Development of a Laboratory-Scale Single-Stage Cake Mix[1]

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ABSTRACT

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Grinding the fat system with the dry ingredients gave a cake mix that produced a lower batter specific gravity but a higher cake volume than that obtained with the same formula but without grinding. Grinding in a Stein mill apparently can replace the action of a cake finisher. Performance of the fat-emulsifier system was improved by cooling the melted mixture at 10° C. Crystal size of the emulsifier-fat blend and its performance in reducing specific gravity did not appear to be directly related. The amount of emulsifier in the blend was of equal or greater importance. Adding xanthan gum improved cake volume.

Mono- and diglycerides were first used in the baking industry in the early 1930s, primarily for producing layer cakes (Hanamoto and Bean 1977). Fats containing mono- and diglycerides gave the baker the means to produce high-ratio cakes with good volume and texture. However, the emulsifiers caused problems in tempering the fats to obtain an optimum crystalline structure and in dispersing the fats in the mix. New emulsifiers have been developed for use in cake mixes, and convenient, one-stage cake mixes can now be prepared.

Polysaccharides or hydrocolloids, commonly referred to as "gums," are found in almost all commercial cake mixes. Gums give a thickening or gelling effect and exhibit such related properties as stabilization and incapsulation. Adding gums to cake mixes changes the rheology of the cake batters and improves the eating quality, texture, appearance, and shelf-life of the cakes.

Our objective was to develop procedures to produce single-stage, white, layer-cake mixes. We also investigated the effect of fat crystal size on cake quality.

MATERIALS AND METHODS

The materials used and their sources were: propylene glycol monostearate (PGMS, PROMOPAN SP), Grindsted Co.; Mono- and diglycerides, Durkee Co.; shortening (D10), Durkee Co.; lecithin (UF 250), Paniplus Co.; xanthan gum, Kelco Co.; dry egg white (White-n-Lite), Monark Co.; and cake flour (pH 4.72), Mennel Milling. Other ingredients, powdered sugar 6X, baking powder ($NaHCO_3$ and SALP), and salt were obtained in quantities large enough to complete all tests.

Cake Procedure

The formula used (Table I) for white layer cakes was established after a series of preliminary trials. The procedure for preparing cake mixes is outlined in Fig. 1. Shortening (D10) and/or emulsifiers (PGMS and mono- and diglycerides) were heated in an aluminum dish on a hot plate until clear and then immediately placed in a cold room (10° C) and cooled overnight. Lecithin was weighed into the aluminum dish containing the described mixture of fat and emulsifiers. To prepare the cake premix, the fatty ingredients and sugar were placed in a Stein mill cup and ground for 2 min; the remaining dry ingredients then were added to the cup and ground for an additional 2 min. Cake batters were prepared by mixing water and cake premix with a Sunbeam household mixer at speed 8 for 3 min; the batter was then scraped from the sides of the bowl and mixed for 3 more min. Batter specific gravity and viscosity were then measured. Cakes (240 g of batter in 6 × 1½ in. pan) were baked at 375° F for 25 min in a National reel oven. Volume, top contour, grain quality, and shrinkage of the cakes were determined. Data reported were based on a minimum of three replications. Standard deviation for cake volume was 19 cc.

Measuring Batter and Cake Characteristics

Specific gravity (expressed as grams per milliliter) of batter was determined by filling a glass cup with batter, weighing it, and comparing its weight with that of the same cup filled with water (water specific gravity was taken as 1.0 g/ml). Standard deviation for determining specific gravity was 0.017 g/ml.

All measurements on cakes were determined after the cakes had cooled 60 min. Cake volume was measured by rapeseed displacement.

