Molecularly Distilled Monoglycerides.[1] II. Cake Baking Experiments[2]

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THE application studies reported in this paper describe the use of distilled monoglycerides in cake baking. Shortenings containing monoglycerides have been termed "superglycerinated" or "emulsifier type." Both the baker and the housewife use such shortenings to prepare cakes that are sweeter and more moist. Discussions of the use of monoglycerides in baked products can be found in several texts such as "Industrial Oil and Fat Products" by A. E. Bailey (1).

In baking cakes, the use of large amounts of sugar requires the use of more liquid; use of this additional sugar and liquid however considerably weakens the structure of a cake unless sufficient monoglyceride is present. The presence of monoglycerides thus contributes toward a light, full-volumed cake, and in its absence the cake collapses and becomes soggy and unattractive. There are many kinds of cakes to cover the wide range of individual appeal. These experimental data however are confined to the action of various types of monoglycerides in the preparation of one particular kind of cake.

TABLE I

Formula for "130% Sugar" Yellow Cake Sugar-Batter Mixing Technique

Ingredients	Parts by Weight	Hobart Mixer Speed	Mixing Time (min.)
Sugar	130	.....	.....
Shortening	50	Medium	3
Whole egg	50	Medium	2
All-purpose flour	100	.....	.....
Milk	100	.....	.....
Baking powder (double acting)	6	.....	.....
Salt	4	Medium	1.5

Scaling Weight: 185 grams in small loaf tin; size top: 3¼ by 6¼; bottom: 2¾ by 5½; 2¼" deep.
Oven Temperature: 350°F.
Baking Time: 35 minutes.

Determination of cake volume provides an absolute measurement and a pertinent means of identifying the action of the monoglycerides. There are of course other factors which influence cake volume, and there are many other ways of scoring a cake. In these experiments an attempt has been made to control these other factors and to evaluate only the action of monoglycerides.

The cake formula used in these experiments is given in Table I. This is a typical formula for a high ratio yellow cake with a 130% sugar content; that is, the quantity of sugar in the formula is 1.3 times the amount of flour. This formula was taken from "Industrial Oil and Fat Products" (1). The cake ingredients are based on 100 parts flour.

In the preparation of these cakes every effort was made to obtain reproducible results. The ingredients such as flour, sugar, and shortening were from a single source. All of the ingredients were weighed on a balance sensitive to 0.1 gram. The batter was prepared by the sugar-batter procedure in a Hobart Mixer, timing each mixing step with a stop watch. Three cakes were baked from each batter, and each cake was scaled to the nearest gram. The oven temperature and baking time were likewise carefully controlled. The baking experiments compare monoglyceride mixtures from commercial sources, when obtainable, or a laboratory preparation of a monoglyceride reaction mixture with the corresponding distilled monoester. The comparisons were made on a monoester basis rather than on a weight basis.

TABLE II

Sample Calculations Showing the Necessary Monoglyceride Product Addition to Obtain Desired Monoester Content in Shortening

	Commercial Mixture	Distilled Product
% monoester in additive	40.0%	93.0%
Amount additive	12.5 g.	5.4 g.
Amount standard shortening	87.5 g.	94.6 g.
Additive in shortening	14.3%	5.7%
% monoester in shortening	5.0%	5.0%

TABLE III

Method of Expressing Cake Volume Scoring

Shortening	Monoester Addition %	Cake Volume ml.	Volume As % of Control	% Volume Increase
Standard (control)	0	432	100	0
Standard plus Distilled monostearate	5	488	113	13
	10	528	122	22

An example of the calculations used in the preparation of a shortening containing 5% monoester is given in Table II. Considerably more of a monoglyceride mixture has to be used than of the distilled product; in this example 14.3% of the mixture and 5.7% of the distilled product. The monoglyceride was added to melted "standard" shortening and mixing was continued until the fat had reached room temperature. The "standard" shortening which served as a control was melted and cooled in a similar man-

