TECHNICAL

Emulsifier/Oil System for Reduced Calorie Cakes

V.F. Rasper[a,*] and B.S. Kamel[b]

[a]Department of Food Science, University of Guelph, Guelph, Ontario N1G 2W1, Canada; and [b]Atkemix Inc., P.O. Box 1085, Brantford, Ontario N3T 5T2, Canada

Several emulsifiers were tested for their effects on the functionality of white layer cake batters in which plastic shortening was replaced with vegetable oil. The RV-1 emulsifier, a water dispersion of a mixture of sodium stearoyl lactylate, sorbitan monostearate and polysorbate 60 gave the best results when used in cake batters having the oil (corn oil or canola oil) content reduced as low as 6 or 3% (on flour basis) and sucrose (30%) replaced with either sorbitol or polydextrose. The cakes were comparable in quality with the plastic shortening control. To achieve this comparable quality, the emulsifier was used at 3% on flour basis and at a higher hydration than that of the control. Somewhat lower, but still acceptable, rating was received by cakes prepared with Atlas A. Propylene glycol mono fatty acid Esters (PGME, Atmul P 44 and RV) were found unsuitable for the tested system under the given conditions of formula and procedure.

The recent trend in consumer preference for low calorie and low cholesterol foods has provided many food scientists and technologists with an impetus to develop ingredients that may aid in producing such foods without affecting their original flavor and texture. In the production of low or reduced calorie cakes, ingredients which can fully or partly replace sucrose and shortening without any adverse effect on the functionality of the batter appear to be the key factors for success.

Sucrose is primarily considered as a sweetener. However, in replacing it with another ingredient, its many divversified functions other than just providing sweetness have to also be given careful consideration. In cake batters, apart from making them taste sweet, sucrose functions as a bulking agent and helps to tenderize the cake by raising the gelatinization temperature of starch and the coagulation temperature of protein. These changes in the two functionally relevant components of the system allow the leavening gases to expand for a longer time and, as a result, a structure with a good volume and mouthfeel is obtained. Shortening is another ingredient relevant for the development of a desired volume and texture. Through a complex interaction with wheat protein molecules and starch it prevents the formation of a tight gluten/starch network and hence, gives a tender and well aerated structure (1,2).

None of these ingredients can be partly or fully removed from the formula, unless conditions for obtaining an end product with proper textural characteristics and a well balanced and pleasant flavor are maintained. A simple replacement of sucrose with either an artificial sweetener or a low calorie bulking agent without taking into consideration all functional implications of such a move, will not solve the problem of producing a low or reduced calorie cake. The same applies for the shortening.

It was reported earlier that an acceptable product can be obtained from a cake batter with a very low or no shortening content, if such a modification to the formula is balanced out by the use of a sufficient quantity of an appropriate type of emulsifier (3). In replacing plastic shortening with vegetable oil, a reduction by 1/3 in the lipid component of the formula has been generally considered suitable for the production of a good cake. But Harnett and Thalheimer (4) confirmed some earlier results of MacDonald and Lensack (5) who reported that a good cake could be obtained with vegetable oil and a proper surface active agent even at a 50 to 60% reduction.

The present work was carried out with the objectives of evaluating the cake baking potential of several emulsifiers when used in combination with levels of vegetable oil representing the reduction in the lipid ingredient as high as 67 and 84%. The emulsifier/oil combinations were tested on layer cake batters in which sucrose was partly substituted with sorbitol or polydextrose.

Sorbitol, a moderately sweet polyol with a caloric value practically identical with that of sucrose (4 cal/g), has often been used as a partial or total replacer for sucrose in a variety of cake formulas (6). Although it does not reduce the actual calorie value of the product, it exhibits some favorable metabolic effects by avoiding high blood glucose peaks because of a slower absorption from the intestine. It reduces the insuline requirement by the virtue of its metabolic mechanism which distinctly differs from that of glucose (7-10). As for the effects of sorbitol on cake quality, the humectancy effect leading to an enhanced shelf-life of the baked product is considered the most beneficial one. Reduced sweetness can also be viewed by many consumers as a beneficial attribute.

