Various Oils, Surfactants, and Their Blends as Replacements for Shortening in Breadmaking[1]

B. L. BRUINSMA and K. F. FINNEY,[2] U.S. Grain Marketing Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Manhattan, KS 66502

Cereal Chem. 61(4): 279-281

ABSTRACT

Various concentrations of 14 different oils, alone and in blends with each of two surfactants, were studied to determine which oils were superior in breadmaking. We determined the amount of each oil sodium stearoyl-2-lactylate (SSL), or diacetyl tartaric acid esters of monoglycerides and diglycerides (DATE) needed to reach the midway volume of bread between those for no shortening (899 cc) and 2–3% shortening (1,009 cc), and then blended those midway amounts of oil and either DATE or SSL to determine whether synergistic effects occurred. Six grams of each oil alone was required to give the loaf volume equal to that for 2–3% shortening in the formula. The midway volume for most of the oils was 2%, and for SSL and DATE 0.2%. When 2% of each oil plus 0.2% SSL or DATE was added in the formula, all bread volumes were equal to or somewhat greater than that for the control containing shortening. When 2% of each oil and only 0.1% of SSL or DATE were added, most loaf volumes were equal to or somewhat greater than that of the shortening control. Thus, the mixture of oil and surfactant produced synergistic effects. The availability, lower cost, and ease of handling the oils, together with the low concentration of a single surfactant (0.1% SSL or DATE), are incentives for the baking industry to use a combination of oil and surfactant.

During the last few years, the baking industry has been shifting from the use of lard and hardened shortenings to that of oils and blends of oil and surfactant (Hartnett and Thalheimer 1979a, 1979b). The advantages of this conversion are increased availability and lower cost, bulk handling and storage, and "all-vegetable" oil package labeling. Disadvantages of oil alone in breadmaking are dough weakness, dull crumb, and poor loaf volume (Pyler 1973).

The function of oil, shortening, and surfactants and their mechanism has been studied. Baker and Mize (1942) demonstrated an excellent relationship between the solid-liquid ratio of fats and baking performance. Pomeranz et al (1966) added oils and waxes with increasing melting points and concluded that the dough strengthening of shortening was due in part to the higher melting components. The evolution of various shortenings, oils, and oil-surfactant blends for the baking industry was described by Smith (1979). Very recently Junge and Hoseney (1981) postulated that the mechanism of shortening or of certain surfactants was to delay the setting of the dough during baking.

We determined the amount of each of 14 different oils, sodium stearoyl-2-lactylate (SSL), and diacetyl tartaric acid esters of mono- and diglycerides (DATE) required to reach the midway loaf volume between those for no-added shortening and 3% added shortening and then blended those midway amounts of each oil and DATE or SSL to determine which oils or blends were equal to or better than shortening in breadmaking.

MATERIALS AND METHODS

Wheat and Flour Samples

Each of many hard winter wheat cultivars harvested in 1980 at several locations throughout the Great Plains of the United States was milled on a Miag Multomat. A composite straight-grade flour (CS-80) contained an aliquot of flour from each milling. CS-80 flour contained 12.9% protein (N × 5.7, 14% mb). It had an excellent loaf volume potential and a medium to medium-long mixing requirement.

Oils and Surfactants

Eleven oils and three oil-surfactant blends were studied. Three oils—soy, corn, and sunflower—were purchased locally. A commercially available cottonseed oil was supplied by John Cherry, Southern Regional Research Center, USDA-ARS, New Orleans, LA. A refined, deodorized, bleached (RDB) soy oil and a winterized (W) RDB soy oil were supplied by Anderson-Clayton Foods Division, Dallas, TX. Five oil samples—an RDB soy oil, a lightly hydrogenated (LH) soy oil, a partially hydrogenated (PH) soy oil, a fluid semisolid partially hydrogenated (FSSPH) soy oil, and an RDB corn oil—were supplied by A. E. Staley Manufacturing Co., Decatur, IL. Durkee Industrial Foods Group, Cleveland, OH, supplied three PH soy oils to which various surfactants had been added. One (B-40) contained mono- and diglycerides, another (B-12K) contained mono- and diglycerides and polyglycerate 60, and the third sample (BETA +) contained SSL in B-12K. The two surfactants that we added to each of the 14 oils were DATE and SSL. They were supplied by Hercules Inc., Wilmington, DE, and Patco Products, Kansas City, MO, respectively.

Analytical Procedures

Moisture and protein contents were determined by AACC approved methods 44-15A and 46-11, respectively (AACC 1976).

