STORAGE STABILITY OF PROTEIN-FORTIFIED FLOUR BLEND A CONTAINING SODIUM STEAROYL-2-LACTYLATE[1]

M. M. BEAN, D. K. MECHAM, M. M. HANAMOTO, and A. P. MOSSMAN, Western Regional Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Berkeley, CA 94710

Cereal Chemistry 53(3): 376-382

ABSTRACT

Flour Blend A was stored at 90° and 120°F and 13% moisture, with and without 0.5% sodium stearoyl-2-lactylate (SSL) added. The SSL partially lost its improving effect on bread loaf volume in a blend stored at 90°F for 6 months, as shown by loaf volumes intermediate to those of a blend stored and baked without SSL added, and the same blend baked with either SSL or shortening added during dough-mixing. Analytical tests showed potassium bromate was stable in blends stored at 90°F. Baking tests confirmed its continued effectiveness. Baking studies were discontinued after 2 months on blends stored at 120°F; severe deterioration in all blends could not be corrected with dough conditioners or shortening added at the time of dough-mixing. A reduced moisture content (10.5%) stabilizes baking properties more than added SSL.

Protein-fortified Flour Blend A, containing 70% bread flour and 30% wheat protein concentrate (WPC), is a high-protein blend used in the Food for Peace program (1). Specifications include a low moisture content (10.5%) to stabilize baking properties under adverse storage conditions (2). If a dough improver could be included to counteract the effects of storage at conventional flour moisture levels, the need for drying would be eliminated. This was suggested by the usefulness of certain dough conditioners for maintaining loaf volume in high-protein breads (3,4). Several have multifunctional properties, *e.g.*, dough strengthener, loaf volume improver, bread softener. One of these is sodium stearoyl-2-lactylate (SSL), a powdered product that can be easily metered into dry flour blends. Present purchase specifications for 6 and 12% soy-fortified flour (5) require 0.28 and 0.5% SSL, respectively. These levels prevent decreases in loaf volume otherwise caused by the soy additions when bread is baked without added shortening.

Previous studies on Blend A stored without dough conditioners (6) showed stability was very poor at a normal moisture content (13%). Dough-mixing time lengthened, loaf volumes decreased, free fatty acids increased, and off-flavors developed during 6 months' storage at 100°F. Adverse effects were diminished at 90°F storage. Stability significantly improved when the moisture was reduced.

Preliminary laboratory tests showed that SSL was effective in maintaining high loaf volume in bread made from fresh (unstored) Blend A when fat was omitted from the formula. In the work reported here, Blend A containing SSL was stored and its baking properties compared at intervals with Blend A samples to which SSL or fat was added only when doughs were mixed.

MATERIALS AND METHODS

The flour and WPC were commercial products meeting the specifications for

[1]Reference to a company or product name does not imply approval or recommendation of the product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

Flour Blend A. Their composition, along with that of the blend, is given in Table I.

The experimental design for the stored blends is shown in Table II. The formulation followed the specifications for government purchases (2) except that potassium bromate was added to only one of the stored blends and moisture content was 13.3%. For the major experiment related to SSL stability, 40 ppm bromate was added fresh at the dough stage to ensure no loss of its effect during storage that might confound the SSL response. In a minor experiment (treatment 5), one portion of the blend was prepared with 40 ppm potassium bromate to determine its stability during storage. All blends were stored at −10°, 90°, and 120°F in double plastic bags in friction-lid cans to prevent loss of moisture. The SSL, added fresh at mixing, was stored in a plastic bag in a refrigerator. Each month, during a 6-month storage period, the cans were brought to room temperature, and sufficient sample was removed for testing. Cans were returned to storage within 24 hr.

TABLE I
Proximate Composition of Flours[a]

	Straight-Grade Flour %	Wheat Protein Concentrate %	Blend A[b] %
Nitrogen[c]	2.13	3.70	2.58
Ash	0.46	3.14	1.62
Crude fiber	0.24	1.76	0.68
Crude fat	1.03	3.54	1.74

[a]14% moisture basis.
[b]70:30 mixture.
[c]Protein conversion factors used in specifications are 5.7, 6.25, and 5.9, respectively.

