Improving Breadmaking Properties with Glycolipids. II. Improving Various Protein-Enriched Products[1]

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ABSTRACT

Bread was baked with 8 or 16 g. soy flour, and 8 g. (per 100 g. wheat flour) defatted cottonseed flour, fish protein concentrate, nonfat dry milk, expeller-extracted sesame seed flour, wheat gluten, defatted wheat germ, air-fractionated protein-rich wheat flour, or food-grade Torula yeast. All protein-rich additives substantially lowered loaf volume and impaired crumb grain. Adding 3 g. shortening counteracted partly the deleterious effects of 16 g. soy flour; higher levels had no additional improving effect. Loaf volumes were increased and crumb grain was improved by adding 1.0 to 6.0 g. sucrose tallowate. The loaf volume of bread containing 3.0 to 6.0 g. sucrose tallowate was substantially above that of the control containing no added soy flour. Highest levels of tallowate increased mixing time and impaired rheological properties. Small amounts (0.5 to 1.0 g.) synthetic glycolipids and free lipids (rich in glycolipids) from wheat flour and *Briza spicata* improved volume and crumb grain of nutritionally improved bread as much as or more than 3 g. shortening. Synthetic glycolipids, but not shortening, rendered commercial wheat gluten functional in breadmaking.

Previous studies from our laboratory were concerned with improving breadmaking properties of soy products with glycolipids (1). Small amounts (0.25 to 2.0%) of synthetic sucroglycerides and polar wheat flour lipids (rich in glycolipids) counteracted the deleterious effects of up to 16% of various soy products on loaf volume, on crumb grain, and bread softness. The effects of sucroglycerides increased with increase in hydrophilic-lipophilic balance; i.e., with decrease in number and chain lengths of fatty acids attached to the sucrose molecule. This report is concerned with the beneficial effects of wheat flour polar lipids, lipids from *Briza spicata* seed that are rich in glycolipids (2), and sucroglycerides on production of bread nutritionally improved by several protein-rich products, including soy, cottonseed, sesame, wheat germ, wheat gluten, an air-fractionated protein-rich fraction from wheat flour, fish, Torula yeast, and NFDM.

MATERIALS AND METHODS

Flour Samples

Most of the experiments were made with an untreated flour, experimentally milled on an Allis mill from a composite grist of several wheat varieties grown at several locations throughout the Great Plains. This flour is designated RBS (Regional Baking Standard). In addition, three wheat samples grown in 1965 were milled at an extraction of about 70% on a Miag Multomat. The wheat samples were composited from equal portions of wheat as described previously for samples from the 1963 crop (3). Some chemical and breadmaking characteristics of the flours (baked by a formula including 4% milk solids and 3% shortening) are summarized in Table I.

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[1]Co-operative investigations between the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Kansas Agricultural Experiment Station, Manhattan, Kansas. Approved May 24, 1968, for publication by the Director as Station Annual No. 279. Mention of a trademark name, proprietary product, or scientific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that may also be available.

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TABLE I. SOME CHEMICAL AND BREADMAKING CHARACTERISTICS[a] OF FLOURS

Flour	Protein (N × 5.7) %	Ash %	Baking Abs. %	Mixing Time min.	Bromate Requirement p.p.m.	Loaf Volume cc.	Crumb Grain
RBS	12.9	0.42	65.5	3-1/4	30	935	S
Comanche	12.7	0.42	64.2	3-5/8	15	919	S
Thatcher	13.0	0.54	64.3	3-1/4	20	922	S
Seneca	8.5	0.39	64.2	3	10	740	Q-S

[a]14% moisture basis.

Lipids

The shortening used was a commercial product of vegetable origin, partly hydrogenated, with m.p. of 41°C. Free polar flour lipids were obtained by fractionating free lipids (petroleum ether-extracted) from the RBS flour by silicic acid column chromatography (4). Free lipids were also obtained by exhaustive extraction of seeds of *B. spicata* with petroleum ether. Bound lipids from the RBS flour and from *B. spicata* were extracted with water-saturated butanol after petroleum ether extraction. The wheat flour contained 0.8% free lipids (a mixture of 0.6% nonpolar components eluted from the silicic acid column with chloroform, and 0.2% polar components eluted with methanol after the chloroform elution) and 0.6% bound lipids. Extraction of *B. spicata* seeds gave 11.1% free and 1.4% bound lipids. The two sucroglycerides, sucrose monolaurate and sucrose tallowate, were commercial products.

