A Rational Method for Evaluating The Creaming Qualities of a Shortening

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IT IS well recognized that the ability of a shortening to cream, or incorporate air, is a highly important factor in determining its quality. This is particularly true if it is to be used for making cakes. While incorporated air is the exclusive leavening-agent only in certain pound cakes, its presence is highly important in other types as well. In general, cakes of good quality are obtained only when the actions of air and of the chemical leavening-agent are properly balanced. If an excess of baking powder is used to compensate for poor air-incorporation, the volume of the cake may be satisfactory; but its grain, texture, and taste will invariably suffer.

Tests of a shortening's creaming power are commonly made by mixing together in a small machine a quantity of shortening and granulated sugar, in definite proportions and amount, and determining the density of the mix at intervals during a somewhat prolonged period of mixing. Sometimes eggs are also included in the mixture. The densities of the finished doughs of test cakes are usually determined, also, and with a given formula these may be correlated with the finished cake volume.

While the simple density data are valuable for comparative purposes, they are inadequate in a number of respects. There has been no way of using them to intercompare doughs made according to different formulas, and, furthermore, they have been of little use in evaluating the different steps of the cake-mixing process with respect to their tendency to cause the dough to gain or lose air. The actual percentages of air in the various mixes may, of course, be calculated from the density data; but these will be found to vary from one formula to another, and from one step to another, in a wholly meaningless manner.

The rationalization of the matter of air incorporation rests upon a comparatively simple discovery; viz., that the *only ingredient in a cake mix*, exclusive of the foam-type cakes, sponge and angel food, *that is active in entrapping air IS THE SHORTENING*. This, naturally, leads to the conclusion that the logical basis for the calculation of incorporated air is not on the weight of the total mix, but *on that of the shortening alone*.

The characteristic structure of cake doughs is shown in the photomicrographs of Figues 1 and 2. In these the fat has been stained with an oil-soluble yellow dye, and the photograph made through a blue filter, so that the fat phase of the dough stands out in distinct dark patches. The incorporated air appears in the form of numerous small, round bubbles, and it will be seen that these appear exclusively in the fat. An interesting feature of the white cake dough of Figures 1 and 2 is that in its preparation the egg whites were beaten to incorporate air before they were added to the mix. Regardless of this, there is no air whatsoever in the aqueous phase of the finished dough. This phenomenon has been repeatedly observed with this and other types of cakes. As the capacity of a shortening for absorbing air is limited and is quite easily approached by ordinary mixing methods, the rather common practice of beating eggs separately from the other ingredients in the attempt to introduce unusual quantities of air into the dough would appear to be a rather futile one if the fat has previously been beaten to incorporate the maximum amount of air it is capable of entrapping.

In making the calculations of percent air incorporated, the densities of the major ingredients of the cake may, without serious error, be assumed to be as follows:

Sugar	1.59
Shortening	0.91
Cake Flour	1.42
Eggs	1.03
Milk	1.03

In mixtures containing either eggs or milk, any reasonable amount of sugar will, of course, be dissolved. In this case, in order to simplify the calculations and make all volumes, as well as weights strictly additive, the density of the sugar should be taken as 1.46. (This is the apparent density of sugar dissolved in a quantity of water approximating its own weight.) Minor ingredients such as flavoring extracts, salt, etc., may be neglected in the calculations. In practice, it will be found that the density determinations are sufficiently accurate if they are simply made by packing the mix into a small cup of known capacity and weight and then weighing the cup and contents to the nearest one-half gram. The density of the mix without incorporation of air, and also the volume percentage of fat in it, must be calculated from the formula.

If,

D_2 = density of mix, as determined
D_1 = calculated density of mix without air
V = percentage fat by volume in the mix
A = percentage air.

