Functional (Breadmaking) and Biochemical Properties of Wheat Flour Components. IX. Replacing Total Free Lipid with Synthetic Lipid[1]

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ABSTRACT

Adding sucrose monotallowate to a standard baking formula increased loaf volume from 7.0 to 18%, depending on the level of shortening in the formula. When two sucroglycerides (sucrose monotallowate and sucrose monopalmitate) were added to petroleum-ether-defatted flour, each replaced the total free flour lipids, and increased loaf volumes 18 and 22%, respectively, above that of the original flour (with shortening). Native free flour lipids could also be replaced with sodium or calcium stearoyl-2-lactylates. However, adding either lactylate, unlike the sucroglycerides, did not increase loaf volumes above that of the control flour. When two nonionic surfactants (pluronic polyols F-108 and F-68) were baked with petroleum-ether-defatted flour, loaf volumes were generally comparable to that of the control flour. However, all loaves baked with pluronic polyols had impaired crumb grains.

Adding small amounts of polar wheat-flour lipids to defatted wheat flour substantially improved loaf volume, crumb grain, and freshness retention of bread (1,2). Preliminary investigations indicated that the improvement was due primarily to glycolipids (3,4).

Audidier and LaPape (5,6) reported that synthetic glycolipids (sucroglycerides) improved dough handling properties, loaf volume, and overall quality of baked products. Sucroesters counteracted the deleterious effects of 8 to 16% soy flour on loaf volume and crumb grain of bread (7,8), and as little as 0.25 to 0.50% of sucroesters replaced 3% shortening in the bread formula. In addition, the deleterious effects of other foreign proteins (in cottonseed flour, sesame flour, torula yeast, and fish meal) were overcome, at least partially, by adding sucrose tallowate (8).

Glycolipids are essentially nonionic surfactants. Recent studies in our laboratory (9) have shown that relatively small amounts of other surfactants [sodium and calcium stearoyl-2-lactylates (SSL and CSL) and pluronic polyol F-108] can replace 3% shortening in the bread formula, and are effective in overcoming the deleterious effects of 12% soy flour. The results with the lactylates have been corroborated by Tsen et al. (10,11).

Studies on the effectiveness of those synthetic surfactants in replacing total free flour lipids (TFL) in breadmaking are reported here.

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MATERIALS AND METHODS

Flour

RBS-69A flour (Regional Bake Standard) was experimentally milled (Allis) from a composite grist of many wheat varieties grown at numerous locations throughout the Great Plains in 1968 and 1969.

Lipids

The shortening was a commercial product of vegetable origin, partly hydrogenated, m.p. 41°C. Total free lipids were obtained by twice extracting RBS-69A flour overnight with petroleum ether (b.p., 35° to 60°C.) in a Soxhlet. Defatted flour was air-dried. Lipids were recovered by evaporation under reduced pressure. Commercial synthetic lipids included sucrose monotallowate (SMT, Colonial Sugars, Gramercy, La.), sucrose monopalmitate (SMP, Di-Nippon Sugar Mfg. Ltd., Tokyo), SSL and CSL (Patterson Co., Kansas City, Mo.), and pluronic polyols F-108 and F-68 (Wyandotte Chemical Co., Wyandotte, Mich.). All reconstituted or substituted lipids were blended with flour in a mortar and pestle.

Breadmaking

All loaves, baked by the 10-g. straight-dough baking procedure described by Shogren et al. (12), contained optimum potassium bromate of 30 p.p.m. The baking formula included: flour, 10 g.; sugar, 0.6 g.; salt, 0.15 g.; shortening, 0.3 g.; yeast, 0.2 g.; nonfat dry milk, 0.4 g.; and 60°L. malt syrup, 0.05 g. Shortening was omitted in some tests. Standard deviation for the average of duplicate loaf volumes was 1.75 cc. Loaf volume was determined by dwarf rapeseed displacement.

RESULTS AND DISCUSSION

Sucrose Monotallowate and Nondefatted Flour

RBS-69A flour (control) had a loaf volume of 81 cc. Adding 0.5% SMT to the formula increased the loaf volume to 87 cc. (Table I). Further additions of SMT up to 3.0% gave small but consistent increases in loaf volume. Doughs containing more than 3% SMT were difficult to handle. When shortening was omitted, adding 0.5% SMT gave a loaf volume of 86 cc., comparable to 0.5% SMT with shortening. However, more SMT (without shortening) gave no significant increases in loaf volume.