Protein Concentrates

Nine protein concentrates were used. Some chemical characteristics of the concentrates are given in Table II. The soy flour used was a commercial, chemically treated product that contained 1.75% lecithin and had a dispersibility index corresponding to 70%. Defatted cottonseed flour, fish protein concentrate, NFDM, expeller-extracted sesame seed flour, wheat gluten, and Torula yeast (food grade) were commercial products. The wheat germ used was a fresh, granular product. The wheat germ was defatted by extraction with petroleum ether, ground to pass a 60-mesh sieve, and re-extracted with petroleum ether. The air-fractionated flour was prepared on a laboratory scale from defatted (petroleum ether-extracted) patent flour that was commercially milled from a mixed grist of HRW wheat. The original patent flour had a protein content of 10.3% and an ash content of 0.44%.

TABLE II. CHEMICAL COMPOSITION OF PROTEIN CONCENTRATES

Protein Concentrate	Moisture %	Protein %	Petroleum Ether Ext. %	Ash %
Soy flour	8.3	52.7	0.5	6.91
Cottonseed flour	4.7	63.1	3.9	6.48
FPC	7.8	69.7	0.2	21.05
Milk powder	10.5	34.6	0.1	7.89
Sesame seed flour	8.8	46.1	5.6	11.75
Wheat gluten	7.8	57.0	0.6	0.89
Torula yeast	7.6	54.9	1.6	7.02
Wheat germ	11.0	30.0	0.2	5.15
Air-fractionated flour	6.8	27.0	1.3	0.78

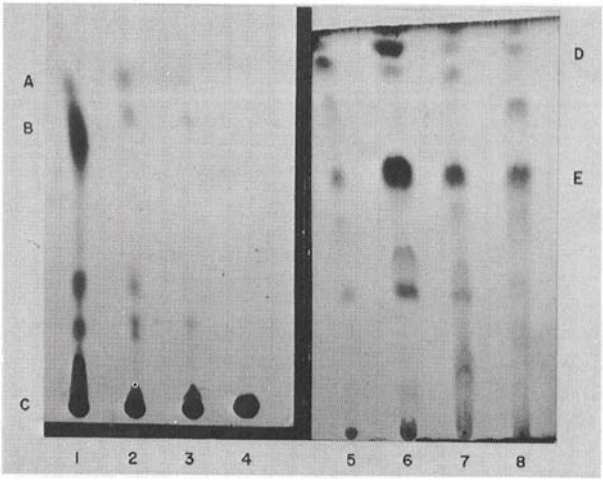

Fig. 1. Thin-layer chromatogram of lipids from wheat flour (1, 4, 5, and 8) and *B. spicata* (2, 3, 6, and 7); free lipids (1, 2, 5, and 6) and bound lipids (3, 4, 7, and 8). Spots 1 through 4 were developed with chloroform, 5 through 8 with chloroform-methanol-water (65:35:4). Spots of 100 γ lipids; visualized by charring with sulfuric acid; picture taken under ultraviolet light. Tentatively identified as: A, mixture of hydrocarbons and steryl esters; B, triglycerides; C, unresolved polar lipids; D, unresolved nonpolar lipids; E, digalactosyl diglyceride.

Analytical Determinations

Moisture, ash, crude fat, and Kjeldahl protein were determined by the AACC method (5). Percent nitrogen was converted to percent protein with the factor 5.7 in wheat products (including gluten) and the factor 6.25 in protein concentrates. Lipids were fractionated by thin-layer chromatography (TLC) as described elsewhere (4). The pure compounds used to identify lipid components included trilinolein, phosphatidyl choline, phosphatidyl serine, phosphatidyl ethanolamine, monogalactosyl diglyceride, and digalactosyl diglyceride. The TLC of lipids in wheat flour and in *B. spicata* in Fig. 1 shows that the latter contained substantial amounts of digalactosyl diglyceride.