TABLE II
Experiment Design

Treatment Number	Composition of Stored Blend[a]	Levels Added after Storage at Time of Dough-Mixing[b]		
		Potassium bromate ppm	SSL %	Fat %
1	Master blend[c]	40	...	3
2	Master blend	40	0.5	...
3	Master blend	40	...	...
4	Master blend + 0.5% SSL[d]	40	...	...
5	Master blend + 40 ppm $KBrO_3$	...	...	3

[a]Stored at −10°, 90°, and 120°F at 13.3% moisture, samples drawn monthly for 6 months.
[b]Blend basis.
[c]Composition of master blend: straight-grade flour, 70% of blend; wheat protein concentrate, 30% of blend; calcium carbonate, 4 g per lb blend; and vitamin A palmitate, 5,000 IU per lb blend.
[d]SSL, a commercial product, Emplex, C. J. Patterson Co.

Duplicate bakes (two pup loaves per bake) were made at each storage period using the Finney and Barmore formula (7), but omitting fat except where noted in Table II.

Titratable acidity was measured in duplicate on a water-saturated *n*-butyl alcohol (WB) extract of stored blends with and without SSL, by the method of Mecham and Mossman (8).

Potassium bromate was measured in duplicate on the blend stored with 40 ppm bromate (treatment 5) by the AACC Approved Method (9).

Duplicate moisture determinations were made in a forced air oven at 120°C for 2 hr.

RESULTS AND DISCUSSION

Moisture determinations on samples stored at −10°F (average, 13.31%) and 90°F (average, 13.29%) showed no trend with storage (standard deviation ±0.17). Blends stored at 120°F averaged 13.17% (range 13.1 to 13.3) for the first 3 months, but the trend was lower for the following 3 months, averaging 13.01% (range 12.6 to 13.4).

Loaf volumes of bread baked with either fat or SSL (treatments 1, 2, and 4) did not differ significantly before storage, and did not change with storage at −10°F. Results were averaged to give a control volume of 728 cc (standard deviation ± 16.3 cc). When the master blend was stored at 90°F, either SSL or fat added at the dough-mixing stage increased loaf volumes about equally (treatments 1 and 2), but volumes decreased steadily to below 600 cc in 6 months (Fig. 1). However, they remained somewhat higher than those obtained with the 90°F blend that contained SSL throughout storage (treatment 4). The small differences were consistent for 5 months and increased slightly at 6 months.

The bottom curve (Fig. 1) shows loaf volumes for the stored blend baked without fat or SSL (treatment 3). Comparisons with the results for treatments 1

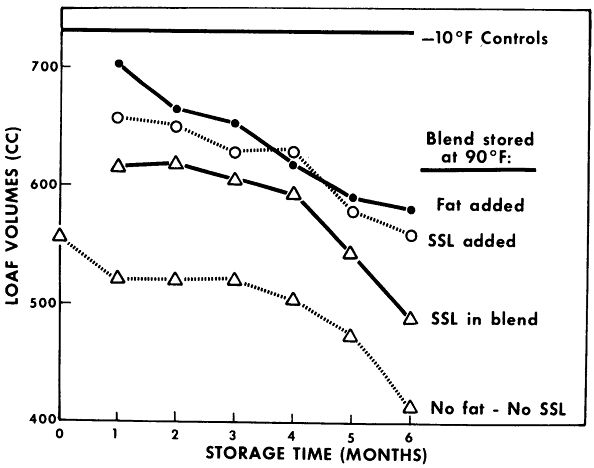

Fig. 1. Pup loaf volumes for Flour Blend A stored at 90°F and 13.3% moisture. The controls at −10°F represent the averages for all treatments containing fat or SSL.

and 2 show that storage-deteriorated, as well as fresh, Blend A produced larger loaf volumes with added fat or SSL. After 6 months the loaf volumes obtained with either fresh fat or SSL were still somewhat greater than those obtained in the blend baked without fat or SSL at the beginning of the storage study.

The blends stored at 120° F deteriorated rapidly. After 1 month of storage, loaf volumes were 58–77% of their −10° controls and breads were unacceptable. After 2 months, volumes were 36–55% of the controls and baking tests were discontinued. Optimum dough mixing time increased from 5 to 30 min in 2 months. Besides the loss of normal functional properties for bread-baking, the flour caked badly and darkened in color by 2 months.