TABLE I. BAKING DATA FOR RBS FLOUR BAKED WITH AND WITHOUT SHORTENING AND WITH INDICATED LEVELS OF SMT

SMT %	Shortening %	Crumb Grain[a]	Loaf Volume cc.	SMT %	Shortening %	Crumb Grain[a]	Loaf Volume cc.
0	3	S	81	0	0	U	68
0.5	3	S	87	0.5	0	S	86
1	3	S	91	1	0	S	87
2	3	S	94	2	0	S	88
3	3	S	96	3	0	S	88

[a]S = Satisfactory; U = unsatisfactory.

Free Flour Lipids and Defatted Flour

RBS-69A flour (defatted with petroleum ether) had a loaf volume of 69 cc. and a distinctly inferior crumb grain (Table II). Restoring the 0.8% TFL produced a loaf of bread fully comparable to the original RBS-69A. Doubling the amount of TFL to 1.6% did not significantly increase loaf volume. Loaf volume of defatted flour without shortening was somewhat higher, but crumb grain was noticeably better than with shortening. However, reconstituting 0.8% TFL to the defatted flour (without shortening) impaired both loaf volume and crumb grain. Increasing TFL to 1.6% increased loaf volume to 78 cc. and somewhat improved the crumb grain. However, both were below the values for the control flour with shortening.

Sucroglycerides and Defatted Flour

Adding 0.2% SMT to defatted flour (3% shortening) gave no higher loaf volume than the defatted flour alone (Table II). Higher levels of SMT (up to 3%) gave progressively increased volumes to 96 cc., about 40% higher than the defatted flour alone and 17% higher than the defatted flour plus native flour lipids. In similar series without shortening, loaf volume was 105 cc. for 3% SMT, about 48% higher than the defatted flour alone and about 57% higher than the defatted flour plus native flour lipids. In addition, crumb grains progressively improved with addition of SMT both with and without shortening. At the higher levels of SMT, crumb grains were distinctly better than those of the original flour (with shortening). Cut loaves of bread are illustrated in Fig. 1.

Data for SMP were similar to those for SMT (Table III). At lower levels (0.5%) of both sucroglycerides, 3% shortening had a positive effect on loaf volumes. As the level of sucroglyceride increased, the shortening effect decreased; and at the highest level (3.0%) of sucroglycerides, the effect of 3% shortening was nil or negative. In contrast, the effect of shortening was quite noticeable when high levels of SMT were added to the original flour (Table I).

When the two sucroglycerides (SMT and SMP, with shortening) were added to defatted flour, each replaced TFL and increased loaf volumes 18 and 22%, respectively, above that of the original flour (with shortening).

TABLE II. BAKING DATA FOR DEFATTED RBS-69A FLOUR BAKED WITH AND WITHOUT SHORTENING AND WITH INDICATED LEVELS OF TFL OR SMT

TFL %	Shortening %	Crumb Grain[a]	Loaf Volume cc.	SMT %	Shortening %	Crumb Grain[a]	Loaf Volume cc.
0 (original flour)	3	S	81	0.2	3	Q	69
0	3	Q-U	69	0.5	3	Q-S	79
0.8	3	S	82	1.0	3	VS	89
1.6	3	S	83	2.0	3	VS	93
0 (original flour)	0	U	68	3.0	3	VS	96
0	0	Q-S	71	0.2	0	Q-S	69
0.8	0	U	67	0.5	0	Q-S	68
1.6	0	Q-U	78	1.0	0	S	82
				2.0	0	VS	90
				3.0	0	E	105

[a]U = Unsatisfactory; Q = questionable; S = satisfactory; VS = very satisfactory; E = excellent.

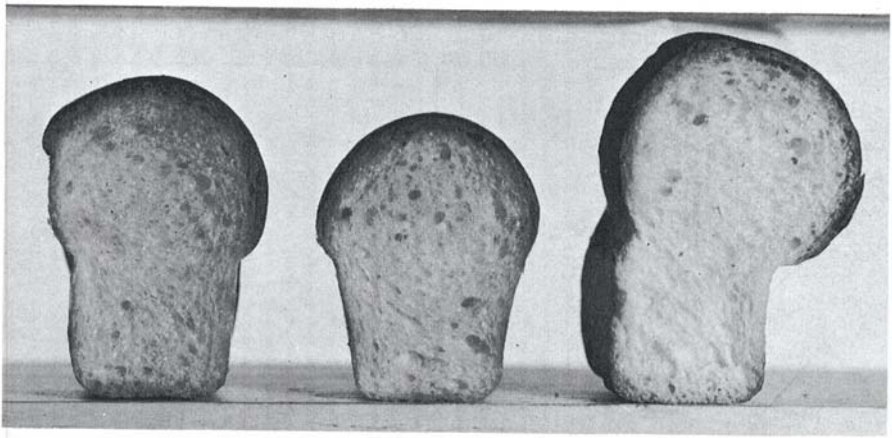

Fig. 1. Cut loaves of bread baked from RBS flour (3% shortening, left), defatted RBS flour (no shortening, middle), and defatted RBS flour with 3.0% SMT (no shortening, right).