Polydextrose, a nonsweet bulking agent, is basically a randomly but heavily cross-linked polymer of glucose with a very low caloric value (ca. 1 cal/g). Its use as a replacement for sugar and fat was reported for a variety of foods, including cakes (2,11).

The 30 and 40% sucrose replacements with the above ingredients (70/30 and 60/40) were chosen as optimum with respect to both textural and sensory qualities of the final product. Although formulas containing higher quantities of either polydextrose or sorbitol were reported by several workers (2,6,11), our previous tests indicated that unfavorable flavor characteristics may develop if the above levels are exceeded (12).

EXPERIMENTAL PROCEDURES

Emulsifiers. The emulsifiers used were: Atlas A—a water dispersion of 32% sorbitan monostearate and 8% polysorbate 60 with added preservative; Propylene glycol mono

*To whom correspondence should be addressed.

fatty acid Esters (PGME); Atmul P 44—a blend of mono- and diglycerides and sodium stearoyl lactylate; RV—a mixture of sodium stearoyl lactylate, sorbitan monostearate and Polysorbate 60; RV-1—a 50% water dispersion of RV. All emulsifiers were supplied by Atkemix Inc. (Brantford, Ontario). They were used at the following concentrations (on flour weight basis): Atlas A, 3%; Atmul P44, 0.8%; PGME, 1.5%; RV, 1%; and RV-1, 3%.

Shortening. A Vream nonemulsified plastic shortening was supplied by Canada Packers (Toronto, Ontario). Canola oil and corn oil were commercial products.

Sucrose replacers. Crystalline sorbitol (Sorbitol USP 834, Atkemix Inc., Brantford, Ontario) and powdered polydextrose (Pfizer Canada, Chemical Division, Kirkland, Quebec) were supplied by the respective companies. Xanthan gum, which was used (0.8% on flour basis) in formulas containing polydextrose, was Keltrol TF, Kelco Division of Merck Co., Inc. (Toronto, Ontario).

Cake baking formula and procedure. A standard 100% white layer cake formula (Table 1) was used for baking test controls containing plastic shortening. In oil-type cake batters used for the comparison of the emulsifiers, the quantity of oil represented 2/3 of the quantity of plastic shortening contained in the standard formula (12% on flour basis). In low-oil formulas, the quantity of oil was further reduced to 6 and 3% (on flour basis).

Dry ingredients constituting part A of the formula were mixed in a V-shaped tumbler for 20 min. The actual mixing of the cake batter was done in a Hobart Kitchen Aid mixer. Part A and Part B were mixed at medium speed (110 rpm) for 2 min. After adding Part C, mixing was continued at the same speed for 3 min, unless otherwise stated, and for an additional 2 min after adding Part D. Cake batter was scaled at 425 g into circular baking pans (20.3-cm diameter and 3.8-cm depth) and baked at 350°F for 22 min. Two cakes were baked from each batch; all treatments were run in duplicates. After 30-min cooling in the pans at 22 to 24°C, the cakes were removed from the pans and let cool on a wire rack for an additional one hr after which their quality was evaluated. For storage tests, the cakes were placed in polyethylene bags (double) and stored at ambient temperature (22 to 24°C) for 24, 48 and 96 hr.

Cake batter and cake quality evaluation. Batter density (g/ml) was measured by comparing the weight of a known volume of cake batter with the same volume of water at ambient temperature (22 to 24°C). Cake volume was measured by rapeseed displacement. Cake density (g/ml) was calculated by dividing cake volume by its weight.

Crumb firmness was measured by compressing a 1-inch slice of cake crumb cut out from the center of the cake using a circular plunger (3-cm diameter) at a compression rate of 20 cm/min. Firmness was recorded as force (kg force) required for an 8-mm compression. The instrument used was a modified extensigraph with electronic strain-gauge recording and adjustable compression cycle (13). "Cohesiveness" was measured as the ratio between the force area under the first and second compression peaks (14).

Moisture, protein and ash of the cake crumb were determined according to the AACC methods 44-18, 46-12 and 08-01, respectively (15). Poetroleum extract was quantified by petroleum ether (bp 60 to 65°) extraction of a vacuum dried sample in a Soxhlet apparatus for 6 hr.

