NOTE

The Effect of Sucrose Esters on Flour-Water Dough Mixing Characteristics[1]

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ABSTRACT

Cereal Chem. 63(1):62–64

The effects of sucrose ester emulsifiers on dough mixing characteristics were studied using the Brabender farinograph and the National mixograph. Addition of emulsifiers tended to reduce the time to peak of the farinogram and increase the mixing endurance, but had no effect on absorption. Sucrose esters increased mixogram optimum mix times.

Emulsifiers have often been an area of research for cereal chemists, as cereal-based foods represent the largest use for food emulsifiers (Rusch 1981). Starch complexing, protein strengthening, and aeration are the primary functions of emulsifiers in baked foods (Garti et al 1980). Sucrose fatty acid esters, among the newer food-grade emulsifiers available, have been shown to have beneficial effects on volume and tenderness of high-ratio white layer cakes (Ebeler and Walker 1984) and bread (Breyer and Walker 1983). Pomeranz et al (1969) also observed that sucrose esters increased loaf volume and improved crumb grain and softness.

Although much has been reported on the effect of sucrose esters (and other emulsifiers) on the finished product, relatively little has been reported on their effect on dough mixing characteristics. Junge et al (1981) proposed that some surfactants improve the bread grain by allowing the dough to form many small uniform air cells. Ebeler and Walker (1984) proposed that emulsifiers improve cake volume and grain by enhancing air incorporation and shortening dispersion. Tsen and Weber (1981) found that yeasted dough absorptions were not significantly altered by the addition of 0.5% of various emulsifiers, but that sodium stearoyl-2-lactylate (SSL), calcium stearoyl-2-lactylate (CSL), and ethoxylated monoglycerides (EMG) delayed developing time. SSL, CSL, and diacetyl tartaric acid esters of monoglycerides and diglycerides (DATA) increased stability.

The objectives of this study were to observe the effects of sucrose ester emulsifiers on: 1) the mixogram time to peak, and 2) the farinogram absorption, time to peak, and mixing endurance.

MATERIALS AND METHODS

Flours

Three different commercial flours were used in this experiment: a bread flour, milled from hard red spring wheat (5.55 pH, 12.1% protein [N × 5.7], 0.6% ash, 11.1% moisture); a general baker's flour, milled from hard red winter wheat (5.50 pH, 11.5% protein [N × 5.7], 0.5% ash, 12.1% moisture); and an all-purpose flour, milled from hard red winter wheat (5.55 pH, 10.8% protein [N × 5.7], 0.5% ash, 12.4% moisture).

Sucrose esters with hydrophyl-lipophyl balance (HLB) values of 6, 11, and 15 (F-50, F-110, and F-160, respectively) were obtained from the Dai-Ichi Kogyo Seiyaku Company, Ltd. of Kyoto, Japan. SSL (Emplex) was obtained from the C. J. Patterson Company, Kansas City, MO. All emulsifiers were used at three concentrations: 0.5, 1.0, and 1.5% of flour weight basis. A control dough containing no emulsifier was also run.

Equipment

Dough mixing characteristics were measured on a 300-g farinograph from C. W. Brabender Instruments, Inc., South Hackensack, NJ, and a 35-g mixograph, National Manufacturing, Lincoln, NE.

Mixing procedures were used as outlined by AACC method 54-21 for the farinograph (1983) and 54-40 for the mixograph. The emulsifier was used in powdered form, dry mixed with the flour for 1 min before adding water. Absorption was held constant after the initial farinograph absorption had been determined for each flour. The farinograph absorptions were used for the mixograph, because the farinograph is more sensitive to changes in absorption measurement than the mixograph. Three replicates were run.

Measurement

The farinograms were measured as follows (Fig. 1): The curves were evenly bisected. The time to peak, or optimum dough development (in minutes), was measured from the addition of water to the first peak on the curve. The mixing endurance was measured as the drop or rise in Brabender units of the curve from the first peak until 8 min past peak, a negative value indicating a fall in the curve, and a positive value indicating a rise in the curve from the first peak. This represents a slight deviation from custom, but it appeared to give more reliable results because it removed the variability of the curve band width, and because some emulsifier/flour combinations caused a second peak. Mixograms were measured for the time (in minutes) to maximum height.

