Functions and Requirements of Fats and Emulsifiers in Prepared Cake Mixes

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ABSTRACT

Accompanying demands for product changes in formulation, recipe preparation and processing of prepared cake mixes have been modifications in the shortening and emulsifier system. Shortenings and emulsifiers are a major consideration in cake mix formulation and can provide the formulator with new opportunities. This research investigates the development of a shortening for a dry cake mix system with consideration given to three major factors. First, the type of fat used—its source, its crystalline structure, its ability to aerate and its physical form. Secondly, the type and amount of emulsifiers—mono- and diglycerides, polyglycerol esters, propylene glycol monoesters and glycerol lacto esters are reported. Third, the processing of the dry mix and its effect on the fat.

HISTORY OF CAKE MIXES

Striving after improved products that are good tasting, convenient and of high quality has resulted in many reformulations in the history of prepared cake mixes. Many of these changes were possible because of shortening and emulsifier technology.

Major improvements began in the 1930s with the introduction of emulsified shortenings. These shortenings gave the baker the potential for high ratio formulas and produced cakes with better volume and texture. To the prepared cake mix industry, these improvements also brought problems of dispersing the shortenings onto the mix and tempering the shortenings to keep them in the optimum crystalline structure. This shortening, when used in prepared mixes, required a rather inconvenient three-stage preparation by the homemaker.

In the late forties and fifties the cake mix industry improved their methods of extruding and plating shortening onto the dry mix and had modified homemaker preparation to a two-stage mixing procedure.

In the late fifties and early sixties another major improvement in cakemixes occurred. Emulsifiers that had been esterified were introduced. The first to be used was the glyceryl lactyl palmitates and later the propylene glycol mixed esters. These emulsifiers increased the ability of the mixes to hold liquids and to distribute the shortening in finer particles. The introduction of these emulsifiers allowed the development of instant cakes—a convenient one-stage preparation process.

The technology of layer cake mixes has remained much the same since that time, but the challenge continues for the development of a cake with the best eating quality, the right texture and appearance and, of course, the right price.

Shortening has played a major role in the changes of cake mixes. But how does a shortening function in a cake system and what is required of a shortening in a dry cake mix system?

FUNCTIONALITY OF SHORTENINGS

A cake shortening has three functions in a cake system. First, it entraps air during mixing. Second, it tenderizes the cake crumb. Third, it has the ability to incorporate water that is added to the dry mix.

A cake batter can be viewed as an emulsion. The dry ingredients, such as sugar, flour, salt and baking powder, are incorporated into the liquid phase but the fat or oil phase remains dispersed in lakes or clumps throughout the continuous or liquid phase and does not become part of the liquid phase.

Figure 1 shows the distinction of the fat and water phases. In the lakes of fat, the air cells are entrapped. Sometimes in staining the air cells appear only as black dots. The background is the protein. Some starch granules can also be identified by the appearance of the maltese cross in the liquid phase. Because the air cells are entrapped in the fat, the fat phase has the function of aerating the batter. The air cells provide sites for the water vapor evolved during baking. The vapor pressure then gives expansion to the cake.

Carlin (1) in his microscopic study of fats in cakes, concluded that during baking the fat quickly melts and releases the air cells into the continuous or liquid phase. The gas produced by the leavening agents coalesces with the air cells to give expansion to the product.

The ability of a shortening to aerate the batter is also a function of its crystalline form. Fats are polymorphic. They can occur in different crystalline states. There are thought to be four crystalline forms: (a) alpha, (b) beta prime, (c) intermediate and (d) beta. The alpha crystals are formed by rapid cooling of the fat; they are the least stable and are quickly transformed into one of the other forms.

For cake baking, the beta prime has been found to be the best. Lutton (2) postulated that three different arrangement patterns existed. In the cross-sectional views the different orientations existed because of different arrangements on the triglyceride chain. Alpha crystals have random orientation and the beta crystals have all the chain axes oriented in one direction.

From the cross-sectional views, the alternate rows and opposite orientation of the beta prime would lead to the conclusion that it would be the most effective form for the entrainment of oil in the plastic type shortening.

