Characteristics and Performance of Some Commercial Shortenings

I. NorAini[a,*], M.S. Embong[b], A. Abdullah[b] and Flingoh C.H. Oh[a]

[a]Chemistry & Technology Division, Palm Oil Research Institute of Malaysia, Ministry of Primary Industries 50720 Kuala Lumpur, Malaysia and [b]Department of Food Science & Nutrition, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

Six different brands of commercial shortenings were evaluated for their physicochemical characteristics and baking performance of cakes and biscuits (cookies). Three of the samples were locally made shortenings supplied by three different refineries (coded A, B and C), and the other three samples were imported shortenings obtained from supermarkets in Kuala Lumpur (D, E and F). Analyses and evaluations included slip melting point, solid fat content, fatty acid composition, triglyceride composition, creaming power and baking performance. All of the shortenings had slip melting points above 40°C. Sample A had the highest solid fat content at all temperatures. However, in terms of baking performance in cakes, sample C gave the highest volume, followed closely by samples B and A. Results indicated that the cakes were significantly different ($P < 0.05$) in terms of grain size and eating quality. Sensory evaluation on biscuits indicated that samples made with shortening D were preferred by a majority of the sensory panel, followed by those made with shortening C. The third, in order of panel preference, was biscuits made with shortening E.

KEY WORDS: **Baking performance, creaming, palm oil, physicochemical characteristics, sensory evaluation, shortening, soybean oil.**

Shortenings are anhydrous plastic fats used in the preparation of many foods. They are used for cooking, frying and as an ingredient in many food products such as cakes, biscuits (cookies), pastries, breads and cream fillings/icings. Besides improving palatability, they aid in lubrication of ingredients, incorporation of air during mixing; they give structure, provide a moisture barrier and extend the shelf-life of the products (1,2). The type and amount of shortenings in the formula affect both the doughs and the quality of the finished baked products (3).

Cakes represent an important area for study because of their unique nature (4). A cake is distinctive among baked products for its combination of extreme sweetness with highly developed cellular structure. The shortening used in cake plays an important role in determining its structure. Consequently, the quality requirements for cake shortenings are much more exacting than for shortenings which are to be used for other baked products (5). Cream icings and fillings are essentially water-in-oil emulsions. When selecting shortenings for these systems, close attention is paid to the potential for lipids to aerate, emulsify and provide lubricity and structure (6).

The objective of this paper is to report physicochemical evaluations conducted on some commercially available shortenings. The shortenings were tested for their baking performance in Madeira cake and short-dough biscuits (cookies).

MATERIALS AND METHODS

Samples evaluated consisted of locally made shortenings of three different brands obtained from three refineries and imported shortenings of three different brands obtained from supermarkets in Kuala Lumpur (Malaysia). The shortenings were coded as samples A, B and C (local shortenings) and D, E and F (imported shortenings). A completely randomized experimental design was employed in the study (7).

Slip melting point. Slip melting point was analyzed in triplicate according to the official AOCS Method Cc 3-25 (8).

Solid fat content. A Newport Analyzer MK III wideline nuclear magnetic resonance (NMR) (Newport Pagnell, England) with a temperature controller was used to determine solid fat content of the shortening samples. The PORIM parallel method was used in which the sample in the NMR tube was first melted at 70°C for 30 min, chilled at 0°C for 90 min, and then held at each measuring temperature for 30 min prior to being measured (9). The PORIM method is similar to IUPAC method 2.150 (10), except that in the IUPAC method the sample is melted at 80°C, transferred to a 60°C water bath for 5 min and then chilled at 0°C for 60 min. It should be noted that this method of determining solid fat content is quite different from that of the AOCS method (8). The results are also different. Four determinations were carried out on each sample.

Fatty acid composition. Fatty acid composition was analyzed as methyl esters, which were prepared according to a method proposed by Timms (11). Analyses were conducted on a glass column (1.8 m × 3 mm i.d.) of 10% SP 2330 on 100-120 Supelcoport (Supelco, Bellefonte, PA) at 200°C with a flow rate of 40 cm^3 N_2/min by using a Perkin Elmer Sigma 100 Gas Chromatograph (Norwalk, CT). Injector and detector temperatures were set at 220°C. Analyses were conducted under isothermal conditions, with a run time of 20 min.