The bread-making method included mixing to minimum mobility (optimum) at 100 rpm, optimum water, and 50 ppm of ascorbic acid (an excess in the absence of nonfat dry milk). Additional formula ingredients were 100 g of flour (14% mb), 6.0 g of sugar, 1.5 g of salt, variable shortening or oil or DATE or SSL, about 2 g of Fermipan dry yeast (Bruinsma and Finney 1981), which gave a gas production equal to that of 5.3 g of compressed yeast, and 0.25 g of barley malt (52 dextrinizing units [DU]/g, 20°C). Ascorbic acid was its own buffer against overoxidation (Shogren and Finney 1974). Straight doughs were fermented 52 min to first punch, 77 min to second punch, and 90 min to pan and were proofed 34 ± 1 min (the time required to proof the controls to 7.9 cm) at 30°C. Baking time was 24 min at 215°C. Loaf volume was determined by dwarf rapeseed displacement immediately after baking. Loaf volumes that differed by 27 cc were statistically significant at $P = 0.05$. Additional related details are given by Finney (1945, 1984), Finney and Barmore (1943, 1945a, 1945b), and Finney et al (1976).

Crumb compressibility was measured with a Bloom gelometer 1 hr and 3 days after baking. The weight required to depress a plunger (25 mm in diameter) 4 mm into the bread crumb, after the crust was removed, was taken as the compressibility measurement. Three-day measurements were made on bread crumb from loaves

[1]Mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.

[2]Research chemists. Present address of B. L. Bruinsma: Universal Foods Corp., 6143 N. 60th Street, Milwaukee, WI 53218.

TABLE I
Loaf Volume and Crumb Grain Response to Increasing Quantities of 11 Liquid or Semiliquid Oils and Three Commercially Available Oil-Surfactant Mixtures[a]

Oil[b]	Loaf Volume (cc) when Quantity (g) Added Was				
	0.5	1.0	2.0	3.0	6.0
Shortening control[c]	950	981	1,012	1,005	1,008
1 Soy	918	923	950	973	1,000
2 Corn	908	928	948	963	995
3 Sunflower	920	931	961	985	1,010
4 Cottonseed	905	920	928	951	1,005
5 RDB soy	926	920	958	970	1,010
6 WRDB soy	903	920	948	958	1,015
7 RDB soy	908	918	941	956	1,015
8 LH soy	895	910	945	968	983
9 PH soy	908	915	938	965	995
10 FSSPH soy	908	925	963	980	1,013
11 RDB corn	925	917	945	963	995
Avg crumb grain[d]	Q-U	Q	Q-S	Q-S	S
12 B-40	923	950	988	973	993
13 B-12K	928	965	998	985	990
14 Beta +	928	985	990	998	1,018
Avg crumb grain[d]	Q	Q-S	S	S	S

[a] B-40, B-12K, and Beta +.
[b] RDB = refined, deodorized, bleached; WRDB = winterized RDB; LH = lightly hydrogenated; PH = partially hydrogenated; FSSPH = fluid semisolid partially hydrogenated.
[c] No-shortening control = 899 cc.
[d] U = unsatisfactory, Q = questionable, and S = satisfactory.

TABLE II
Loaf Volume Response to Increasing Concentrations of SSL and DATE[a]

Amount (g)	Loaf Volume (cc)	
	SSL	DATE
0.00	899	899
.10	891	914
.15	928	935
.20	958	954
.25	979	1,005
.30	978	1,030
.40	974	1,045
.50	968	1,040
.60	...	1,045
.70	...	1,048
.75	965	1,063
1.00	940	1,060

[a] SSL = sodium stearoyl-2-lactylate; DATE = diacetyl tartaric acid esters of mono- and diglycerides.

TABLE III
Loaf Volumes of Bread that Contained 0.2 g (midway-volume amount) or 0.10 g of DATE or SSL, Together with the Midway-Volume Amounts of Each of 11 Oils and Three Oil-Surfactant Mixtures

Oil		Loaf Volume (cc) when Quantity (g) Added Was			
		DATE		SSL	
No.	g	0.20	0.10	0.20	0.10
	0.00	954	914	958	891
1	2.0	1,027	1,014	1,040	1,024
2	2.0	1,020	1,008	1,018	1,010
3	2.0	1,028	1,023	1,023	1,013
4	2.0	1,015	1,030	1,010	1,004
5	2.0	1,018	1,003	1,037	1,008
6	2.0	1,018	1,000	1,015	995
7	2.0	1,028	1,033	1,023	1,010
8	2.0	1,013	998	1,023	1,025
9	2.0	1,018	985	998	1,005
10	2.0	1,013	1,023	1,037	1,010
11	2.0	1,020	990	1,023	1,018
12	1.0	1,070	1,018	1,031	984
13	0.75	1,058	1,023	1,028	1,003
14	0.75	1,048	1,035	1,035	1,015

that had been sealed and stored in plastic bags at room temperature (about 25° C).

RESULTS AND DISCUSSION

Oils and Shortening

Loaf volume of bread increased from 899 cc (no added shortening) to a maximum of 1,012 cc at 2 g. Thereafter, volume remained essentially constant up to 6 g (Table I).

Loaf volumes of bread baked with each of the 14 oils did not approach or equal that for 2–3 g of shortening until 6 g had been added in the formula, except for bread containing B-40, B-12K, or Beta + (Table I). Only 2 g of each of those three were required, because they contained commercially added surfactants.