TABLE III. BAKING DATA FOR DEFATTED RBS-69A FLOUR BAKED WITH AND WITHOUT SHORTENING AND INDICATED LEVELS OF SMP

SMP %	Shortening %	Crumb Grain[a]	Loaf Volume cc.	SMP %	Shortening %	Crumb Grain[a]	Loaf Volume cc.
0 (original flour)	3	S	81	0 (orginal flour)	0	U	68
0	3	Q-U	69	0	0	Q-S	71
0.2	3	Q	70	0.2	0	Q-S	71
0.5	3	S	80	0.5	0	Q-S	73
1	3	S	88	1	0	S	84
2	3	S	93	2	0	VS	92
3	3	VS	99	3	0	VS	99

[a]U = unsatisfactory; Q = questionable; S = satisfactory; VS = very satisfactory.

Stearoyl Lactylates and Defatted Flour

Adding SSL or CSL to defatted flour, with or without 3% shortening, gave loaf volumes and crumb grains comparable to the control flour (Table IV). Thus, the stearoyl lactylates effectively replaced the native flour lipids; but adding high levels of stearoyl lactylates did not increase loaf volumes above that of the original flour, as did the sucroglycerides.

The effects of SSL and CSL on the original, nondefatted flour (without shortening) have been demonstrated (9).

Pluronic Polyols and Defatted Flour

Two nonionic surfactants (pluronic polyols F-108 and F-68) were baked with defatted flour (Table V). As little as 0.1 to 0.3% pluronic polyol F-108 (with

TABLE IV. BAKING DATA FOR DEFATTED RBS-69A FLOUR BAKED WITH AND WITHOUT SHORTENING AND WITH INDICATED LEVELS OF SSL OR CSL

SSL %	Shortening %	Crumb Grain[a]	Loaf Volume cc.	CSL %	Shortening %	Crumb Grain[a]	Loaf Volume cc.
0 (original flour)	3	S	81				
0	3	Q-U	69	0	3	Q-U	69
0.2	3	Q-U	69	0.2	3	Q-U	69
0.5	3	Q-S	74	0.5	3	Q-S	72
1	3	S	82	1	3	Q-S	80
2	3	S	75	2	3	S	73
0 (original flour)	0	U	68				
0	0	Q-S	71	0	0	Q-S	71
0.2	0	S	69	0.2	0	S	70
0.5	0	VS	81	0.5	0	S	75
1	0	S	83	1	0	S	79
2	0	S	80	2	0	S	78

[a]U = Unsatisfactory; Q = questionable; S = satisfactory; VS = very satisfactory.

TABLE V. BAKING DATA FOR DEFATTED RBS-69A FLOUR BAKED WITH AND WITHOUT SHORTENING AND WITH INDICATED LEVELS OF PLURONIC POLYOL F-108 OR F-68

F-108 %	Shortening %	Crumb Grain[a]	Loaf Volume cc.	F-68 %	Shortening %	Crumb Grain[a]	Loaf Volume cc.
0 (original flour)	3	S	81				
0	3	Q-U	69	0	3	Q-U	69
0.1	3	Q	76	0.1	3	Q-U	72
0.2	3	Q	77	0.2	3	Q-U	73
0.3	3	Q	79	0.3	3	Q-U	73
0.5	3	Q-U	77	0.5	3	Q-U	70
0 (original flour)	0	U	68				
0	0	Q-S	71	0	0	Q-S	71
0.1	0	Q-S (open)	79	0.1	0	Q (open)	82
0.2	0	Q-S (open)	85	0.2	0	Q (open)	80
0.3	0	Q-S (open)	86	0.3	0	Q (open)	78
0.5	0	Q-S (open)	76	0.5	0	Q (open)	79

[a]U = Unsatisfactory; Q = questionable; S = satisfactory.

shortening) gave loaf volumes nearly equal to that of the original flour (with shortening). Thus, 0.3% F-108 (79 cc.) approached the effect of 0.8% free lipids (equivalent to original flour, 81 cc.). Omitting shortening, it is particularly noteworthy that only 0.2% of F-108 increased loaf volume more than did 0.8% TFL plus 3% shortening (Table II, equivalent to original flour plus shortening). Also, 0.1% F-108 (no shortening) was as effective as 1.6% TFL and greatly superior to 0.8% TFL (Table II, no shortening). Pluronic polyol F-68, in general, was less effective than F-108. However, the crumb of all loaves baked with defatted flour and pluronic polyols was at least somewhat impaired.

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