LALLEMAND
BAKING UPDATE
VOLUME 2 / NUMBER 17
Cakes and Muffins

Practical technology from Lallemand Inc., parent of American Yeast Sales, producers and distributors of Eagle® yeast, fresh and instant.

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Disappearing Bubbles

Bakery products such as breads are characterized by a typical porous structure and a high specific volume. To obtain such a porous structure, air bubbles have to be incorporated during a mixing or blending step. Gas retention and final volume of the baked good depend, therefore, to a large extent on how fast these bubbles disappear again by one of the following processes:

Buoyancy is the process by which bubbles rise to the surface and is driven by a difference in density between the gas and the liquid phase. This process can be described by Stokes law, stating that the velocity by which bubbles rise depends on the difference in density between the gas and the liquid, the viscosity of the liquid phase, and the radius of the bubble. So the larger bubbles rise faster to the surface, especially when the viscosity of a cake batter or dough is low.

Disproportionation is the process by which larger bubbles grow while smaller bubbles gradually disappear. This process is driven by the difference in surface pressure ($P = 2\gamma/R$), which is higher in smaller bubbles than in larger bubbles and which is lower when the surface pressure at the gas water interface is lower (e.g., by adding surfactants). The speed at which the smaller bubbles decrease in size while the larger increase in size is controlled by diffusion, i.e., by how fast the gas in a small bubble can diffuse through the liquid phase into a larger bubble. Because carbon dioxide gas is more soluble in water and is in equilibrium with bicarbonate that is highly soluble in water, carbon dioxide gas bubbles will equilibrate (disproportionate) much faster than air bubbles.

Coalescence is the process by which the thin lamella between two adjacent bubbles collapses to form one bigger bubble. Coalescence is the most important process (more important than disproportionation and buoyancy) by which bubbles disappear in porous bakery products such as bread and cakes where gas retention is maximized by stabilizing the lamella between the bubbles.

Cake Process and Ingredients

CAKE AND CAKE-LIKE products are produced from batters using rich formulas characterized by a high level of sugar. Apart from high levels of sugar, most cake formulas also contain variable levels of fat, flour, and eggs. Other commonly used ingredients are baking powders, emulsifiers, preservatives, and milk powder. Ingredients like cocoa powder, nuts, fruits, icings, and certain flavorings are used for specialty cakes.

While a light, porous structure contributes to the desirable eating characteristics of most cakes, some baked goods made from cake-like formulas are rather dense. Brownies, for example, are made from a very rich formula without baking powder to yield a dense baked product with a pronounced chocolate taste. Cake donuts and cake muffins are produced from a rich formula with baking powder to give a more porous structure to these products. Despite the use of baking powder, cake donuts and cake muffins remain dense products without much of an open and porous structure.

To produce a cake with an open structure and high volume, a procedure and recipe is needed that creates a stable batter with many tiny air bubbles. These bubbles act as nuclei and grow in size when the carbon dioxide gas generated from baking powder leavens the product during baking. Yeast-raised bread-like products retain gas in the dough differently than do cake-like products produced from a batter. For bread-like products, gas retention, crumb structure, and loaf volume depend greatly on the quality and quantity of the gluten protein in the flour and how this gluten protein is developed during dough mixing. For cakes there are basically two different methods to produce a high-quality batter that can be baked into a cake with acceptable volume and grain.

The multi-stage mixing method creates a stable batter with many tiny air bubbles through a creaming step in which fat (not oil) and sugar are mixed together to form a cream. The purpose of this creaming step is to incorporate air into the fat. Because of the semisolid nature of the fat, these batters tend to be very stable over time. A second and sometimes a third mixing step is used to incorporate the other ingredients and liquids into the batter without destroying the creamed fat structure. The tiny air bubbles in the creamed fat will only be released into the aqueous phase when the fat melts during baking. These air bubbles will grow in size when the leavening gas is released during baking from the decomposing baking powder. This leavens the product until its structure is set when the starch in the batter gelatinizes and forms a starch gel. A typical formula for rich white layer

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TYPICAL FORMULAS FOR THREE TYPES OF CAKES

INGREDIENTS	RICH WHITE LAYER CAKE	ANGEL FOOD CAKE	COMMERCIAL POUND CAKE
Flour	100	100	100
Sugar	140	500	100
Shortening	55		50
Egg white	76	500	
Milk	95		
Baking powder	1.3		50
Cream of tartar		20	
Salt	0.7		

(% on flour)

Cake Process and Ingredients *(Continued)*

cake and pound cake produced by the multi-stage mixing method is shown in the table. While the original formula for pound cake is simple and easy to remember (one part flour, one part eggs, one part shortening or butter, and one part sugar), the commercial formula shown in the table gives better quality at lower costs.