Statistical evaluation. The SAS (16) procedure for analysis of variance (ANOVA) for a completely randomized design was applied. Comparison of the means was performed by Duncan's multiple range test. The use of the word "significant" implies a significant difference at the 95% level of confidence.

TABLE 1

Formulation of Control Cakes (100%, white)[a]

Ingredient[b]	%	Part
Flour	100	A
Sugar (granulated)	100	A
Skimmed dried milk	12.6	A
Salt	1.8	A
Baking powder (double action)	5.0	A
Vanilla	0.3	A
Shortening (nonemulsified)	18.0	B
Emulsifier[c]	See footnote	B
Water	57.2	B
Water	14.0	C
Water	22.0	D
Egg whites (dry)	20.2	D
Whole eggs	5.0	D

[a] All emulsifiers are approved by FDA and Canadian Food Regulations to be used in cakes.

[b] Ingredient expressed as percentage of flour weight.

[c] Emulsifiers used at the following concentrations (on flour basis): Atlas A, 3%; Atmul P44, 0.8%; PGME, 1.5%; RV, 1%; RV-1, 3%.

RESULTS AND DISCUSSION

Prior to experimentation with the calorie reduced formulas, the five selected emulsifiers were tested for their baking potential using standard formula batters with either plastic shortening or vegetable oil. In the presence of plastic shortening, the best baking results were obtained with emulsifiers Atlas A and RV-1. They produced cakes of practically identical density and volume (Table 2). The identical values for these two quality attributes, however, contrasted with a significant difference in crumb firmness. Not only did cakes containing Atlas A give higher firmness readings than the RV-1 ones, but their firmness values were found at the top, while those for the RV-1 cakes at the bottom of the recorded range for all the tested samples. Apart from this considerable difference in crumb firmness, the RV-1 cakes distinguished themselves from the Atlas A cakes by a somewhat drier mouthfeel and lighter crust color. Ranking next to these two emulsifiers was Atmul P-44. Despite a lower volume and higher density, cakes prepared with this emulsifier were still rated as acceptable. Less satisfactory results were obtained with Propylene glycol mono fatty acid esters (PGME) and RV. They were found unsuitable for cake baking under the conditions of the given formula and procedure.

When vegetable oil was used in a quantity representing two thirds of the plastic shortening in the standard formula (12% on flour basis), RV-1 was found to be the only emulsifier to give an end product which equaled in quality to the corresponding plastic shortening cake. In the

TABLE 2

The Effects of Five Emulsifiers on the Quality of Cakes Prepared With Plastic Shortening or Vegetable Oil

		Emulsifier				
Lipid	Evaluated property	Atlas A[a]	Atmul P-44[a]	PGME[a]	RV[a]	RV-1[a]
Plastic shortening	Batter density, g/ml	0.737^{c}	0.833^{a,b}	0.861^{a,b}	0.873^{a}	0.779^{c,b}
	Cake volume, ml	1416^{a}	1325	1188	1269	1415^{a}
	Cake density, g/ml	0.275^{a}	0.296	0.324	0.311	0.276^{a}
	Firmness, Kg force	1.45	1.13	—	1.27	0.98
Canola oil	Batter density, g/ml	0.756	0.992	1.086^{a}	1.082^{a}	0.715
	Cake volume, ml	1273	1121	925	967	1439
	Cake density, g/ml	0.307	0.345	0.437	0.405	0.269
	Firmness, Kg force	1.56	1.88	3.83	3.02	0.85
Corn oil	Batter density, g/ml	0.747^{b}	0.983	1.066^{a}	1.049^{a}	0.710^{b}
	Cake volume, ml	1321	1156	940	965	1464
	Cake density, g/ml	0.294	0.333	0.417^{a}	0.402^{a}	0.265
	Firmness, Kg force	1.58	2.11	3.77	2.98	0.79

All data are means of four determinations. Values in horizontal lines not followed by the same letter are significantly different ($P < 0.50$).
[a]The emulsifiers were used at the following concentrations (on flour basis): Atlas A, 3%; Atmul P-44, 0.8%; PGME, 1.5%; RV, 1%; RV-1, 3%.