Because most commercial cake mixes contain mono- and

TABLE I
White Layer-Cake Formula

Ingredient	Flour Weight Basis (%)	Total Weight Basis (%)
Flour	100.00	24.82
Sugar (6X)	110.00	27.30
Shortening (D10)	18.80	4.67
Propylene glycol monostearate	4.00	0.99
Mono- and diglycerides	3.00	0.75
Lecithin	0.81	0.20
Dry egg white	3.50	0.87
Sodium bicarbonate	3.00	0.74
Sodium aluminum phosphate	3.30	0.82
Salt	1.50	0.37
Water	155.00 (ml)	38.47

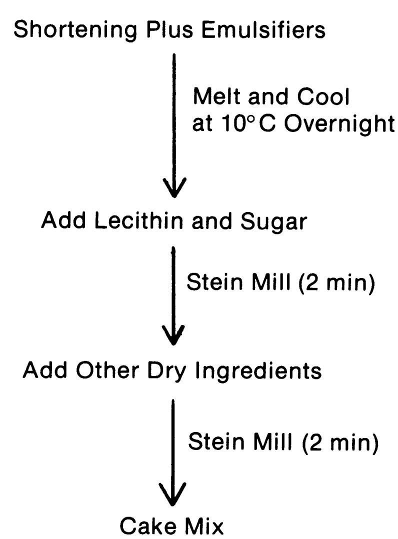

Fig. 1. Procedure for preparing white layer cake mixes.

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TABLE II
Cakes Made from Different Test Cake Mixes and a Commercial White-Cake Mix

Sample	Specific Gravity (g/ml)	Volume (cc)
Premix 1	1.074	520
Premix 2	0.879	545
Premix 3	0.881	535
Premix 4	0.775	535
Premix 5	0.578	580
Premix 6	0.655	620