The percent air, on the basis of the shortening, is given by the following formula:

$$A = \frac{\left(1 - \frac{D_2}{D_1}\right)(10{,}000)}{\frac{VD_2}{D_1}}$$

Some very interesting results are obtained when the new method is used to follow the incorporation of air through the various steps of mixing a cake. In one test, for example, two different shortenings were used to make pound cakes according to the following formula:

Shortening	88 parts
Sugar	100
Eggs	112
Milk	12
Flour	100

The mixing of the various ingredients was carried out as follows:

Mixing Period	Minutes	Operation
1	5	Sugar and shortening creamed
2	5	Eggs gradually added
3	5	Mixing continued
4	3	Milk and flour added

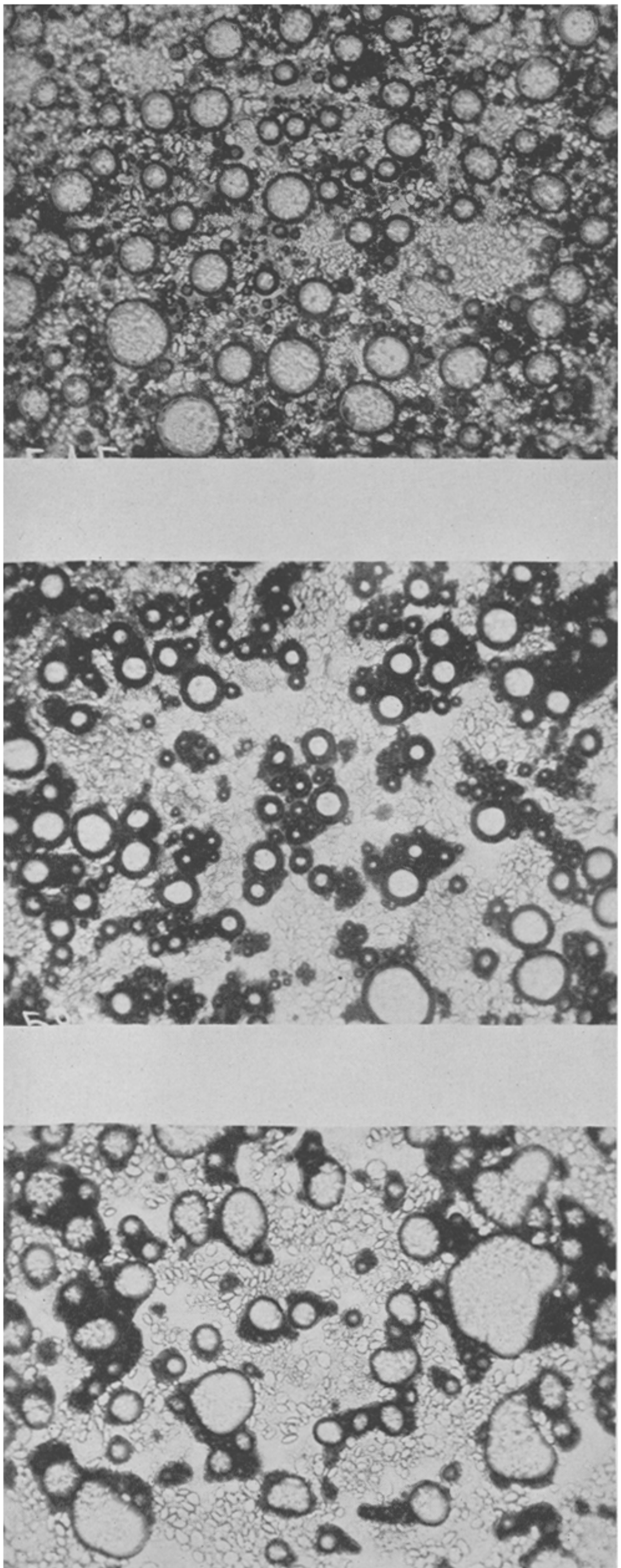


Fig. 1—Photomicrographs of Cake Doughs x 90
Top: Pound Cake Dough
Center: Yellow Cake Dough
Bottom: White Cake Dough