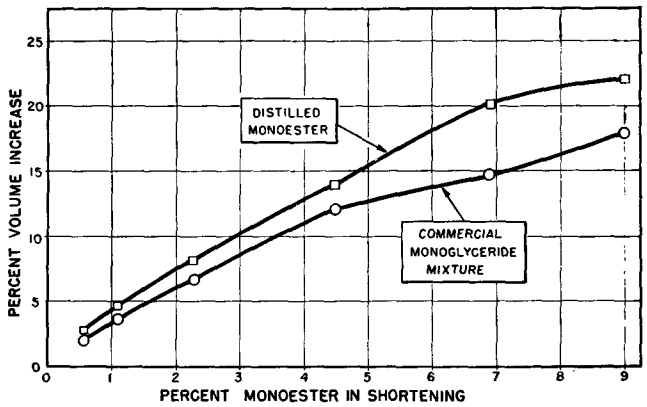

FIG. 1. The effect on cake volume of various percentages of monoesters from triple-pressed stearic acid monoglyceride products.

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[2] Communication No. 166 from the Laboratories of Distillation Products Industries.

TABLE IV

Effect of Different Methods of Monoglyceride Incorporation on Cake Volume

Monoester	Addition Method	% Cake Volume Increase
1.0% distilled cottonseed oil monoglycerides	Dissolved in shortening	20.0
	Added to batter	19.0
3.5% distilled stearic acid monoglycerides	Flakes dissolved in shortening	11.0
	Flakes added to batter	0.0
	Powder added to batter	8.0
	Water dispersion	9.0

ner. This "standard" shortening was a commercial hydrogenated vegetable oil shortening with no added emulsifier. The baked cakes were tested for volume by placing the cake in a standard pan and filling to the top with mustard seeds.

Table III illustrates the method of cake volume scoring. The volume of the cakes was measured in mls., and any increase in volume was compared with that of a control baked with standard shortening. The effect of the addition of varying percentages of the glyceryl monoester to shortening can thus be measured, and its action expressed as percentage of cake volume increase. Using this technique, the variation in cake volume between the three cakes of a single batter or similar batters on different days was not more than 1%. Control cakes were baked each day, using standard shortening, and the results were reproducible within ± 0.5% for the three-cake average. Cake volume measurements can be sufficiently precise to use in the evaluation of monoglycerides and in the comparison of types of monoglycerides.

Commercial bakers often prefer to add monoglycerides and standard shortening separately to the cake batter. For successful addition by the baker it is necessary to have the monoglyceride readily dispersed in the batter. The data in Table IV show that the distilled glyceryl monoester of cottonseed oil is readily incorporated into any batter without a premix with the shortening. In order to disperse a monostearate in a batter some preliminary treatment is necessary. The distilled glyceryl monostearate, because of its very high melting point, must either be dissolved in the shortening or reduced to a fine particle size before addition to the batter. The distilled monostearate, reduced to a powder of talcum fineness,

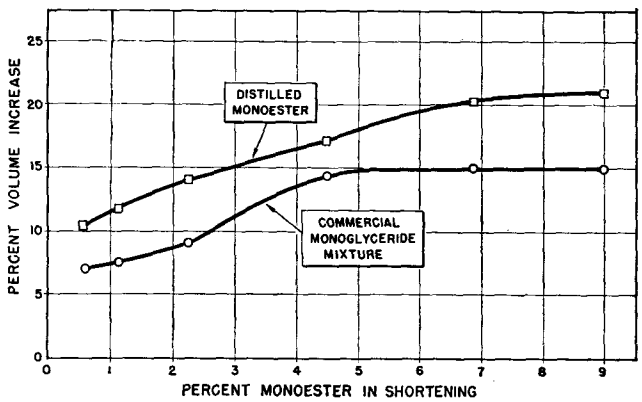

FIG. 2. The effect on cake volume of various percentages of monoesters from partially hydrogenated vegetable oil monoglyceride products.