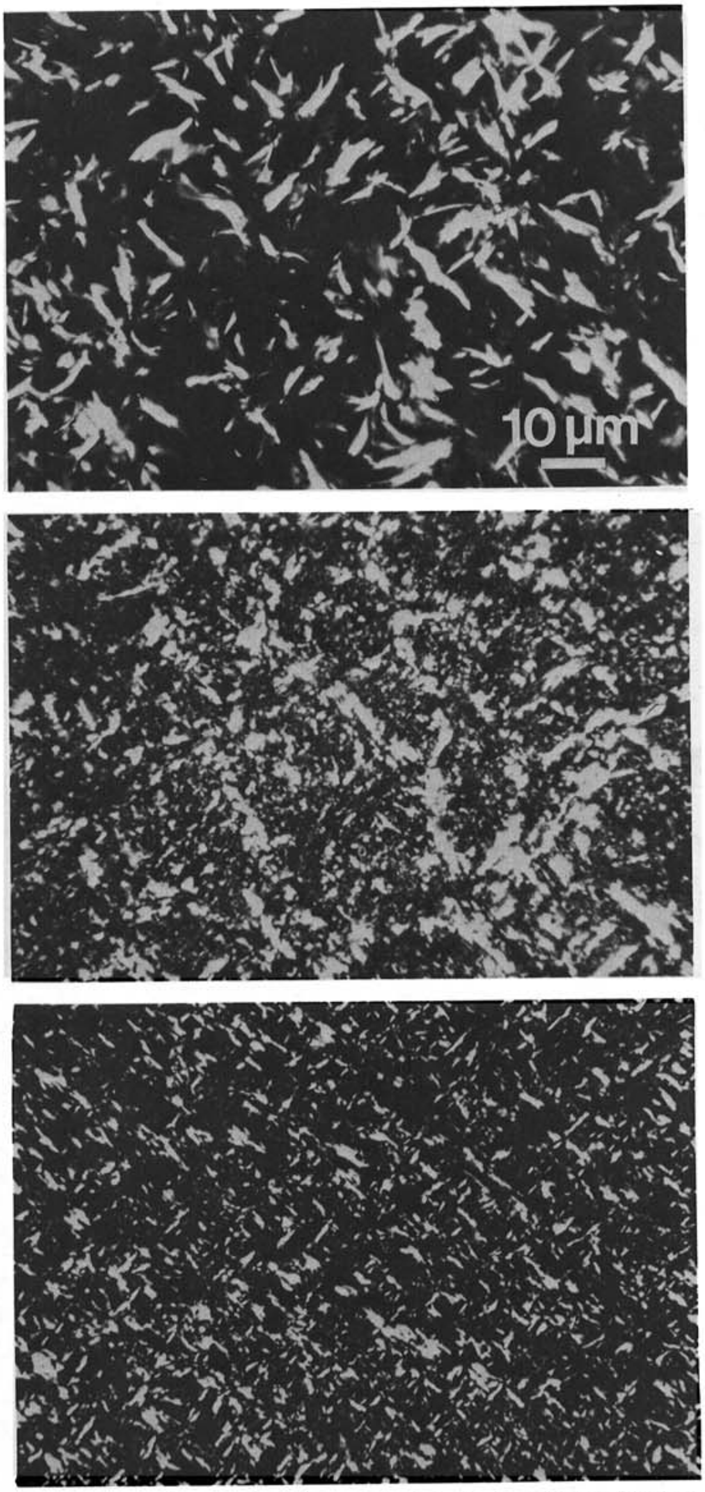

Fig. 2. Photomicrographs of fat crystals of shortening D10 at 25° C (**top**), 10° C (**middle**), and −79° C (**bottom**).

diglycerides and PGMS, those emulsifiers were chosen for this study. Our first question was how to add the emulsifiers. Cake mixes produced commercially are processed through cake finishers. We hoped to use a small laboratory grinder (Stein mill) as a cake finisher. During the preliminary studies, a tentative cake formula (Table I) was used.

Cakes made from a commercial white-cake mix were compared with those made from each of five cake mixes prepared by different premix procedures.

Premix 1. PGMS was melted (60° C) and spread on top of the flour; this mixture was ground in a Stein mill for 1.5 min, then mixed, using a hand mixer with the rest of the dry ingredients to form a cake premix.

Premix 2. Sugar was mixed using a hand mixer with shortening (D10) and lecithin for 1.5 min; the flour and emulsifiers (prepared as described for premix 1) and the rest of the dry ingredients were then added and blended in a Hobart mixer at slow speed for 1 min to form a cake premix.

Premix 3. The procedure for making cake premix was the same as that for cake 2, except that PGMS was melted with mono- and diglycerides rather than being spread alone on top of the flour.

Premix 4. PGMS was melted with D10 (60° C) to form a fat-emulsifier blend. After the mixture had cooled at 10° C overnight, a hand mixer was used to mix that blend with lecithin and sugar for 1.5 min. The remaining dry ingredients were added, and the mixture was blended in a Hobart mixer at slow speed for 1 min to form a cake premix.

Premix 5. The procedure for making cake premix was the same as for cake 4, except that the fat-emulsifier blend was ground with lecithin and sugar in a Stein mill for 2 min; the remaining ingredients were then added and ground for 2 more min to form a cake premix.

Premix 6. Duncan Hines white cake mix (143 g) was mixed with 2.29 g of dry egg white. To form a cake batter, 105 ml of water was used.

RESULTS AND DISCUSSION

Preparing Cake Premixes

Batters were prepared from the cake mixes by adding water and mixing in a Hobart mixer at slow speed for 2 min and medium speed for 3 min. Specific gravity of batters and volumes of cakes were measured (Table II). The data show that the preparation process and the preparation of the fat-emulsifier blend are important factors controlling the specific gravity of cake batters. Low specific gravity indicates good aeration of the batter. The cake from premix 1 had a high specific gravity, indicating poor aeration of cake batter. The resultant cake was severely cracked and of small volume.

In premix 2, shortening and sugar were dry-mixed before they were blended with the flour-plus-emulsifiers and the rest of the dry ingredients. Both specific gravity and volume of cake 2 were improved by the premixing step. In premix 3, adding mono- and diglycerides with the PGMS did not improve batter specific gravity or cake volume. However, the grain quality of the resultant cake seemed improved.

In premix 4, melting the shortening and PGMS together before making the cake mix improved batter specific gravity. That improvement may be related to the crystalline form of fat and emulsifier. Cake volume, however, was not improved.

An examination of premix 4 and the commercial cake mix (premix 6) under a microscope revealed that the shortening was distributed much better in the commercial mix. To improve fat distribution, we processed premix 5 by replacing the hand mixing (used in premix 4) with Stein milling. Batter specific gravity was greatly improved (lowered), and in fact, was lower than that of the cake batter from the commercial cake mix. Cake volume was also improved, although it was still less than that of the cake made from the commercial cake mix.