Statistical Analysis

Second order regression was used to analyze the collected data, and the resulting regression equations were used to prepare Figures 2, 3, and 4 (Table I).

RESULTS AND DISCUSSION

Farinograph

Absorptions were optimized for each run, but there were no apparent effects on absorption by the sucrose esters or by SSL, in agreement with Tsen and Weber (1981). The absorption for the bread flour ran from 59.0 to 59.5%; the all-purpose flour ran from 58.8 to 59.0%, and the baker's flour varied from 58.2 to 58.8%. The effects of sucrose ester HLB value or emulsifier concentration on the time to peak and endurance of farinogram doughs were not statistically significant for the F-50 and SSL doughs, although some trends did appear for the F-110 and F-160 doughs. Doughs containing F-160 tended to produce narrow, flat curves. Curves of

[1] Published as Paper 7755, Journal Series, Nebraska Agricultural Experiment Station. Presented in part at the AACC 69th Annual Meeting, Minneapolis, MN, 1984.

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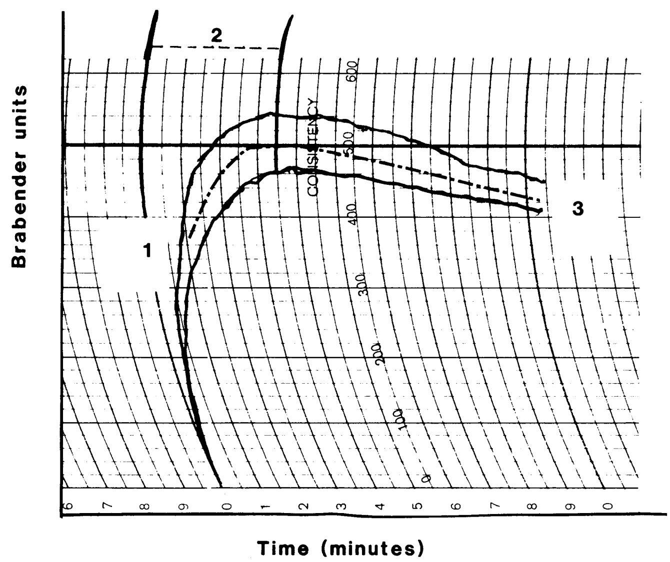

Fig. 1. Sample farinogram showing method of measurement. **1,** Curve bisection (dotted line); **2,** time to peak; **3,** mixing endurance.

the bread and baker's flours showed second peaks. The mixing endurance tended to increase with HLB value and concentration (Fig. 2). The F-110 doughs showed good mixing endurance, but less than the F-160 doughs.

The time to peak for the F-110 doughs tended to decrease with increasing concentration (Fig. 3). The F-160 and SSL data fit the predicted curves very well and were significantly different from one another, but the F-50 and F-110 doughs showed relatively fewer differences.

Curves for doughs containing SSL tended to be quite narrow and to drop quickly. They had shorter peak times and a lower endurance than the control or sucrose ester doughs.

Mixograph

The sucrose ester emulsifiers did not differ significantly from each other but were obviously different from the SSL curves. Doughs containing SSL tended to increase mix time with increasing concentration (Fig. 4), leveling off or decreasing at 1.5% concentration. This effect was more pronounced with the higher protein flours. The optimum mix times for doughs containing sucrose esters tended to increase somewhat, except for the all-purpose flour dough containing F-110. Sucrose-ester-containing doughs had shorter mix times than the SSL samples.