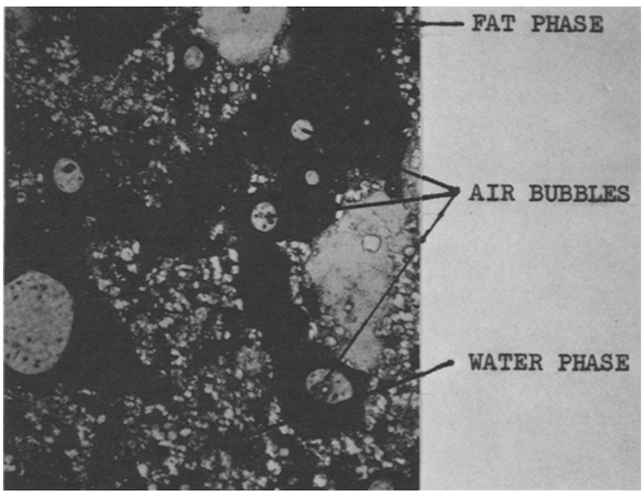

FIG. 1

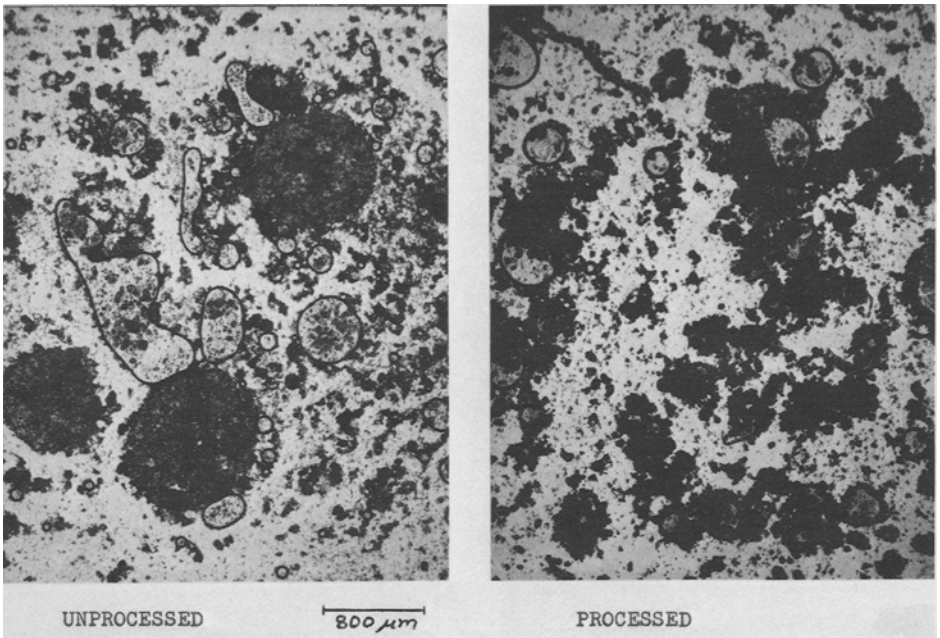

FIG. 2

It is desirable that the fat phase be as finely dispersed as possible throughout the batter to obtain the maximum number of suspended air cells. The dispersion of the shortening and the air cells aid in the development of the proper grain, which is fine and regular; a good texture or eating quality, which is characterized as soft, tender and moist; and a volume that is large with a well-rounded top.

In prepared cake mixes, the mixing time of the batter is very short and consists of a one-step operation compared to a bakery formulation where fat can be creamed and liquids added in various stages. With this restriction, the demands of the shortening to aerate, tenderize and emulsify is accentuated. The plating of the fat onto the dry ingredients is the normal method of distribution. This plating consists of smearing the fat onto the mix in such minute particles that the fat is widely dispersed.

Figure 2 shows the distribution of the fat when it is processed in this fashion, compared to an unprocessed mix. In both figures the large dark areas are the fat. The fat is not as finely dispersed in the unprocessed mix as it is in the processed mix. The baked cake also shows a marked difference as seen in Figure 3. Volumes of both cakes were identical. A difference is seen in the grain of the cakes. The unprocessed cake has an open, thick-walled cell structure compared to the fine, even grain of the processed cake. Processing also produces a softer crumb and a moister eating quality.