TABLE 3

The Effects of the Emulsifier (PGME, RV) Condition on the Cake Quality

	Plastic shortening		Corn oil				Canola oil			
	RV[a]		PGME[a]		RV[a]		PGME[a]		RV[a]	
	Powdered	Melted	Powdered	Melted	Powdered	Melted	Powdered	Melted	Powdered	Melted
Batter density, g/ml	0.873	0.975	1.066	0.793	1.049	0.869	1.086	0.811	1.082	0.982
Cake volume, ml	1269^{a}	1212^{a}	940^{c}	1112^{b}	965^{c}	1213^{a}	925^{c}	1120^{b}	968^{c}	1100^{b}
Cake density, g/ml	0.311^{b}	0.322	0.417^{a,b}	0.351^{c}	0.402^{b}	0.321^{d,c}	0.437^{a}	0.348^{c,d}	0.405^{b}	0.358^{c}
Firmness, Kg force	1.27^{d}	1.57^{c,d}	3.77^{a}	1.50^{c,d}	2.98^{b}	1.68^{c,d}	3.83^{a}	1.80^{c}	3.02^{b}	1.62^{d}

All data are means of four determinations. Values in horizontal lines not followed by the same letter are significantly different ($P < 0.05$).
[a]The emulsifiers were used at the following concentrations (on flour basis): RV, 1%; PGME, 1.5%.

case of RV-1, the oil type cakes even surpassed the plastic shortening control in volume and lower firmness. Atlas A, which in the presence of plastic shortening displayed a baking potential comparable with RV-1, failed to perform equally well in the oil-type batters. Nevertheless, it still produced cakes of a satisfactory volume, grain and texture. The three other emulsifiers performed poorly, especially PGME and RV. Their performance improved when they were melted in the lipid ingredient prior to their incorporation into the batter rather than when being used in the original powdered form. While such a procedure, when applied to batters containing plastic shortening, resulted in only a marginal change in the quality of the cake, it had a noticeable effect on the quality of the oil type cakes (Table 3). Nevertheless, the improvement in their quality was not of a magnitude sufficient to make them comparable with those containing the other tested emulsifiers.

As for the type of vegetable oil, there were no significant differences between the canola oil cakes and those prepared with corn oil. The profiles and the internal appearance of the plastic shortening and canola oil type cakes can be judged from Figure 1.

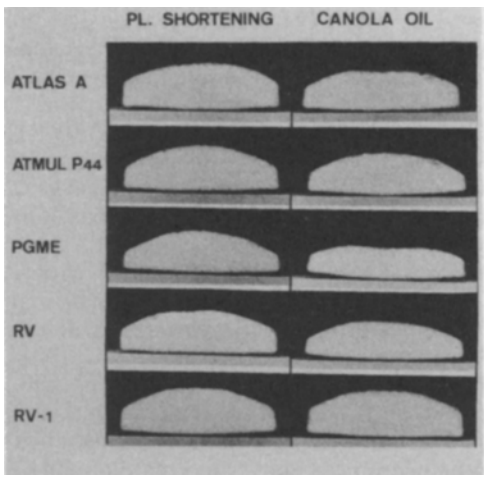

FIG. 1. Profiles of cakes baked with plastic shortening or vegetable oil and different emulsifiers. Emulsifiers used at following concentrations (on flour basis): Atlas A, 3%; Atmul P 44, 0.8%; PGME 1.5%; RV, 5%; RV-1, 1%.

TABLE 4

Comparison of Oil/Emulsifier Combinations in Sucrose/Sorbitol (70/30) Cakes

		Canola oil, %[a]					Corn oil, %[a]		
		12		6			6		
		Hydration, %		Hydration, %			Hydration, %		
Emulsifier	Measured property	100	110	110	120	130	110	120	130
RV-1[b]	Batter density, g/ml	0.696	0.670	0.599	0.584	0.585	0.601	0.630	0.620
	Cake volume, ml	1480[b]	1450[b,c]	1538[a]	1468[b,c]	1463[b,c]	1543[a]	1415[c]	1405[c]
	Cake density, g/ml	0.264[b]	0.266[b,c]	0.250[a]	0.258[b]	0.260[b,c]	0.251[a]	0.271[c]	0.274[c]
	Firmness, Kg force	0.80[a]	0.80[a]	0.78[a]	0.78[a]	0.68[b]	0.68[b]	0.77[a,c]	0.75[c]
Atlas A[b]	Batter density, g/ml	—	—	0.751	0.723	0.732	—	0.757	0.750
	Cake volume, ml	—	—	1330	1313	1268	—	1288	1275
	Cake density, g/ml	—	—	0.289	0.292	0.303	—	0.295	0.302
	Firmness, Kg force	—	—	1.30	0.98	0.85	—	1.03	0.84