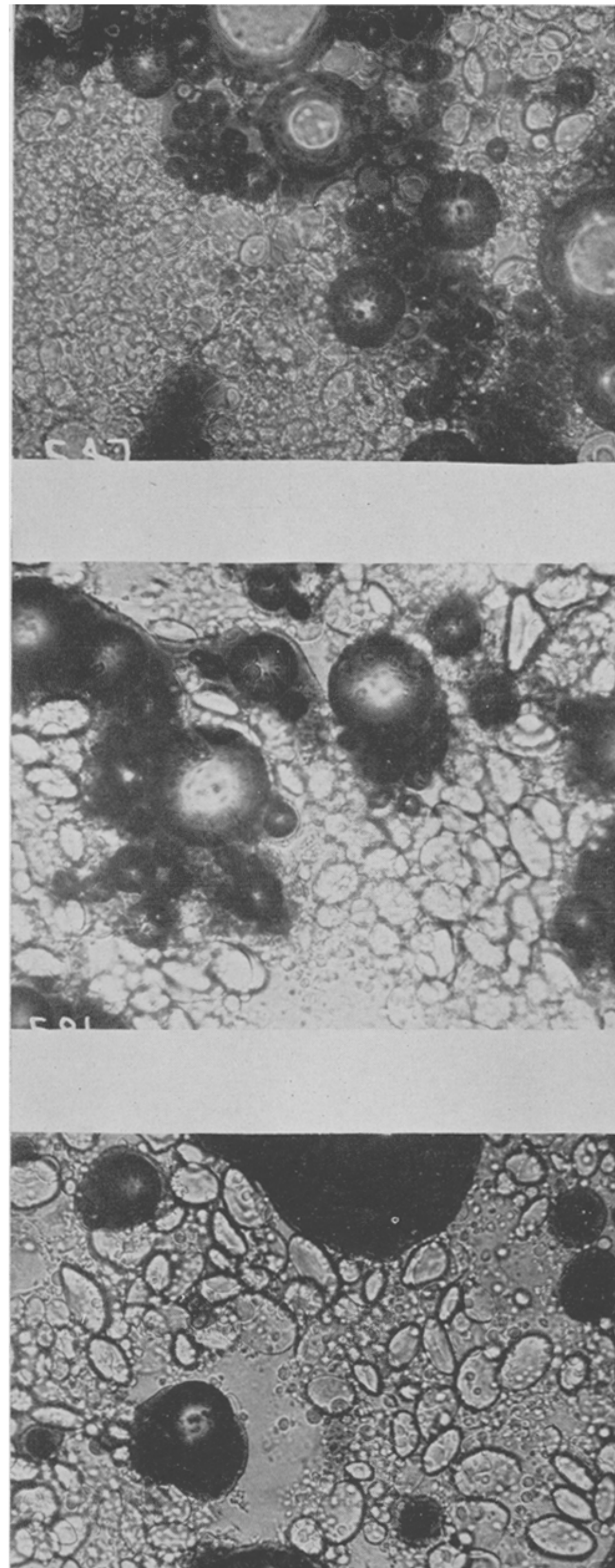


Fig. 2—Photomicrographs of Cake Doughs x 360
Top: Pound Cake Dough
Center: Yellow Cake Dough
Bottom: White Cake Dough