Assuming that heat would be generated during cake finishing, we also tested the effect of heating the PGMS-flour mixtures on cake quality. We prepared the cake mixes as for premix 2. Before a cake mix was formed, we heated the flour-plus-emulsifier for 10 min in an oven at six different temperatures: 40, 50, 60, 70, 80, and 90° C. Heating did not affect either batter specific gravity or cake volume.

Early in this work, cake batters were prepared by mixing water and cake premixes in a Hobart mixer at slow speed for 2 min and at medium speed for 3 min. Cake was made by scaling 240 g of cake batter into a greased and floured pan (6 × 1½ in.) and baking it at 375° F for 30 min.

Stein milling greatly improved the specific gravity of the cake batter; we therefore decided to use that grinder for subsequent work. Because the Stein mill can grind only about 60% of that cake mix at one time, however, we adjusted to 60 g of flour and used a household mixer (Sunbeam) with a small mixing bowl for subsequent work. The household mixer gave a specific gravity of 0.585 g/ml, which was close to that from the Hobart mixer (0.579 g/ml); the cake volume of 555 cc was greater (505 cc).

Effect of Temperature and Emulsifier Content on Cakes

Most fats normally exhibit four crystalline forms: α, β', I (intermediate), and β. In cakes using two-stage mixing, the ability of shortenings to produce the desired effect in cake is directly related to their crystalline characteristics (Hoerr et al 1966); however, emulsifiers greatly reduce the dependence on solid fats and their crystalline forms for aerating properties of the fat systems (Birnbaum 1978). Although shortenings and emulsifiers are frequently treated as separate subjects, their performance in cakes must be considered as a coordinated system.

In the following experiments, we studied the effect of processing conditions of the fat systems on the quality of white layer cakes. Fat and/or emulsifiers were processed at one of three different temperatures (room temperature, 25° C; cold room temperature, 10° C; and dry ice temperature, −79° C) before being used in cakemaking.

Photomicrographs of shortening fat crystals as affected by recrystallization temperature are shown in Fig. 2. At 25° C, the fat crystals were about 15 μm (I-β); at 10° C, about 6 μm (β'-I); and at −79° C, about 3 μm (β'-I). Thus, as the recrystallization temperature decreased, the crystal size decreased.

The effects of fat-emulsifier blends processed at 25° C with different PGMS levels on specific gravity and cake volume are shown in Table III. The cake formulation, batter, and cake preparation were the same as for premix 4. As shown in Table III, the cake batter made from the lowest level of PGMS had the highest specific gravity, and the cake volume was the lowest. Cakes made from batters with other levels of PGMS had equal specific gravities and volumes.

Fat-emulsifier blends processed at 10° C gave batters that became lighter as more PGMS (up to about 7 g) was added (Table III). Thus, PGMS aids in incorporating air into cake batter. As the PGMS level was increased, the air cells became smaller and more numerous (Fig. 3), and the resultant cake gained in volume.

The quality of white layer cakes made from cake mixes containing fat-emulsifier blends processed at −79° C with different PGMS levels is shown in Table III. Although the specific gravity of the cake batter made from the least amount of PGMS was higher than the three other levels, it was still fairly low. The volume of the cakes made from batters with different amounts of PGMS was not significantly different.

From these results, we concluded that the processing condition (temperature) and the amount of emulsifier affects the specific gravity of cake batters. The distribution of air cells in cake batter, as viewed with the microscope, is consistent with that conclusion (Fig. 3). Therefore, the optimum amount of emulsifier in a fat system for a cake depends on the processing condition (temperature). For example, less PGMS can be used in a D10-PGMS blend processed at −79° C to achieve the same cake batter specific gravity as that for cakes made from the fats processed at 10 or 25° C. Microscopic examination showed that the effect of emulsifier content in fat-emulsifier blends did not affect the fat crystal sizes. The crystal size was affected only by temperature. Thus, no direct relationship appears to exist between crystal size and performance of the fat-emulsifier blend in reducing specific gravity. The amount of emulsifier in the blend is also important.