All data are means of four determinations. Values in horizontal lines not followed by the same letter are significantly different ($P < 0.05$).
[a]On flour basis.
[b]The emulsifiers were used at the following concentrations (on flour basis): RV-1, 3%; Atlas A, 3%.

Based on the above results, the two best performing emulsifiers—Atlas A and RV-1—were selected for tests involving oil-cake batters having oil content reduced and sucrose partly replaced with either sorbitol or polydextrose. Table 4 summarizes results obtained with the 70/30 sucrose/sorbitol batters. At this extent of sucrose replacement, the functionality of the batters was not affected to any significant degree provided the quantity of oil in the formula was maintained at the original 12% level (on flour basis). Expectedly, as the oil content was reduced to 6%, the "whip-ability" of the batters increased. This change was followed by an excessive increase in cake volume with the development of a less desirable "fluffy" texture and dry-mouth feel of the crumb. In order to prevent this deterioration in quality, the water content in the formula was increased. Optimum results were obtained when the hydration was raised from 110 to 120%. At this hydration level, the RV-1 cakes with 6% oil differed very little in volume and other characteristics from the 12%-oil control. Further increase in hydration left the volume and density of the cakes practically unchanged but created a danger of enhanced crumb stickiness. The Atlas A cakes displayed similar tendencies in their response to the changing formula but were all found to be of a distinctly poorer quality compared with the RV-1 cakes. Some differences between the functioning of the two mentioned emulsifiers were also noticed when the firmness data were compared. While increased hydration led to a steady decrease in the firmness of Atlas A cakes, the firmness values of cakes emulsified with RV-1 remained more or less unaffected. As for the type of oil, there were no significant differences which could be related to this variable.

In comparing the low-oil cakes with the plastic shortening control or the 12% oil-type cake, a tendency toward a more open grain with occassional tunnel-shaped vertical holes in the crumb was noticed. One plausible explanation of this phenomenon may refer to a stronger gluten matrix developed in the prsence of an insufficient lipid quantity. A stronger matrix offers a greater resistance to expansion within the cake with the result of a number of ruptures in the structure in the direction of the crown of the cake (17). Reducing the mixing time at stage 2 of the baking procedure (see Materials and Methods) from 3 min to 2 min eliminated this fault in the internal appearance to a satisfactory degree without any significant changes to the cake density or volume. Profiles of some of the low-oil sucrose/sorbitol cakes prepared under such conditions are presented in Figure 2.

Results obtained with low oil batters containing polydextrose are summarized in Table 5. The emulsifier used was RV-1 and all batters contained 0.8% xanthan gum (on flour basis). In general, the batters gave a poorer performance than those in which sucrose was partly replaced with sorbitol. Once again, reduced oil content in the batters enhanced their whip-ability but, unlike sorbitol batters, this enhancement had to be viewed as highly desirable. The volume and density of the cakes moved closer to the range associated with the standard formula control. Further improvement followed after the hydration had been raised from 110% to 120%. At 120% hydration and oil levels of 6 or 3% (on flour basis), cakes baked