Triglyceride composition. Triglyceride composition was analyzed in duplicate according to carbon number with a glass column (46 cm × 3 mm i.d.) in a Pye 104 gas chromatograph (Pye Unicam, Cambridge, U.K.). The stationary phase was 1% Dexil 300 on 100–120 mesh Supelcoport (Supelco). The operating conditions for the analysis were as follows (12): Injector and detector temperatures were 370°C; column temperature was programmed from 280°C to 345°C with a temperature rise of 4°C/min; and carrier gas was nitrogen with a flow rate of 80 mL/min.

Creaming test. The shortenings were evaluated for their creaming ability, in duplicate, by using procedures described by NorAini *et al.* (13).

Baking test in a cake. Performance of the commercial shortenings as one of the ingredients in a cake formulation was evaluated in triplicate by using the shortenings in a Madeira cake formulation (Table 1), as described previously (13). Volume of the cakes was determined with rapeseed displacement (14). Cake volume was divided by its weight and results were reported as specific cake volume, in units of cm^3/g.

Baking test in biscuits (cookies). A short-dough type of biscuit (cookie) formula (Table 2) was used to assess the performance of shortenings in biscuits (cookies). The procedure for making the biscuit has been described else-

*To whom correspondence should be addressed at Chemistry & Technology Division, P.O.R.I.M., Ministry of Primary Industries, P.O. Box 10620, 50720 Kuala Lumpur, Malaysia.

TABLE 1

Formula for Madeira Cake

Ingredients	Wt (g)
Super-fine cake flour	475
Finely granulated white sugar	460
Shortening	169
Fresh whole egg	236
Water	230
Skimmed milk powder	11
Single action baking powder[a]	11
Salt	8.4
Liquid egg yolk color	1 mL
Vanilla flavor	1 mL

[a]Contains starch, sodium acid pyrophosphate and sodium bicarbonate.

TABLE 2

Short-Dough[a] Biscuit Formula

Ingredients	Wt (g)
Shortening	170.0
Finely granulated white sugar	200.0
Fresh whole egg	50.0
Vanilla flavor	2.5
All purpose plain wheat flour	400.0
Baking powder[b]	3.0

[a]Reference 15.
[b]Contains starch, sodium acid pyrophosphate and sodium bicarbonate.

where (16). Biscuit diameter and thickness were measured by taking the average of five biscuits. For thickness measurements, the biscuits were stacked, measured and the average reading was recorded. The baking test was carried out in triplicate.

Sensory evaluation. Two types of sensory tests were conducted, including a preference test (17) for biscuits and a scoring test (18) for cakes. For biscuit evaluation, panelists were asked to indicate which sample they most preferred among the six samples given. For cake, samples were evaluated for grain size, texture, eating quality and flavor. Scores of 1 to 9 were used: For grain size, 1 denotes very coarse and 9 denotes very fine; for texture, 1 denotes very firm and 9 denotes very soft; for eating quality, 1 denotes very dry and tough and 9 denotes very moist and tender; for flavor, 1 denotes very poor and 9 denotes excellent.

Sample preparation and presentation. Sensory evaluations were conducted one day after baking. Biscuit samples were placed on polystyrene plates, coded with three-digit random numbers and presented in random order. Cake samples were prepared separately on a different day. The cakes were cut into 1-cm thick slices. The cake slices were then further cut into equal sizes with a square cutter, 4 cm × 4 cm. Cake samples were presented as described for biscuits. Judges consisted of staff members of the Palm Oil Research Institute of Malaysia (PORIM). For the first test, 52 staff members served as judges. Only trained panelists (n = 20) were used for the second test. Panelists were provided with a glass of warm tap water to cleanse their palates before tasting each sample.

Facilities. Sensory tests were conducted in an air-conditioned sensory evaluation laboratory equipped with 10 individual panel booths. The lighting system consisted of white fluorescent lights and red and blue colored lights, which served to mask any color differences among samples. The sensory evaluations for cakes and biscuits were repeated twice.

Statistical analysis. The data obtained were subjected to analysis of variance with a main frame computer (IBM; The program used was developed based on IBM scientific sub-routine package.). When significant differences occurred among sample means, Duncan's multiple range test (19) was used to locate the differences.