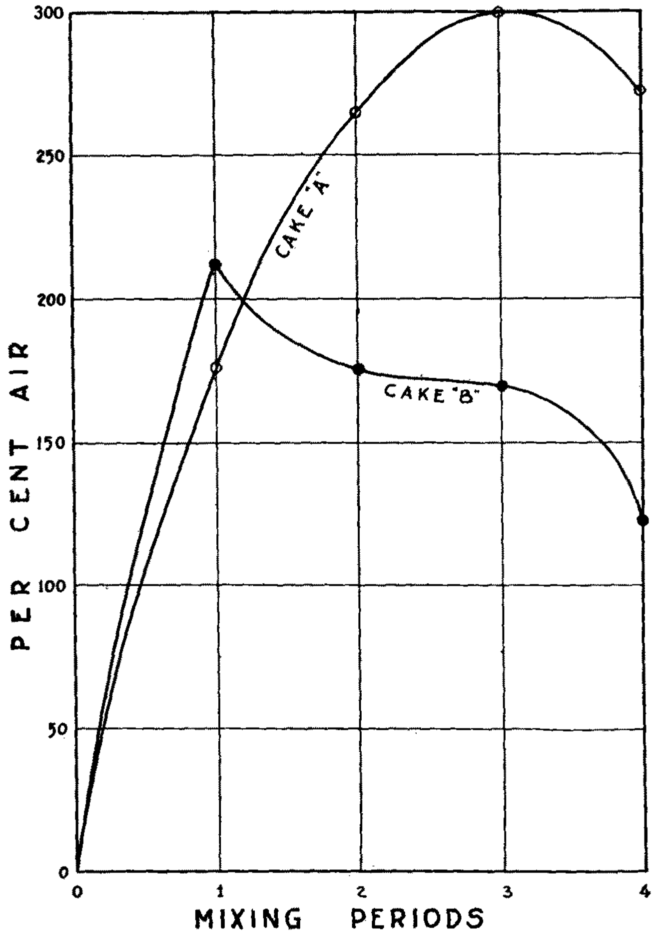
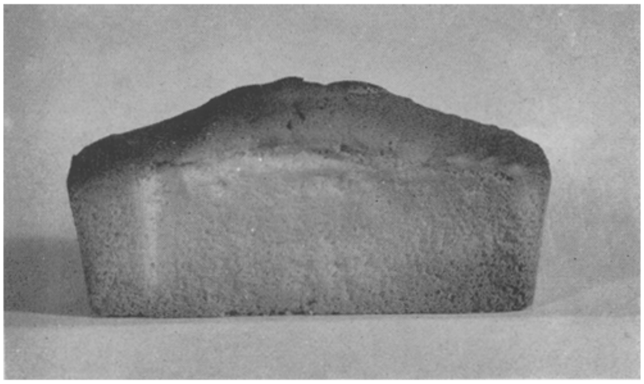


Fig. 3—Incorporation of Air in Mixing Pound Cakes Using Shortenings "A" and "B"



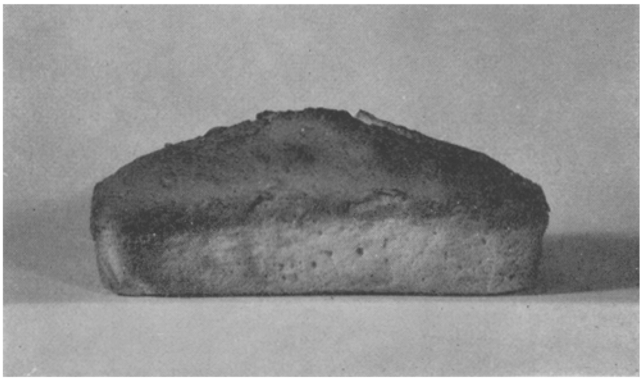


Fig. 4—Finished Pound Cakes
Top: Cake made with Shortening "A"
Bottom: Cake made with Shortening "B"

The percentages of air in the two shortenings at the end of each mixing period are shown graphically in Figue 3. With Sample A it will be seen that the air content increased smoothly up to the point where the milk and flour were added. Sample B incorporated more air than Sample A during the first period, but not only failed to gain additional air after the eggs were added, but actually lost some 40%. The great difference in volume of the finished cakes is evident from Figure 4.

The writers have examined a considerable variety of shortenings by the above method, and their results have yielded some generalizations of possible value and interest. Good shortenings have been found to incorporate a maximum of about 270% air when creamed with granulated sugar in the most favorable proportions (about two parts by weight of shortening to three parts of sugar). In the actual preparation of cakes, however, the first mix of sugar and shortening is seldom creamed to its maximum air-capacity. The air is usually carried to 150-200% in this stage, and the remainder of the air beaten in after the addition of the eggs. The presence of eggs increases the ability of the shortening to absorb air; after they are added the air-content will rise to 300-375%. Some air is always lost when the milk and flour are added, so that finished yellow-cake doughs usually contain 275-350% of air on the basis of the shortening. Inferior shortenings may fail to incorporate air satisfactorily at all; may lose air with the addition of the eggs as in the example noted above, or may lose abnormal quantities of air when the milk is added.