Breadmaking

The breadmaking formula included 100 g. flour, 1.5 g. salt, 2 g. yeast, 4 g. NFDM, 6 g. sucrose, 0.50 g. 60°L. malt syrup, 3 g. shortening, water as needed, and optimum potassium bromate, except for these changes: In experimental baking with protein concentrates, NFDM was replaced by 8 or 16 g. protein concentrate. Similarly, in some experimental baking, shortening was omitted, added at various levels, or replaced by polar lipids. An optimum mixing time with the straight-dough procedure and a 3-hr. fermentation time at 30°C. were employed. Panning and punching were performed mechanically. Baking time was 24 min. at 218°C. Baking tests were replicated at least twice. Loaf volumes of bread baked from each whole dough mix were determined by dwarf rapeseed displacement immediately after the bread was taken from the oven. After cooling, the loaves were cut and their crumb grain and texture evaluated. This code was employed: S = satisfactory, Q = questionable, and U = unsatisfactory.

ABLE III. LOAF VOLUME AND CRUMB GRAIN OF BREAD BAKED WITH 16 g. SOY FLOUR ER 100 g. RBS FLOUR) AND VARIOUS LEVELS OF SHORTENING OR SUCROSE TALLOWATE

ipid	Lipid Level	Loaf Volume	Crumb Grain
	g.	cc.	
		675	U-
hortening	3	900	S-
	6	885	Q-S
	9	887	Q-S
ucrose tallowate	1	875	Q
	2	938	Q
	3	993	S
	4	1,030	S
	6	1,100	S

RESULTS AND DISCUSSION

Effects of various levels of vegetable shortening and sucrose tallowate on loaf volume and crumb grain of bread baked with 16 g. soy flour (per 100 g. RBS flour) are summarized in Table III. Pictures of some loaves baked with 16 g. soy flour alone and with 4 g. sucrose tallowate are compared with the control baked with 4 g. milk solids and 3 g. shortening (Table I) in Fig. 2. Both shortening and sucrose tallowate increased loaf volume and improved crumb grain; but, whereas high levels of shortening (6 g. and 9 g.) were probably slightly detrimental, increasing the level of sucrose tallowate to 6 g. per 100 g. flour consistently increased loaf volume and maintained satisfactory crumb grain at high levels of tallowate. Loaf volumes of bread baked with 16 g. soy flour and 3 to 6 g. sucrose tallowate were substantially higher (993 to 1,100 cc., Table III) than loaf volume of bread baked by the complete formula without soy flour (935 cc., Table I). Increasing the level of sucrose tallowate from 0 to 6 g. gradually lengthened mixing time from 4 to about 6.5 min. Doughs containing 6 g. sucrose tallowate were tough, short, and difficult to handle. Crust color deepened significantly and consistently with increase in level of sucrose tallowate.

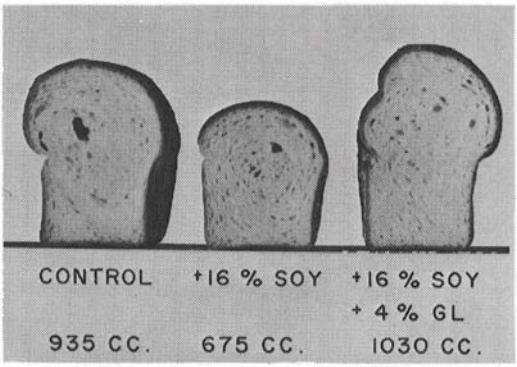

Fig. 2. Bread baked from 100 g. RBS flour. Left to right: with 4 g. milk powder and 3 g. shortening; with 16 g. soy flour; and with 16 g. soy flour and 4 g. sucrose tallowate.

TABLE IV. LOAF VOLUME AND CRUMB GRAIN OF BREAD BAKED WITH 8 g. SOY FLOUR OR 8 g. COTTONSEED FLOUR AND VARIOUS LIPIDS (PER 100 g. RBS FLOUR)

Lipid Source	Lipid Level g.	Loaf Volume cc.	Crumb Grain
	Soy flour		
None	...	755	Q
Shortening	3.0	870	S
Sucrose tallowate	0.5	915	S
B. spicata	0.5	883	S
	Cottonseed flour		
None	...	733	Q-U
Shortening	3.0	835	S
Sucrose tallowate	0.5	850	S
B. spicata	0.5	833	S
Polar-free (wheat flour)	0.5	900	S

Effects of various lipids on loaf volume and crumb grain of bread baked with either 8 g. soy flour or 8 g. cottonseed flour are summarized in Table IV. In bread enriched nutritionally with either of the two oilseed flours, loaf volume and crumb grain were improved by adding 3 g. shortening or as little as 0.5 g. polar lipids. Sucrose tallowate increased loaf volume more than shortening, and polar wheat flour lipids increased loaf volume most. The effects on loaf volume of lipids from *B. spicata* were smaller than the effects of sucrose tallowate.