RESULTS AND DISCUSSION

Physicochemical characteristics. Table 3 shows the physicochemical characteristics of the shortenings. Slip melting points of the samples were all above 40°C. Locally produced shortenings (samples A, B and C) had relatively higher slip melting points than did imported shortenings (samples D, E and F). Similarly, solid fat content profiles of the local shortenings were higher at all temperatures than the imported shortenings (Fig. 1). Sample A had the highest solid fat content at all temperatures, followed by samples B, C, D, E and F, respectively. The imported shortenings had much flatter solid fat content profiles than did the local ones. It should be emphasized again that solid fat content results by the IUPAC method are much higher than by the AOCS method. Fatty acid composition analysis showed that local shortenings (samples A, B and C) were higher in palmitic acid (48.6, 50.4 and 47.6%, respectively) than imported shortenings (samples D, E and F at 17.3, 22.8 and 18.3%, respectively). On the other hand, samples D, E and F had higher contents of stearic, oleic, linoleic and linolenic acids. Based on fatty acid composition, especially the palmitic acid content, it is most likely that the local shortenings contained palm oil with added palm stearin whereas the imported shortenings contained soybean and palm oils. Palm oil contains approximately 44% 16:0 and soybean 10% 16:0 (20,21). In terms of triglyceride composition, samples A, B and C were rich in C_{50} and C_{52}, and samples D, E and F were rich in C_{54}, confirming that A, B and C contained palm oil (20) and D, E and F contained soybean oil (22). Palm oil contains approximately 11% C_{54} and soybean 66% C_{54}.

Performance evaluation. Figure 2 shows the creaming performance of the shortenings. In general, the imported shortenings (samples D, E and F) had better creaming performance than the local shortenings did (samples A, B and C). The initial creaming performance at 2 and 4 min of beating was significantly ($P < 0.05$) related to the solid fat content of the shortenings, with correlation coefficients of $r = -0.82$ and $r = -0.87$, respectively (Table 4). The imported shortenings contained approximately 15–20% solid fat at temperature of use (25°C), while the local ones had rather high solids of approximately 28–37% at the same temperature. Imported shortenings with lower solid fat content at 25°C had better creaming power at the initial stage of beating than did local shortenings with

TABLE 3

Slip Melting Point, Fatty Acid and Triglyceride Compositions of Shortenings

Sample code	A	B	C	D	E	F
Slip melting point (°C)	49.5	48.0	45.9	42.3	42.4	42.5
Fatty acid composition (wt%)						
12:0	0.2	0.1	0.2	trace	0.2	0.5
14:0	1.2	1.2	1.2	0.3	0.7	0.4
16:0	48.6	50.4	47.6	17.3	22.9	18.3
18:0	4.8	4.8	3.8	7.2	9.8	8.0
18:1	36.3	34.6	36.2	41.2	47.4	41.9
18:2	8.7	8.1	10.8	33.1	16.9	29.9
18:3	trace	0.1	0.1	0.8	1.7	1.0
20:0	0.2	0.1	0.1	trace	0.4	0.2
Triglyceride composition (wt%)						
Carbon number						
44	0.1	0.1	0.1	—	—	—
46	1.1	1.3	1.3	—	—	0.4
48	13.3	16.4	15.0	2.2	2.3	5.0
50	41.2	40.9	41.7	12.2	5.8	8.2
52	35.1	32.3	33.5	27.8	27.9	21.5
54	8.9	8.7	7.8	60.0	63.2	63.9
56	0.3	0.2	0.4	0.3	0.8	0.4
58	—	0.1	0.2	0.5	—	0.5