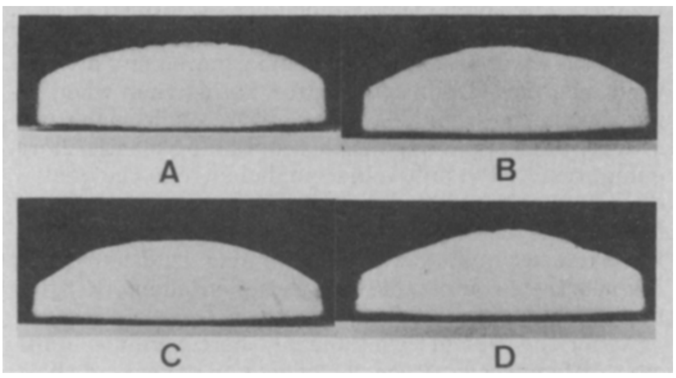

FIG. 2. Comparison of cakes baked from low oil (6% on flour basis) sucrose/sorbitol batters. (A) Plastic shortening; Atlas A, 3%; control. (B) Canola oil; Atlas A, 3%; 120% hydration. (C) Canola oil; RV-1, 3%; 110% hydration. (D) Canola oil; RV-1, 3%; 120% hydration.

TABLE 5

Quality Indicators of Cakes Prepared With Sucrose/Polydextrose Mixtures at Different Oil Levels and Hydration. (All Cakes Prepared With RV-1 Emulsifier)

	Sucrose/polydextrose—70/30						Sucrose/polydextrose—60/40			
	Oil level %^{a}									
	12		6		3		12		3	
	Hydration, %									
	100	110	110	120	110	120	110	120	110	120
Batter density, g/ml	0.735	0.771^{b}	0.676	0.787^{b}	0.757^{c}	0.701	0.790^{a}	0.806^{a}	0.767^{b,c}	0.722
Cake volume, ml	1275^{b}	1223^{c,d}	1300^{b}	1405^{a}	1438^{a}	1493	1180^{c,d}	1155^{d}	1385^{a}	1405^{a}
Cake density, g/ml	0.303^{a,b,c}	0.317^{a,b}	0.295^{b,c,d}	0.272^{f}	0.267^{e,f}	0.250	0.327^{a}	0.332^{a}	0.278^{c,d,e}	0.272^{c,d,e,f}
Firmness, Kg force	1.33^{a}	1.30^{a}	1.08^{c}	0.88^{b}	1.15	0.806	1.23^{d}	1.25^{d}	1.06^{c}	0.86^{b}

All data are means of four determinations. Values in horizontal lines not followed by the same letter are significantly different ($P < 0.05$).
[a]On flour basis.

from the 70/30 sucrose/polydextrose batters were of a good quality fully comparable with that of the plastic shortening "full-sucrose" control. However, a tendency toward denser crumb and lower volume was noticed when the sucrose/polydextrose ratio was changed to 60/40. This deterioration in quality was accompanied by the development of a slight, but easy to perceive, bitter aftertaste. On the other hand, the 70/30 cakes were pleasant to taste and did not require any artificial sweetener to compensate for the reduction in sucrose content.

Comparing the baking potential of the RV-1 emulsifier with Atlas A in the sucrose/polydextrose cakes produced results which were consistent with those previously discussed for the other tested oil-type cakes (Table 6). The profiles of the polydextrose containing cakes are shown in Figure 3. It should be noted that these cakes were the only ones which seemed to have their quality attributes affected by the type of oil. Corn oil, compared with the canola oil, tended to give cakes with a lower volume and firmer crumb.

The final stage of this work was concerned with the firming of the tested low-oil cakes during storage (Table 7). Cakes prepared for this testing were baked from batters containing RV-1 (3% on flour basis). All reduced calorie cakes were characterized by a lower initial crumb firmness compared with the plastic shortening control. Their firmness, however, increased at a much higher rate over the first 48 hr of storage. After a 96-hr storage, the relative increase, expressed as percentage of the initial firmness, was in a relatively narrow range for both the control and the reduced calorie cakes, with the only exception of the 60/40 sucrose/polydextrose cake prepared at the 3%-oil level. The latter distinguished itself from the rest of the reduced calorie cakes by a considerably faster firming throughout the whole storage period. Despite this faster firming, its final firmness at the end of the 96-hr period, like the firmness of all other reduced calorie cakes, was still below that of the "full-shortening" control. Moisture analysis revealed differences in the capability of the cakes to retain moisture under the given storage conditions, but these appeared unrelated to the firming data. Evidently, the firming process was, to at least some extent, a result of internal changes in the structure of the crumb rather than solely of a loss in moisture. Cohesiveness data were less consistent and did not reveal any conclusive trend.