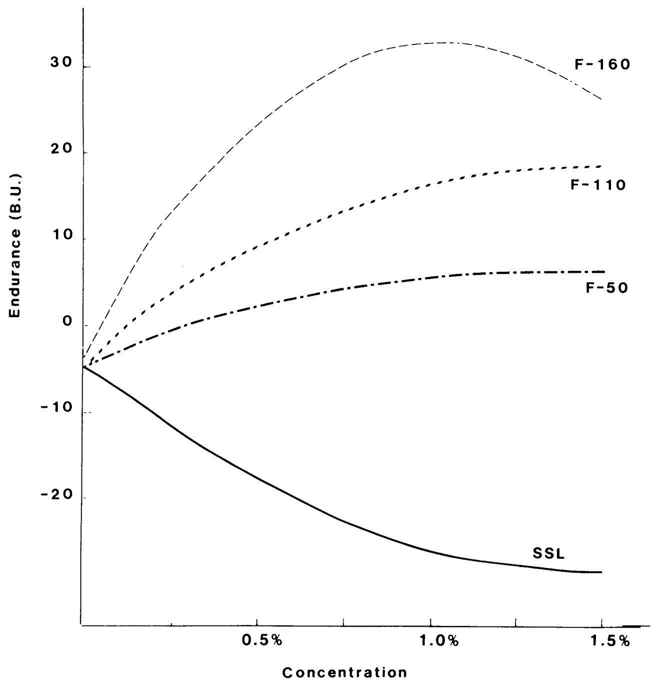

Fig. 2. Effect of emulsifier concentration (flour weight basis) on farinograph endurance (Brabender units) of general baker's flour. Coefficient of correlation (R) = 0.51 for F-50, 0.71 for F-110, 0.85 for F-160, and 0.67 for sodium stearoyl-2-lactylate (SSL). Standard error of estimate (S) = 7.28 for F-50, 9.37 for F-110, 9.67 for F-160, and 12.5 for SSL.

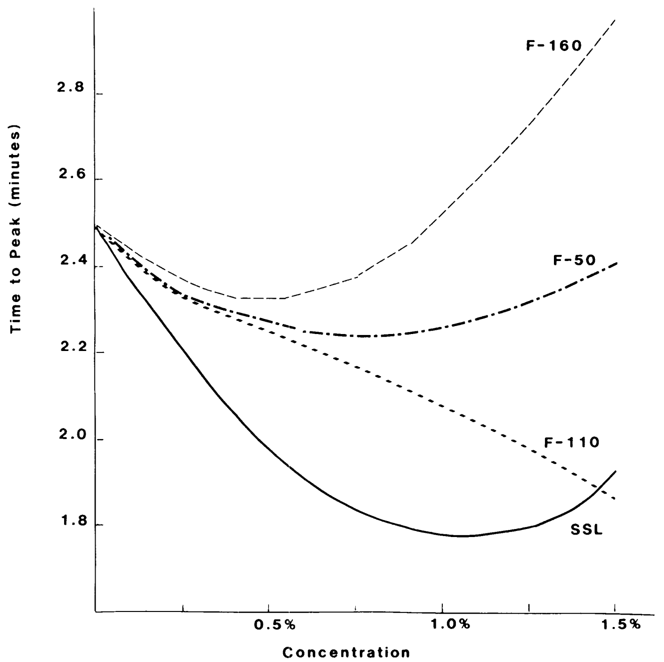

Fig. 3. Effect of emulsifier concentration (flour weight basis) on farinograph time to peak (minutes) of general baker's flour. R is 0.42 for F-50, 0.55 for F-110, 0.96 for F-160, and 0.98 for sodium stearoyl-2-lactylate (SSL). S is 0.19 for F-50, 0.35 for F-110, 0.08 for F-160, and 0.07 for SSL.

TABLE I
Summary of Results Using Second Order Regression on Experimental Results

	Emulsifier Control	F-50			F-110			F-160			SSL		
Concentration	0%	0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	0.5%	1.0%	1.5%	0.5%	1.0%	1.5%
All-purpose flour													
Farinogram time to peak (min)	2.0	2.0	2.0	1.9	1.8	1.7	1.7	1.9	1.8	1.9	1.9	1.8	1.8
Endurance (BU)	53	−55	−55	−51	−51	−44	−33	−22	−5	−2	−68	−73	−67
Mixogram time to peak (min)	4.7	4.7	4.8	5.0	4.8	4.7	4.6	4.7	4.7	5.0	5.2	5.4	5.3
Bread Flour													
Farinogram time to peak (min)	2.7	2.5	2.3	2.3	2.3	2.2	2.5	2.6	2.5	2.5	2.4	2.2	2.1
Endurance (BU)	−6	1	4	1	14	33	52	18	35	4.4	−15	−19	−17
Mixogram time to peak (min)	4.7	4.6	4.8	5.1	4.7	4.8	4.7	4.8	4.8	4.8	6.5	6.7	5.0
Baker's Flour													
Farinogram time to peak (min)	2.4	2.3	2.3	2.4	2.2	2.1	1.9	2.3	2.5	3.0	2.0	1.8	1.9
Endurance (BU)	−4	2	6	6	9	16	18	23	33	25	−18	−26	−29
Mixogram time to peak (min)	3.7	4.0	4.1	4.0	4.0	4.2	4.2	3.9	4.0	4.0	4.1	4.7	5.5