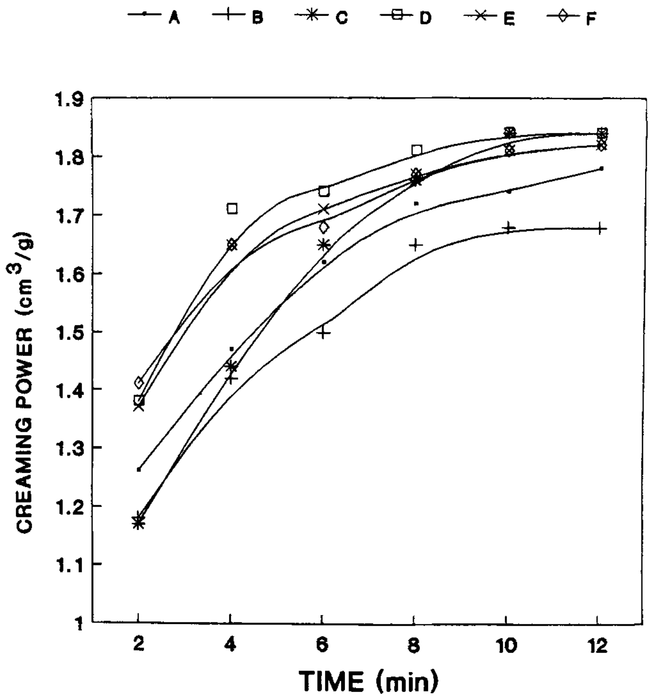

FIG. 2. Creaming performance of the commercial shortenings (A–F).

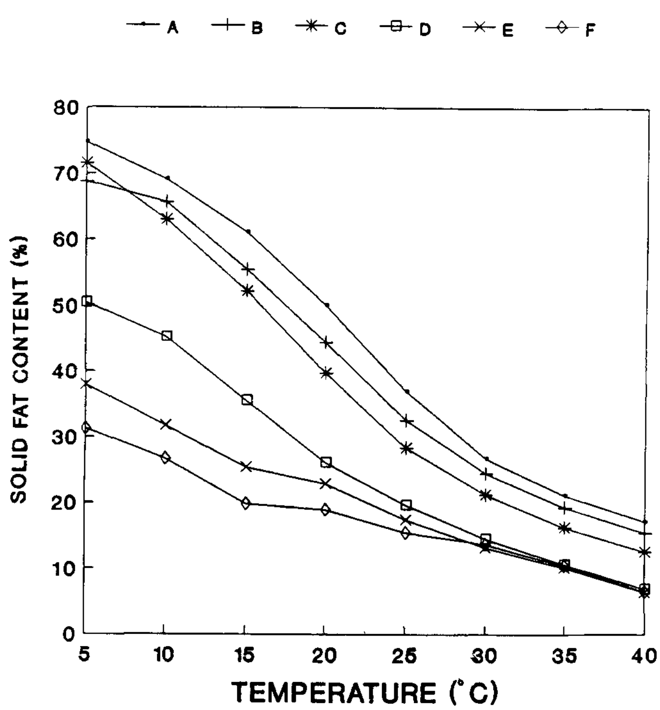

FIG. 1. Solid fat content of the commercial shortenings (A–F) according to IUPAC method.

higher solid fat content at 25°C. After 8 min of beating, 1 local shortening (sample C) had a creaming ability similar to the imported shortenings, although its solid fat content was higher at usage temperature. Sample C probably contained an emulsifier, which may have contributed to its better creaming ability.

Table 5 shows mean (n = 4) specific volumes of cakes made with various shortenings. Shortening C gave the best cake volume, followed closely by shortenings A and B. Imported shortenings D and F produced significantly ($P < 0.05$) lower cake volumes than local shortenings. The specific volume of the cake made with shortening F was significantly lower ($P < 0.05$) than those made with shortenings A or B.

These results indicate that the shortening with the best creaming performance did not necessarily produce the cake with the highest volume, which agrees with the findings of Meara (23). Although creaming power (at 8, 10 or 12 min of beating) did not correlate well with specific cake volume, there was a high correlation ($P < 0.05$) between specific cake volume and initial creaming power of the shortenings at 2 and 4 min of beating ($r = -0.93$ and $r = -0.89$, respectively, values not shown). Meanwhile, there was a significantly high correlation ($P < 0.05$) between cake volume and solid fat content of the shortenings with correlation coefficient of $r = 0.84$. A high correlation ($P < 0.05$) also was found between cake volume and palmitic acid content ($r = -0.92$). Cake volume was highly correlated with triglyceride content of C_{50} and C_{52} with correlation values of $r = 0.93$ and $r = 0.91$, respectively. On the other hand, cake volume was inversely (negatively) related to the C_{54} content of the shortening ($r = -0.94$).