TABLE 6

Comparison of Oil/Emulsifier Combinations in Sucrose/Polydextrose (70/30) Cakes[a]

	Canola oil		Corn oil	
	RV-1	Atlas A	RV-1	Atlas A
Batter density, g/ml	0.676	0.878	0.740	0.890
Cake volume, ml	1300	1278^{a}	1263^{a}	1120
Cake density, g/ml	0.295^{a}	0.303^{a}	0.304^{a}	0.343
Firmness, Kg force	1.08	1.31	1.50	1.78

All data are means of four determinations. Values in horizontal lines not followed by the same letter are significantly different ($P < 0.05$).
[a]Cakes prepared at 110% hydration, 6% oil (on flour basis), 3% RV-1 (on flour basis).

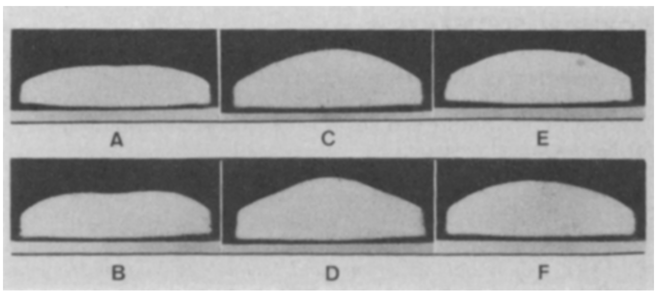

FIG. 3. Comparison of cakes baked from low-oil sucrose/polydextrose batters. (A) Sucrose/polydextrose 70/30, Atlas A, 6% corn oil, 110% hydration. (B) Sucrose/polydextrose 70/30, Atlas A, 6% canola oil, 110% hydration. (C(Sucrose/polydextrose 70/30, RV-1, 3% canola oil, 110% hydration. (D)Sucrose/polydextrose 70/30, RV-1, 3% canola oil, 120% hydration. (E) Sucrose/polydextrose 60/40, RV-1, 3% canola oil, 110% hydration. (F) Sucrose/polydextrose 60/40, RV-1, 3% canola oil, 120% hydration.

TABLE 7

Storage Tests on Cakes Prepared With Selected Formulas

		Sucrose/sorbitol		Sucrose/polydextrose	
		70/30		70/30	60/40
	Control[a]	3% oil[b]	6% oil[b]	3% oil[b]	3% oil[b]
Cake volume, ml	1370	1370	1314	1463	1378
Firmness, Kg force[c]					
24 hr	1.45	0.83	1.02	0.95	1.03
48 hr	1.48	0.90	1.10	1.08	1.28
	(1.7)	(8.4)	(7.8)	(13.2)	(24.4)
96 hr	1.84	1.10	1.25	1.23	1.55
	(26.9)	(32.5)	(22.5)	(28.9)	(51.2)
Cohesiveness					
24 hr	1.18	1.07	1.05	1.12	1.01
48 hr	1.22	1.09	1.13	1.16	1.11
96 hr	1.23	1.19	1.25	1.26	1.32
Dry solids, %[c]					
24 hr	72.6	64.8	65.8	68.1	68.2
96 hr	75.5	74.4	68.5	69.0	69.4
	(3.8)	(14.8)	(4.2)	(1.2)	(1.7)

All cakes prepared with 3% RV-1 (on flour basis).
[a]Plastic shortening control with Atlas A (see Table 1).
[b]On flour basis.
[c]Values in parentheses indicate the % increase in firmness or dry solids compared with the respective 24 hr values.

REGULATORY STATUS

The data presented is considered an experimental work. Before adaption to commercial use, the usage level of the individual emulsifier and its approved status as a food additive in each country has to be checked. To the best of the author's knowledge each emulsifier used in this work is approved in cakes by the Canadian Food and Drug regulation in the following pages: SSL (67-A2), Polysorbate 60 (67-128), Sorbitan Monostearate (67-17), Mono and Diglycerides (67-12-26-60) and PGME (67-14). The emulsifiers are approved by the U.S. FDA as food additives under 21CFR 172.846, 172.836, 172.842, 182.4505 and 172.856 respectively. In Europe, the ECC approved numbers are E481, 435, 491, 471 and E477 respectively.

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