TABLE III
Effect of Fat Systems Processed at Various Temperatures with Different Levels of Propylene Glycol Monostearate (PGMS) on White Layer Cakes

	25° C		10° C		−79° C	
Amount of Emulsifier	Specific Gravity (g/ml)	Volume (cc)	Specific Gravity (g/ml)	Volume (cc)	Specific Gravity (g/ml)	Volume (cc)
D10 + 2 g of PGMS	0.924	460	0.947	510	0.711	555
D10 + 3 g of PGMS	0.748	505	0.782	520	0.631	560
D10 + 4 g of PGMS	0.710	490	0.697	515	0.630	560
D10 + 5 g of PGMS	0.714	505	0.658	530	0.642	545
D10 + 6 g of PGMS	···	···	0.646	570	···	···
D10 + 7 g of PGMS	···	···	0.604	550	···	···
D10 + 8 g of PGMS	···	···	0.620	550	···	···

TABLE IV
Effect of Xanthan Gum on Batter Specific Gravity and Cake Volume

Level[a] (%)	Specific gravity (g/ml)	Volume (cc)
Control[b]	0.565	460
Xanthan gum, 0.1%	0.613	500
Xanthan gum, 0.5%	0.604	500
Xanthan gum, 1.0%	0.614	530
Commercial mix	0.655	533

[a]Based on flour weight.
[b]Cake formulation, batter, and cake preparation was as with premix 5, except mono- and diglyceride was used, and the batter was scaled to 200 g instead of 240 g.

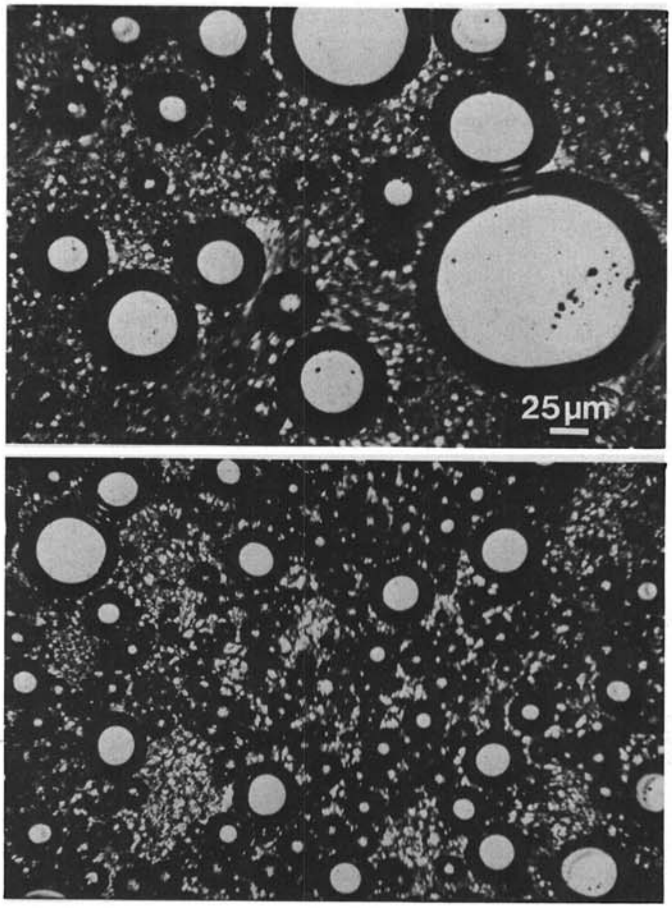

Fig. 3. Photomicrographs of cake batters, 2% (**top**) and 6% (**bottom**) of propylene glycol monostearate based on flour weight at 10° C.

Most commercial, single-stage cake mixes contain a hydrophilic gum. We used xanthan as a representative gum. Adding small amounts of the gum increased cake volume. At 1% xanthan (based on the flour weight), the cake mix gave a cake that equalled the commercial cake mix (Table IV) in volume and a batter that was lower in specific gravity.

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