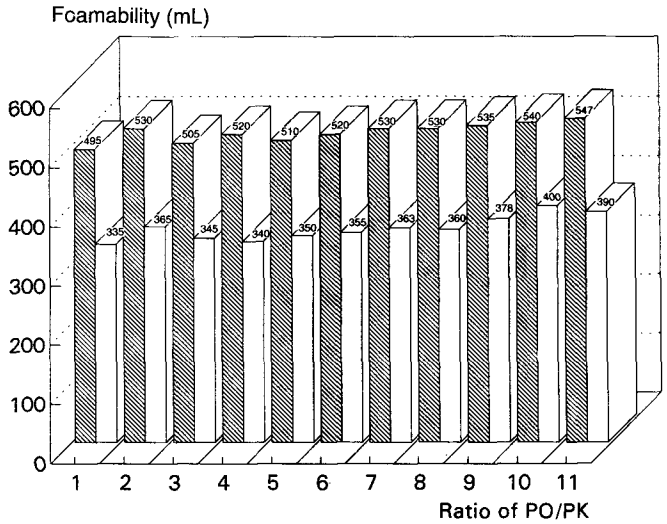

FIG. 4. Penetration values of blends of PO/PK soap base. Abbreviations as in Figure 1.

mL (SD 9.8387, coefficient of variation 6.07327%). These results also show that foamability or lathering properties of soap increase with the amount of PK (C_{12}–C_{14}) fatty acid in the raw material blends. Foamability of soap samples made from the eleven blends is comparable to that of commercial palm-based samples and tallow-based soaps from Japan and Europe.

The penetration value of various soaps made from eleven blends of PO/PK fatty acids is shown in Figure 4. Penetration value is a reflection of the hardness of soaps. Low penetration value indicates that the soap is hard, and vice versa. The value decreased with increasing amount of PK or C_{12}–C_{14} fatty acids in the blend. Soaps made with high contents of C_{12}–C_{14} fatty acids were harder compared to those with high contents of PO or C_{16}–C_{18} fatty acids. This is observed in blend 1 (100 PO/0 PK) with a penetration value of 54, while blend 11 had a penetration value of 35. These soap samples were softer compared to those of commercial toilet soap samples because the penetration value was taken immediately after production of the soap. Soaps are normally softer immediately after production than when they have been on the shelf for some time.

Table 3 shows the properties of some commercial palm-based soaps. An examination of the properties of soaps made from the eleven blends of PO/PK fatty acids shows that soaps made from blends 2 and 3 had properties similar to those of commercial toilet-soap samples. The titer of palm-based toilet soaps was slightly higher than tallow-based toilet soaps, however. Soaps derived from blends 2 and 3 PO/PK fatty acids had titers of 43.0 and 41.3°C, respectively, which is within the range of commercial palm-based soaps. Values are slightly higher compared to the tallow soap base (Table 3). Of the two blends, blend 3 had higher whiteness (86%), which was comparable to Malaysian and European commercial samples.

Soaps made from blend 4 PO/PK fatty acids also had properties almost similar to those of commercial samples, except for titre value. An analysis of the titer graph in Figure 1 shows that the titer for this blend of PO/PK fatty acids is greater than 37.2°C. Extrapolation of the value from the graph came to approximately 38°C.

TABLE 3
Properties of Some Commercial Toilet-Soap Samples[a]

Parameter	Malaysia palm-based FA[a]	Europe tallow-based FA	Japan tallow-based FA
Iodine value	39–44	28.3–38.5	30.5–53.6
Total fatty matter (%)	83–86	83–85	83–85
Free caustic content (%)	<0.1	<0.1	<0.1
Sodium chloride (%)	<1	<1	<1
Titer (°C)	39–43	30–38	37–38
Moisture (%)	6–9	6–8	8–11
Penetration values	26–38	19–29	14–19
Hunter whiteness	81–86	85	89.2
Foamability	460/295[b]	530/360[b]	345/220[b]

[a]FA, Fatty acid. [b]Volume of foam after 5 min.

In summary, three palm-based soap samples, obtained in this experiment, were comparable to commercial toilet-soap samples. Quality of soaps made from blends 2–4 PO/PK fatty acids was the best among the eleven samples.

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