Once the fat is dispersed, the performance of the cake mix depends on how readily the shortening can aerate and how good the liquid holding capacity of the shortening is.

FUNCTION OF EMULSIFIERS

The introduction of emulsifiers are a major breakthrough in cake mix development. Figure 4 shows the difference in the performance of an emulsified versus an unemulsified shortening system. Both mixes were processed in the same manner. That is, the dispersing or smearing of the fat onto the dry ingredients was consistent. There was a marked difference in the specific gravities of the batters. The unemulsified batter had a specific gravity greater than the emulsified, indicating that not as much aeration was taking place. As the specific gravity increases, the indicated amount of aeration decreases. The unemulsified cake was

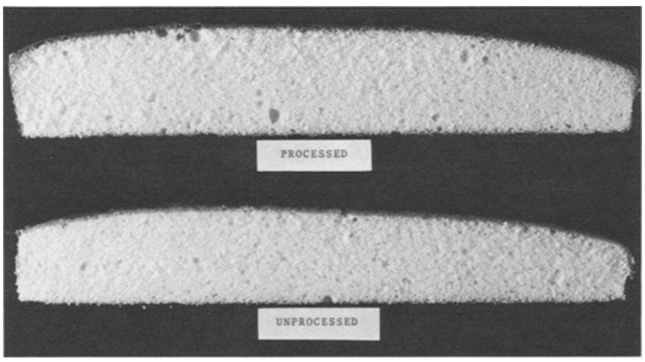

FIG. 3

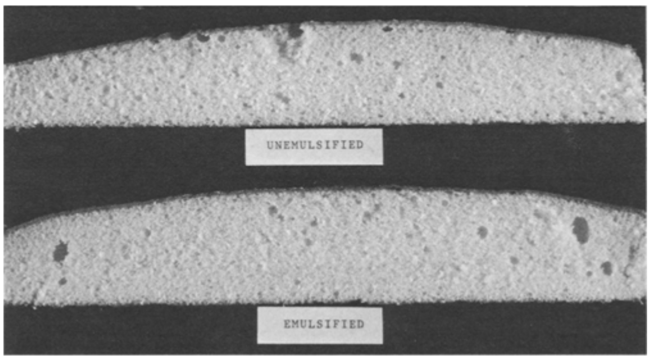

FIG. 4

flat, very firm, and had a very close compact grain.

An emulsifier functions in two ways: (a) it aides in the incorporation of air and (b) it disperses the shortening in smaller particles to give the maximum number of available air cells.

Emulsifiers contain both a hydrophilic and a lipophilic portion, usually not in an evenly balanced ratio but either primarily hydrophilic, being attracted to water, or primarily lipophilic, being attracted to fat. It is thought that the hydrophilic emulsifiers promote the uniform dispersion of fat which contains the entrapped air cells, therefore, giving many sites for both water vapor expansion and carbon dioxide given off by the chemical leavening agents. The hydrophilic portion of the emulsifier extends itself into the aqueous phase of the batter and creates a membrane between the oil-water boundaries. This membrane appears to coat or encapsulate the fat droplets distributed throughout the batter. This prevents the fat droplets containing air cells from migrating into the liquid-aqueous phase. If this migration were to take place, it is postulated by Wooton (3) that the fat droplets would reduce the foaming or aerating abilities of the proteins in the system. Therefore, emulsifiers can be said to aid in the aeration of the batter.

Emulsifying of shortening began in the 1930s with the introduction of mono- and diglycerides. Later, glycerol lactyl palmitates and propylene glycol mixed esters were used. More recently, development has centered around polyglycerol esters. All four will be discussed further.

It was noted earlier that mono- and diglycerides were used in the three-stage mixing procedure early in the production of cake mixes and in order to change the mixing procedures to a two-stage or single stage method, the glycerol lactyl palmitates (GLP) and propylene glycol mixed esters (PGME) were developed.