The single-stage mixing method for foam-type cakes has the air incorporated directly into the aqueous phase in a single step (called mixing, beating, or whipping). Gas bubbles created in a liquid phase normally disappear quickly through various mechanisms unless these gas bubbles are stabilized. Even then, foam cakes made from batters containing gas-in-water bubbles tend to be less stable than creamed batters. Both eggs and emulsifiers are important ingredients for stabilizing the gas-in-water bubbles created through the single-stage mixing method.

Eggs, egg white (ovalbumin), and to a lesser extent milk proteins are important foam stabilizers, which slow down the coalescence of air bubbles. The most dominant mechanism by which air bubbles disappear in a single-stage mixing batter is by coalescence. When a lot of air has been incorporated to form a light, fluffy batter, the lamella separating the individual air bubbles become extremely thin and will therefore easily collapse. Many proteins, but egg white protein in particular, are able to unfold (denaturate) at the liquid water interface of the air bubbles, thereby stabilizing the thin lamella between the bubbles. The foam-stabilizing effect of egg white is used in the production of meringues, when a mixture of sugar and egg white is beaten or whipped into a fluffy foam that is baked on a sheet.

Shortening and oil are used in cake formulas to give a more tender structure and to avoid the dry mouthfeel of sponge cakes made without fat. While egg white is a protein with excellent foaming properties, shortening and oil are important foam destabilizers. The shortening and oil particles that are larger than the thickness of the lamella separating the air bubbles in a foamed batter will destabilize the lamella and cause a foam to collapse quickly. The foam-destabilizing effect of shortening can be reduced when the oil- or fat-containing material is carefully blended (folded in) with the foamed egg white. This is common practice when preparing chiffon cakes and angel food cakes (see the table for a typical formula). Another way to reduce the foam-destabilizing effect of shortening or oil particles is by binding the fat or oil to the flour. For this reason some cake flours are finely ground to a small particle size in a pin-mill, while cake mixes containing high levels of fat are run through a cake finisher to bind up to 25 percent fat to the flour.

Emulsifiers are also useful for reducing the foam-destabilizing effect of fat in foam-type cakes by emulsifying the fat. The emulsified fat particles remain well-dissolved in the aqueous phase without having the tendency to destabilize the thin foam lamella between the gas bubbles. Cake emulsifiers also help to reduce surface tension, making it easier to incorporate air into a batter during mixing. Without the use of cake emulsifiers, it would be difficult to produce a foam-type cake of acceptable quality in a single-stage mixing method. For this reason most cake mixes and shortening or oils used for cakes contain emulsifiers.

Baking powder for cakes is usually a double-acting baking powder based on MCP as the fast-acting leavening acid to produce a lighter batter directly after mixing, and slower acting SAPP or SALP and sometimes SAS to produce carbon dioxide gas for extra leavening during baking. The rate of reaction of the slower acting leavening acid is most critical. It should be fast enough to give sufficient leavening before the cake structure sets (when starch gelatinizes), but not too fast, causing tunnels when the gas escapes early in the baking process when the batter viscosity is still low. Baking powder also affects the pH of the product, consequently affecting coloring during baking and color of the baked product. Color and pH of the baked product is also affected when the sodium bicarbonate and the leavening acids are not balanced, which can be desirable for some products.

Flour used for cakes is different from flour used for bread. Gas retention in cakes does not depend on gluten, and usually flour with a low protein content is preferred for cakes. Because flour particles do not disintegrate to the same extent during batter formation as during dough mixing, a finely ground flour is preferred. A finely ground flour also helps to expose the starch that will set the cake structure during baking when the starch gelatinizes to form a starch gel. Because high levels of sugar increase the gelatinization temperature of starch, crumb-setting can become a problem in high-ratio cakes with more sugar than flour in their formula. While a high level of sugar is desirable for taste and freshness of the cake, it tends to cause the cake to collapse immediately after baking. To prevent high-ratio cakes from collapsing, cake flours are often chlorinated. The improving effect of chlorine treatment is probably related to a reaction with starch, affecting its swelling and gelatinization behavior.

Cake and Muffin Problem-Solvers

LALLEMAND supplies a full range of ingredients for cakes distributed through Lallemand Distribution and American Yeast Sales.

Eagle® Double Acting Baking Powder and Eagle® Bakers Cream are available for cake production in ten-pound pails and fifty-pound bags.

Essential® SOFT II and Fermaid® Softerzyme are enzyme-based dough conditioners for improving softness (moistness) of cake products, cake donuts, muffins, brownies, and other baked goods with low specific volume.

Preservatives for cakes, such as sodium propionate, potassium sorbate, and sorbic acid, are available in both granular and dust-free formulations.

Emulsifiers, special shortening and flavorings (a.o. cocoa powder) for cakes, pan release agents, icing powders, and egg products are some of the other ingredients that cake producers can obtain from Lallemand.

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Lallemand Baking Update is produced by Lallemand Inc. to provide bakers with a source of practical technology for solving problems. If you would like to be on our mailing list to receive future copies, or if you have questions or comments, please contact us at:

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