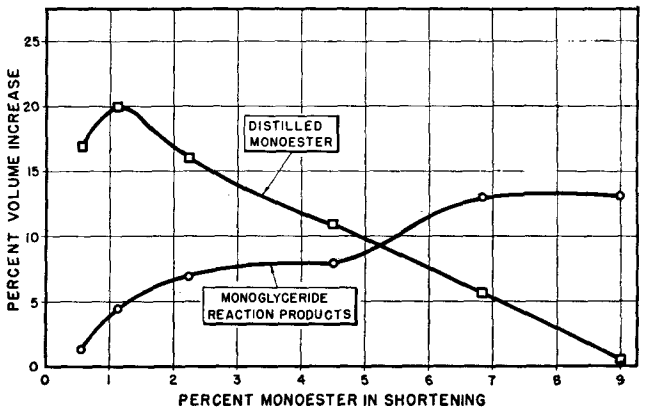

FIG. 3. The effect on cake volume of various percentages of monoesters from cottonseed oil monoglyceride products.

can be added to the batter to obtain almost full activity. A 30% aqueous monostearate premix is a soft plastic material which is equally effective.

In our judgment, to obtain the best flavor and texture for this type of cake, the desirable shortening level should be about 50% of the weight of the flour. Because certain cake formulas use lower levels of shortening, a few experiments have been carried out to study the action of monoglyceride in this yellow cake made with a lower fat content. In Table V the cake volumes which are produced by varying amounts of the distilled glyceryl monoester of cottonseed oil are given for these cakes with different shortening contents.

The shortening content may be reduced by a small amount without seriously interfering with cake volume. Increased amounts of monoglyceride however are required to obtain maximum cake volume. When the shortening is reduced to 25% of the weight of the flour, the volume of the cake is seriously diminished. Increased amounts of monoglycerides will not compensate for the shortening reduction. Even though the cake volume may be good, the cakes become progressively less rich and have lower scores in taste tests as the shortening content is reduced.

The food industry has become accustomed to the use of monoglyceride preparations of the predominately saturated acid type. Recent experiments (2) have demonstrated differences in the emulsifying activity of monoglycerides of the saturated and unsaturated types. The object of the following work has been to investigate possible differences in the activity of saturated and unsaturated monoesters in cake baking.

Monoglycerides from three different types of fatty acids have been examined. The action of the monoester is shown by plotting the percentage of cake volume increase obtained in baking a 130% sugar yellow cake against percentage of the actual monoester added to the standard shortening.

Figure 1 compares the action of a commercial glyceryl monostearate mixture containing 41% monoester and that of a distilled monostearate containing 92% monoester. In order to compare the distilled monoester with the reaction mixture on a monoester basis, it is necessary to use approximately 2.2 times more of the reaction mixture. The distilled monoester is about 30% more active than the monoester in the mixture containing the other products of the reaction.

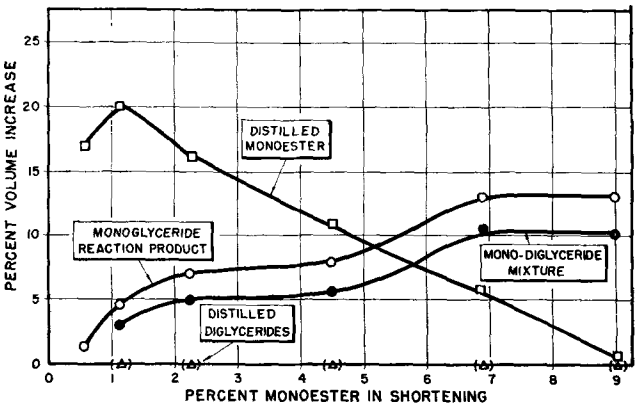

FIG. 4. The effect on cake volume of various percentages of distilled monoesters, distilled diesters, and natural and simulated mixtures of mono- and diesters of cottonseed oil.

The performance of a commercial monoglyceride mixture made from partially hydrogenated vegetable oil containing 41% monoester is compared with that of a distilled monoglyceride product containing 94% monoester in Figure 2. A depressing effect of the diester on the action of the monoester is very noticeable.

In Figure 3 is plotted the percentage of volume increase obtained using cottonseed oil monoglycerides. Low concentrations of the distilled monoester are extremely effective. At levels above 4% of monoester the distilled monoester of cottonseed oil is such a powerful emulsifier that it results in excessive action and is detrimental to the structure of this type of experimental cake. These levels, of course, are higher than are used in practical cake baking with any type of monoglyceride. The cottonseed oil monoglyceride reaction product has neither the ability to produce a large volume increase at low addition levels nor the excessive activity at the higher addition levels.