Figures 5a and 5b show the cake systems in which these emulsifiers were applied. All cakes were prepared using emulsified plastic shortenings. The base stock for these shortenings is a hydrogenated animal fat. The three-stage mono- and diglyceride system had a greater specific gravity and a lower volume than the other two systems. The characteristics of this cake are a very flat crown; a very fine, close grain; and a dry, crumbly eating quality. Since the

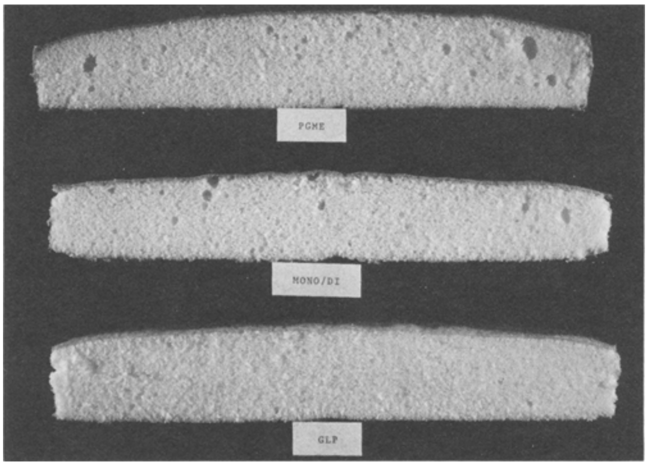

FIG. 5A

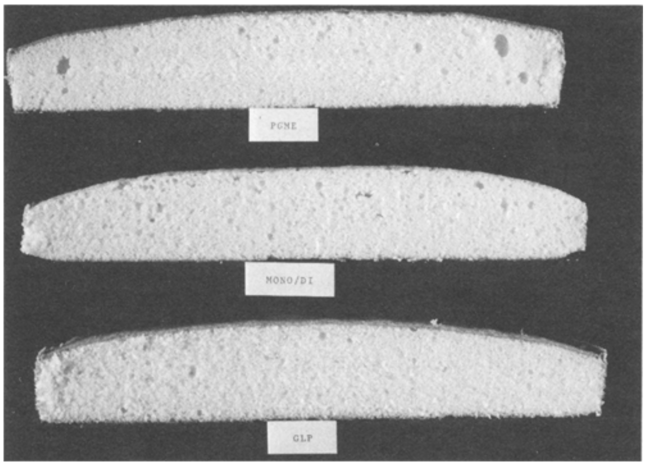

FIG. 6A

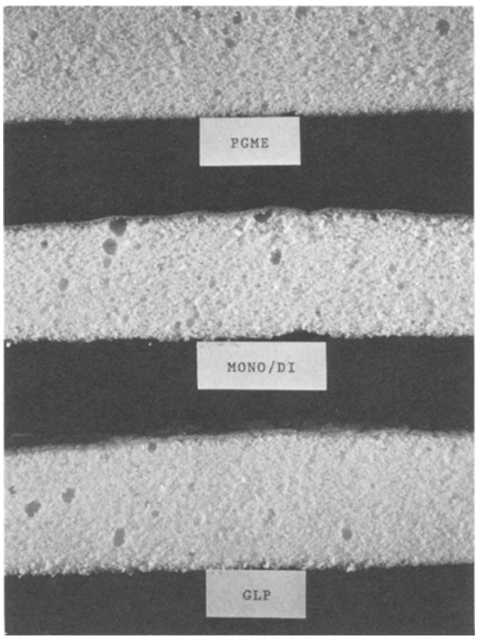

FIG. 5B

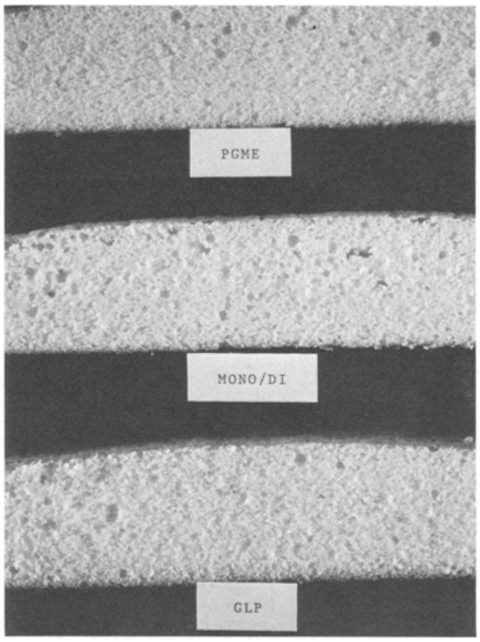

FIG. 6B

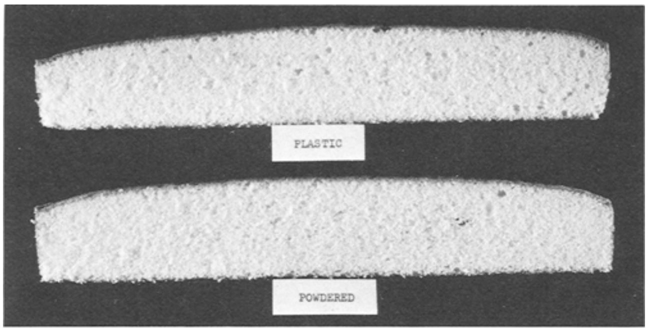

FIG. 7

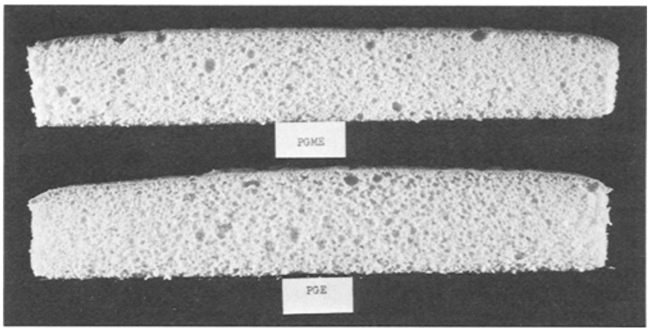

FIG. 8

specific gravity was in an upper range for a layer cake, the characteristics seen would be somewhat expected. The two-stage GLP system produced a larger volume cake with a good crown, but a crust that was very bubbly. The grain was very fine but the texture was weak and dry. The use of PGME in a one-stage method produced the largest volume cake with a very fine grain, moist eating quality, but a slightly flat crown.

The three previous applications were made in different formulations. The mixing procedure differed and other ingredients were adjusted to optimize the formula for each shortening system.

An attempt was made to apply all three emulsifiers into a one-stage formula, keeping mixing procedure and other ingredients constant. Figures 6a and 6b show this application.

The mono- and diglyceride system produced a cake that had an open and irregular grain, a batter that was very thin and a low volume. The specific gravity of the batter was greater than in the previous application using the three-stage mixing procedure. This complex mixing procedure was one of the disadvantages of using straight mono- and diglycerides in prepared cake mixes. The GLP, when used in a one-stage