Adding to three flours 8 g. (per 100 g. flour) of milk powder, air-fractionated wheat flour, or defatted wheat germ (without adding lipids), impaired loaf volume (Table V). Loaf volumes of bread baked from the three flours by the complete control formula, which included 4 g. NFDM and 3 g. shortening, were 919, 922, and 740, respectively, for Comanche, Thatcher, and Seneca (Table I). Addition of commercial shortening or sugar (sucrose) increased loaf volume and improved

TABLE V. LOAF VOLUME OF BREAD BAKED WITH MILK POWDER, AIR-FRACTIONATED FLOUR, OR DEFATTED GERM AND 3 g. SHORTENING OR 0.5 g. SUCROSE MONOLAURATE

	NFDM 4 g.[a]	8 g.[a]	Air-Frac. Flour 8 g.[a]	Defatted Germ 8 g.[a]
	cc.	cc.	cc.	cc.
Commanche Flour				
No lipid added	...	870	870	688
Shortening	919	950	945	853
Sucr. Monolaurate	...	940	990	815
Thatcher Flour				
No lipid added	...	793	890	668
Shortening	922	938	923	835
Sucr. Monolaurate	...	915	945	813
Senaca Flour				
No lipid added	...	655	680	...
Shortening	740	780	715	...
Sucr. Monolaurate	...	760	680	...

[a]Concentrate per 100 g. flour.

TABLE VI. LOAF VOLUME AND CRUMB GRAIN OF BREAD BAKED WITH 8 g. OF VARIOUS PROTEIN CONCENTRATES (PER 100 g. RBS FLOUR) AND COMMERCIAL VEGETABLE SHORTENING OR SUCROSE TALLOWATE

Protein Concentrate	Shortening g.	Sucrose Tallowate g.	Loaf Volume cc.	Crumb Grain
Torula yeast	...	...	773	Q-S
	3	...	803	S
	...	1	850	S
Sesame flour	...	...	678	U
	3	...	775	Q
	...	1	848	Q
Fish meal	...	...	710	U
	3	...	843	Q
	...	1	860	Q
Wheat gluten	...	...	805	Q
	3	...	845	Q
	...	1	990	S

crumb grain (data not given) of bread baked with 8 g. of any of the three protein concentrates. There was no significant or consistent difference between the improving effects of 3 g. shortening or 0.5 g. sucrose monolaurate. Loaf volume was restored (to that of bread baked by the complete control formula) in bread baked with either 8 g. milk powder or 8 g. air-fractionated flour and either shortening or sucrose monolaurate. Loaf volume of bread baked with 8 g. defatted germ and added lipids continued to be lower than that of bread baked by the complete control formula.

Loaf volume and crumb grain of bread baked with 8 g. of four protein concentrates and 3 g. commercial vegetable shortening or 1.0 g. sucrose tallowate (per 100 g. RBS flour) are summarized in Table VI. Bread baked with 8 g. of any of the protein concentrates and without added lipids was inferior to that of bread baked by the complete control formula (935 cc., Table I). In each case, addition of shortening or sucrose tallowate increased loaf volume and improved crumb grain. The improvement was consistently larger from adding 1 g. sucrose tallowate than from adding 3 g. vegetable shortening. The difference is most significant in bread baked with 8 g. functionally impaired (in breadmaking potential) commercial gluten. The results indicate that adding synthetic glycolipids (but not shortening) might restore functional properties of commercial gluten. More-detailed results of similar investigations will be reported shortly.

Acknowledgment

The following generously provided samples used in this study: G. A. White, USDA, Beltsville, Maryland, seed of *B. spicata*; Archer-Daniels-Midland Co., Minneapolis, Minnesota, soy flour; Traders Protein Division, Fort Worth, Texas, cottonseed flour; and Colonial Sugars Co., Gramercy, Louisiana, sucroglycerides.

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[Received August 5, 1968. Accepted October 18, 1968]