As the unsaturated acid content of the monoglycerides is increased from the triple-pressed stearic acid to the partially hydrogenated vegetable oil and finally to the cottonseed oil monoesters, the spread in action obtained between the distilled monoglycerides and the monoglyceride reaction products becomes more pronounced. It can be concluded that the diester of the unsaturated acids counteracts much of the effect of the monoester.

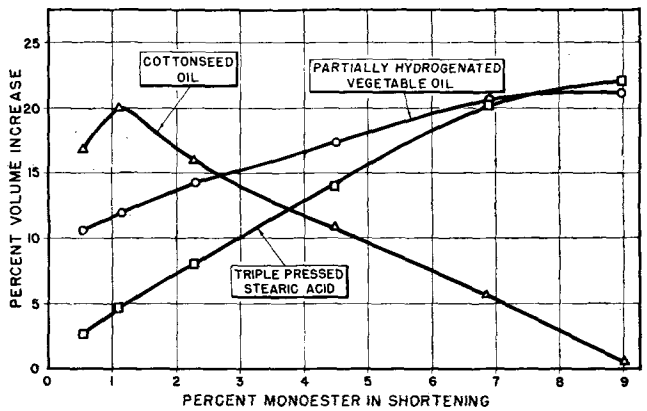

FIG. 5. The effect on cake volume of various percentages of distilled monoesters differing in their content of unsaturated fatty acids.

Figure 4 shows the effect of diglycerides on the cake volume. Diglycerides of cottonseed oil were prepared by molecular distillation of a reaction mixture. The points on the curve marked by the triangles and lying on the abscissa were obtained by adding varying percentages of the diglycerides to standard shortening and testing their action on cake volume. No increase or decrease in cake volume was obtained, using the pure diglycerides. A blend containing 40% monoester and 60% diester was made from the distilled monoesters and the distilled diesters of cottonseed oil. This prepared mixture was added to shortening at various percentages based on the monoester content. The cake volume curve closely follows that of the cottonseed monoglyceride reaction product, thus confirming the depressing effect of the diester on the action of the monoester. It will be noted that the two curves do not superimpose perfectly. This may be due to minor differences, such as the absence of catalyst in the blended mixture or to the presence of slightly more diester in the blended mixture which lacked the small amount of triester that would be present in the reaction product.

The action of the three types of distilled monoglycerides is compared in Figure 5. The activity of the monoester is greatly influenced by the content of unsaturated fatty acids. The volume increase obtained with distilled monoesters of cottonseed oil at about 1¼% level was comparable to that produced by the monoester of triple-pressed stearic acid at about a 7% addition level. The monoester of partially hydrogenated vegetable oil is intermediate in its action at the low addition levels; this would be expected from its content of unsaturated acids.

TABLE V

Effect on Cake Volume of Different Contents of Variously Modified Shortenings

Distilled Cottonseed Oil Monoglyceride Addition Level	% Cake Volume Increase			
	Shortenings as % of Flour			
	50.0%	37.5%	32.5%	25.0%
0.0% (Control)	0.0	8.0	2.6	−3.8
1.00%	13.8	15.0	.....	.....
1.25	20.6	28.0	.....	.....
2.00	18.0	31.0	18.5	2.0
3.00	14.0	18.0	23.5	3.0
4.00	12.0	9.4	10.0	4.0
5.00	.....	.....	.....	5.0

Summary

Different types of monoglycerides have been shown to possess marked differences in their activity in cake baking. Improved activity has been observed when the monoesters made from fats containing unsaturated acids were used. The activity of a distilled monoglyceride would be expected to be proportional to its monoester content or about 2.2 times more active than the reaction mixture. It has been shown however that, at practical concentrations in an experimental cake, the distilled monoesters were considerably more active than expected. This greater activity has been shown to be due primarily to the absence of the diester.

REFERENCES

1. Bailey, A. E., "Industrial Oil and Fat Products," Interscience Publishers, Inc., New York, N. Y.
2. Kuhrt, N. H., Welch, E. A., and Kovarik, F. J., "Molecularly Distilled Monoglycerides. I. Preparation and Properties," (In publication.)

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