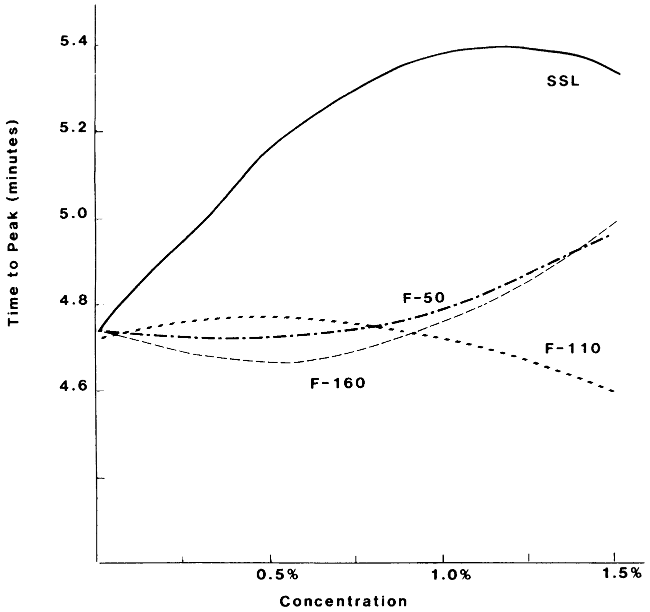

Fig. 4. Effect of emulsifier concentration (flour weight basis) on mixograph time to peak (minutes) of all-purpose flour. R is 0.88 for F-50, 0.86 for F-110, 0.96 for F-160, and 0.94 for sodium stearoyl-2-lactylate (SSL). S is 0.06 for F-50, 0.05 for F-110, 0.04 for F-160, and 0.11 for SSL.

CONCLUSIONS

Addition of emulsifiers tended to reduce farinograph time to peak, and doughs containing SSL and F-110 tended to show the greatest effect. The mixing endurance increased with concentration and HLB value of the sucrose esters but decreased with SSL. These results disagree with those of Tsen and Weber (1981), who reported that SSL increased stability of the curve. A possible explanation may be in the method of incorporation of the emulsifiers. Tsen and Weber suspended the SSL in water before use, whereas the emulsifiers in this study were added dry. The sucrose esters had no apparent significant effect on water absorption. The sucrose esters and SSL both generally tended to increase mixograph optimum mix times. The sucrose esters apparently act as dough strengtheners and increase mixing tolerance, but we are uncertain of the mechanism. The differences in results between the mixograms and farinograms are probably due to the different mixing actions and speeds.

ACKNOWLEDGMENTS

This work was supported in part by Dai-Ichi Kogyo Seikayu Co., Ltd., Kyoto, Japan. The authors wish to acknowledge the assistance of M. J. Lindell.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1983. Approved Methods of the AACC. Methods 54-21 and 54-40, approved April 1961. The Association: St. Paul, MN.

BREYER, L. M., and WALKER, C. E. 1983. Comparative effects of various sucrose-fatty acid esters upon bread and cookies. J. Food Sci. 48:955.

EBELER, S. E., and WALKER, C. E. 1984. Effects of various sucrose fatty acid ester emulsifiers on high ratio white layer cakes. J. Food Sci. 49:380.

GARTI, N., LINDNER, C., and PINTHUS, E. J. 1980. The evaluation of food emulsifiers in the bread baking industry. Bakers Dig. 54:24.

JUNGE, R. C., HOSENEY, R. C., and VARRIANO-MARSTON, E. 1981. Effects of surfactants on air incorporation in dough and the crumb grain of bread. Cereal Chem. 58:338.

POMERANZ, Y., SHOGREN, M. D., and FINNEY, K. F. 1969. Improving breadmaking properties with glycolipids. I. Improving soy products with sucroesters. Cereal Chem. 46:503.

RUSCH, D. T. 1981. Emulsifiers: Uses in cereal and bakery foods. Cereal Foods World 26:110.

TSEN, C. C., and WEBER, J. 1981. Dough properties and proof times of yeasted doughs affected by surfactants. Cereal Chem. 58:180.

[Received April 9, 1985. Accepted October 24, 1985.]