The approximate midway volume between those for no added shortening (899 cc) and 2–3 g of added shortening (1,009 cc) was reached by 2 g of oils 1–11. Only 1 g of oil 12 and 0.75 g (interpolate) of oils 13 and 14 were required.

Crumb grains were satisfactory when bread volumes were approximately equal to that for 2–3 g of shortening. Loaf characteristics, handling properties, and essentially all loaf volumes did not differ significantly at a given concentration of oils 1–11 or oils 12–14.

DATE and SSL

Approximate midway loaf volumes between 899 and 1,009 cc were obtained when the formula contained 0.2 g of SSL or DATE (Table II). Loaf volume reached a maximum for 0.25–0.30 g of SSL and decreased thereafter. Loaf volume increased as the amount of added DATE increased from 0.10 to 0.75 g. Optimum volume for DATE was 84 cc higher than that for SSL.

Oils Plus DATE or SSL

When 0.20 g of SSL or DATE, enough to reach the midway volume potential for shortening (954 cc), was combined with 2.0 g each of oils 1–11 (Table I), also enough to reach the midway volume potential for shortening, bread volumes (Table III) were equal to or somewhat higher than that for the average of 2–3 g of shortening (1,009 cc, Table I). Loaf volumes of the commercial fluid products that contained surfactants (oils 12–14) were significantly higher than 1,009 cc, even though only enough of each was added (1.0, 0.75, 0.75 g) to give approximately the midway volume for shortening (954 cc).

When DATE or SSL was decreased to 0.1%, bread volume was not significantly different from that for 2–3 g of shortening (Table III). When the added DATE or SSL was appreciably less than 0.1 g, loaf volume and crumb grain were inferior to those for 2–3 g of shortening, especially when oils 1–11 were involved (data not shown).

The need for only 1.0, 0.75, and 0.75 g of the fluid oil-surfactant blends already available (oils 12, 13, and 14, respectively) indicate that each of those amounts contains the equivalent of about 0.15 g of DATE or SSL.

The advantages of oils are accessibility, bulk storage, and ease of handling, together with the need for a very low concentration of a single surfactant (0.1% of either DATE or SSL).

Crumb Compressibility

Crumb compressibility of bread that contained the oil-surfactant combinations was not significantly different from that of bread containing 3 g of shortening (data not shown).

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1976. Approved methods of the AACC. Methods 44-15A and 46-11, approved April 1967. The Association, St. Paul, MN.

BAKER, J. C., and MIZE, M. D. 1942. The relation of fats to texture, crumb, and volume of bread. Cereal Chem. 19:84.

BRUINSMA, B. L., and FINNEY, K. F. 1981. Functional (breadmaking) properties of a new dry yeast. Cereal Chem. 58:477.

FINNEY, K. F. 1945. Methods of estimating and the effect of variety and

protein level on the baking absorption of flour. Cereal Chem. 22:149.
FINNEY, K. F. 1984. An optimized, straight-dough, bread-making method after 44 years. Cereal Chem. 61:20.
FINNEY, K. F., and BARMORE, M. A. 1943. Yeast variability in wheat variety test baking. Cereal Chem. 20:194.
FINNEY, K. F., and BARMORE, M. A. 1945a. Varietal responses to certain baking ingredients essential in evaluating the protein quality of hard winter wheats. Cereal Chem. 22:225.
FINNEY, K. F., and BARMORE, M. A. 1945b. Optimum vs. fixed mixing time at various potassium bromate levels in experimental bread baking. Cereal Chem. 22:244.
FINNEY, P. L., MAGOFFIN, C. D., HOSENEY, R. C., and FINNEY, K. F. 1976. Short-time baking systems. I. Interdependence of yeast concentration, fermentation time, proof time, and oxidation requirement. Cereal Chem. 53:126.
HARTNETT, D. I., and THALHEIMER, W. G. 1979a. Use of oil in baked products. I. Background and bread. J. Am. Oil Chem. Soc. 56:944.
HARTNETT, D. I., and THALHEIMER, W. G. 1979b. Use of oil in baked products. II. Sweet goods and cakes. J. Am. Oil Chem. Soc. 56:948.
JUNGE, R. C., and HOSENEY, R. C. 1981. A mechanism by which shortening and certain surfactants improve loaf volume in bread. Cereal Chem. 58:408.
POMERANZ, Y., RUBENTHALER, G. L., and FINNEY, K. F. 1966. Studies on the mechanism of the bread-improving effect of lipids. Food Technol. 20:105.
PYLER, E. J. 1973. Baking: Science and Technology. Siebel Publishing Co., Chicago, IL.
SHOGREN, M. D., and FINNEY, K. F. 1974. A mixture of ascorbic acid and potassium bromate quickly optimize loaf volume. (Abstr.) Cereal Sci. Today 19:397.
SMITH, W. M. 1979. Evolution of fluid bread shortenings. Bakers Dig. 53(4):8.

[Received October 11, 1983. Accepted February 5, 1984]