During baking, the shortening should not melt too quickly, or the body-forming properties of the egg protein and starch will not have reached the point at which they can retain the air. Since melting points of samples A, B and C were higher than those of samples D, E and F, they were able to stabilize the air cells during baking better, hence producing cakes of higher volume.

Biscuit baking tests which included measurements of

TABLE 4

Relations Between Solid Fat Content (at 25°C) and Creaming Power of Shortening During Beating

Shortening	Solid fat content at 25°C	Creaming power at different times (min)					
		2	4	6	8	10	12
A	36.9	1.26	1.47	1.62	1.72	1.74	1.78
B	32.5	1.18	1.42	1.50	1.65	1.68	1.68
C	28.3	1.17	1.44	1.65	1.76	1.84	1.87
D	19.6	1.38	1.71	1.74	1.81	1.84	1.84
E	17.4	1.37	1.65	1.71	1.77	1.81	1.82
F	15.4	1.41	1.65	1.68	1.77	1.81	1.82
Correlation coefficient[a]		r = −0.82	r = −0.87	r = −0.73	r = −0.71	r = −0.67	r = −0.50

[a]Relation between solid fat content at 25°C and creaming power.

TABLE 5

Mean (n = 4) Specific Volume of Cake Made with Various Shortenings[a]

Shortening	Specific cake volume (cm^3/g)
A	2.47[a]
B	2.45[a,b]
C	2.50[a]
D	2.39[c]
E	2.40[b,c]
F	2.37[c]

[a]The a–c values in the column followed by different letters are significantly different ($P < 0.05$).

TABLE 6

Mean (n = 12) Diameter, Thickness and Sensory Preference Score of Biscuits Made with Different Shortenings[a]

Shortening	Diameter (cm)	Thickness (cm)	Sensory (n = 52) preference score (%)
A	4.7[a]	0.7[a]	5.6
B	4.7[a]	0.8[a]	10.1
C	4.7[a]	0.7[a]	19.0
D	4.7[a]	0.7[a]	30.7
E	4.7[a]	0.7[a]	18.5
F	4.6[a]	0.7[a]	6.1

[a]Values in the same column followed by a similar letter are not significantly different ($P < 0.05$).

biscuit diameter and thickness indicated that there were no significant differences in biscuit diameter and biscuit thickness after baking (Table 6). The diameter of the biscuit gives an indication of its spreadability, the larger the diameter, the more spreadable the biscuit.

Sensory evaluation. Sensory evaluations of the biscuits showed that the majority of the panelists (30.7%) preferred the biscuit made with shortening D (Table 6). The biscuit made with shortening C was preferred by 19.0% of the panelists, followed closely by the biscuit made with shortening E (18.5%). Further testing by using discrimination tests with trained panelists may help to explain why sample D was preferred by a majority of the panelists and sample A was preferred least.

Sensory evaluations of cakes made with different shortenings showed that there was a significant difference

TABLE 7

Mean (n = 20) Sensory Score[a] for Grain Size, Texture, Eating Quality and Flavor of Cakes Made with Different Shortenings[b]

Attribute[a]	Shortening A	B	C	D	E	F
Grain size	5.1[c]	5.5[b,c]	5.8[b]	5.5[b,c]	5.9[b]	5.6[b,c]
Texture	5.5[b]	5.3[b]	5.6[b]	5.6[b]	5.6[b]	5.5[b]
Eating quality	5.5[b,c]	5.1[c]	5.6[b]	5.8[b]	5.8[b]	5.7[b]
Flavor	5.4[b]	5.5[b]	5.5[b]	5.6[b]	5.6[b]	5.5[b]

[a]For grain size, 1 = very coarse and 9 = very fine; for texture, 1 = very firm and 9 = very soft; for eating quality, 1 = very dry and tough, 9 = very moist and tender; and for flavor, 1 = very poor and 9 = excellent.

[b]The b,c values in the same row followed by different letters are significantly different ($P < 0.05$).

($P < 0.05$) in scores for grain size among the cakes (Table 7). Grain size refers to size of air cells of the cake crumb. The finer the grain, the better the structure of the cake and the higher the score. Cakes made with shortenings C and E were significantly better in grain size than the cake made with shortening A.