system, came close to the PGME system which could be considered as the control. The volume was slightly lower with the GLP and grain was fine and close, but the structure was weaker than the PGME system. The use of GLP was discontinued in prepared cake mixes because lactic acid was produced in the mix during storage.

More recently, attempts have been made to make use of the polyglycerol esters. At this point, hydration of these emulsifiers appears to be the only feasible method of application. Hydrated systems are not as appropriate for dry mix systems as they are for bakery formulas. With this restriction, further work must be done to achieve a feasible form for the use of polyglycerol esters. Figure 7 shows a comparison of the conventionally or plastic shortening emulsified with PGME to the polyglycerol ester hydrated system.

Using the polyglycerol ester, a larger volume is obtained. A significant decrease in specific gravity is seen, indicating greater aeration with the polyglycerol ester. A very moist, soft texture is also achieved through using the polyglycerol ester.

In recent years, the availability of powdered shortening systems has been of interest to the cake mix industry. The powdered shortenings have the advantage of ease of handling. The normal method of preparing powdered shortening is spray drying the fat and emulsifiers onto a carrier—normally nonfat dry milk, corn syrup solids or sodium casenate. Figure 8 shows that the functionality of the emulsifiers and the shortening can still be maintained when used in the powdered form. Adjustments in usage levels need to be made in formulation to take into account the extra protein provided by the carrier in the powdered system. The emulsifier type and level was held constant in both shortenings. Cakes of equivalent volumes are obtained. The cake using the powdered shortening appeared to be a stronger structured cake.

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