There were significant differences ($P < 0.05$) in scores for eating quality among the cakes made with different shortenings. Eating quality refers to the degree of moistness and tenderness of the cake crumb. The more moist and tender the cake, the better the quality, thus the higher the score. The cake made with shortening B was significantly ($P < 0.05$) lower in eating quality than cakes made with shortenings C, D, E and F. There were no significant differences in texture and flavor among the samples. Among the local shortenings (samples A, B and C), sample C tended to produce cake with the best sensory characteristics (Table 7). There were no significant differences among the imported shortenings (samples D, E and F).

ACKNOWLEDGMENT

The authors are grateful to the Director-General of PORIM for his permission to publish this paper.

REFERENCES

1. Greethead, G.F., *Food Technology in Australia 21*:228 (1969).
2. Cochran, W.M., and R.S. Baeuerlen, *Bakers Dig. 55*:16 (1981).
3. Matz, S.A., and T.D. Matz, *Cookie and Cracker Technology*, 2nd edn., AVI Publishing Co. Inc., New York City, 1978, p. 48.

4. Harnett, D.I., and W.G. Talheimer, *J. Am. Oil Chem. Soc. 56*:948 (1979).
5. Mattil, K.F., *Bailey's Industrial Oil and Fat Products*, 3rd edn., edited by D. Swern, John Wiley and Sons, New York, 1964, p. 265.
6. Moncrieff, J., *Bakers Dig. 44*:60 (1970).
7. Cochran, G.M., and G.M. Cox, *Experimental Designs*, 2nd edn., John Wiley & Sons, Inc., New York, 1957, p. 95.
8. *Official and Tentative Methods of the American Oil Chemists' Society*, 4th edn., edited by D. Firestone, American Oil Chemists' Society, Champaign, IL, 1989.
9. Flingoh, C.H. Oh, and K.G. Berger, *Proc. of Int. Palm Oil Products Technology in the Eighties*, edited by E. Pushparajah and M. Rajadurai, Incorporated Society of Planters, Kuala Lumpur, 1980, p. 383.
10. *Standard Methods for the Analysis of Oil Fats and Derivatives*, International Union of Pure and Applied Chemistry, 6th edn., Pergamon Press, Oxford, 1979.
11. Timms, R.E., *Aus. J. Dairy Tech. 3*:4 (1978).
12. Tan, Y.A., *PORIM Bulletin No. 21*, Palm Oil Research Institute of Malaysia, 1990, p. 7.
13. Nor Aini, I., K.G. Berger and A.S.H. Ong, *J. Sci. Food Agric. 46*:481 (1989).
14. Griswold, R.M., *The Experimental Study of Foods*, Houghton Mifflin Co., Boston, 1962, p. 525.
15. Manley, D.J.R., *Technology of Biscuit, Crackers and Cookies*, Ellis Horwood Ltd., Chichester, England, 1983, p. 204.
16. Nor Aini, I., A. Abdullah and M.S. Embong, *Elaeis 3*:302 (1991).
17. Institute of Food Technologists (IFT), *Food Technol. 35*:50 (1981).
18. *Manual on Sensory Testing Methods*, American Society for Testing and Materials, Philadelphia, 1968, STP 434, p. 31.
19. Duncan, D.B., *Biometrics 11*:1 (1955).
20. Rossell, J.B., B. King and M.J. Downes, *J. Am. Oil Chem. Soc. 62*:221 (1985).
21. Pryde, E.H., *Handbook of Soy Oil Processing and Utilization*, edited by D.R. Erickson, E.H. Pryde, O.L. Brekke, T.L. Mounts and R.H. Falb, American Soybean Association and American Oil Chemists' Society, Champaign, 1980, p. 17.
22. deMan, L., J.M. deMan and B. Blackman, *J. Am. Oil Chem. Soc. 66*:1777 (1989).
23. Meara, M.L., *Fats and Oils: Chemistry and Technology*, edited by R.J. Hamilton, and A. Bhati, Applied Science Publishers, London, 1980, p. 193.

[Received November 7, 1991; accepted June 21, 1992]