It was at first considered that the loss of effectiveness of some of the SSL during storage at 90° F might be attributed to enzymatic hydrolysis. Blend A contains substantial levels of lipolytic enzymes (esterases) (10) which might hydrolyze SSL as well as native wheat lipid. However, measurements of titratable acidity (Table III) indicate that, beyond an initial increase, SSL did not contribute significantly to acidity measured on a WB extract of the stored blend. The blends containing SSL and stored at 90° F had a slightly higher acid value after 1 month than the control blend (no SSL) stored at 90° F. This value remained higher, but the acidity of the control increased gradually to the same value by 6 months. Part of the difference in acidity between the two blends at 1 month was contributed by the SSL, as shown by the difference in titratable acidity values for the samples stored at −10° F. This difference was greater in the samples stored at 90° F for 1 month (0.62 mg *vs.* 0.35 mg), indicating some type of deterioration of the SSL during the early part of storage. Beyond 1 month, most of the increase in acid value must have been due to hydrolysis of native lipid components in the Blend A, as shown by the increases in acid values for the control blend stored at 90° F.

At 120° F, the acid values rose faster for both blends. The values for the blend containing SSL remained consistently higher than those for the control at 120° F. However, the difference between the two widened only slightly throughout storage, again suggesting only minimal breakdown of SSL to acid components beyond an initial breakdown apparent at 1 month of storage.

The acidity contributed by the commercial conditioner might be accounted for by components other than SSL. While most of the product is 2-lactylate, it is

TABLE III
Titratable Acidity (mg KOH/g blend)

Storage Temperature °F	SSL %	Storage Time (months) 0	1	2	3	4	5	6
−10°	...	0.85	0.87	0.83	0.90	0.76	0.82	0.87
	0.5	1.20	1.22	1.23	1.22	1.20	1.15	1.20
90°	...	...	1.25	1.48	1.83	1.89	2.11	2.02
	0.5	...	1.87	1.89	2.23	2.03	2.19	2.00
120°	...	...	1.62	2.15	2.67	2.67	3.06	3.06
	0.5	...	2.26	2.86	3.38	3.60	3.84	3.89

reported to contain mixtures of other analogs (11) which may be readily hydrolyzed. In spite of the apparent lack of continued hydrolysis of SSL to acid components, the more rapid decrease in loaf volume of the 90°F blend containing SSL, compared with that for SSL added fresh at the mixer (Fig. 1), indicates deterioration of functional behavior of the SSL. It may be that hydrolysis does occur, and the products complex with flour components and thus are not measured in WB extracts. It is also possible some of the intact compound was inactivated through complexing or some other mechanism, thus reducing the level of effective additive before doughs are processed.

Purchase specifications for Blend A require 40–60 ppm of potassium bromate. To assess the storage stability of bromate, an additional comparison included a stored blend containing 40 ppm, the optimum bromate level for this Blend A. Table IV shows the loaf volumes obtained for this blend (treatment 5) compared with a control containing 40 ppm bromate added at the dough-mixing stage (treatment 1).

At 90°F, the rate of deterioration was slightly less for treatment 5, but loaf volume differences were not consistent nor large enough to establish that storage enhanced the effect of bromate in the blend. Most noteworthy, the bromate did not contribute to deterioration. Previous studies (6) showed that the optimum

TABLE IV
Storage Stability of Flour Blend A Containing Potassium Bromate[a]

Storage Temperature °F	Storage Time (months) 0	1	2	3	4	5	6
Bromate added at mixer							
−10°	710	737	728	728	752	740	742
90°	...	703	665	651	619	590	580
120°	...	559	375	...	...	...	...
Bromate in blend during storage							
−10°	710	723	745	725	765	...	755
90°	...	714	650	660	634	...	615
120°	...	554	375	...	...	...	...

[a]Loaf volume (cc); baking formula included 3% fat.

TABLE V
Residual Potassium Bromate[a]

Storage Temperature °F	Storage Time (months) 0	1	2	3	4	5	6
−10°	47	...	...	47	...	48	...
90°	...	...	...	49	...	46	48
120°	...	44	44	37	29	25	22

[a]Measured by ppm in Flour Blend A.

bromate level may be less in stored Blend A, but decreasing the level would not improve loaf volume. At 120° F, loaf volume deterioration of the bromate blend was as marked, as previously noted for the other blends. Baking tests were discontinued after 2 months.

Determinations of residual potassium bromate in some of the stored samples (Table V) indicated no loss of improver in blends stored at −10° and 90° F. When stored at 120° F, the bromate content decreased significantly, especially after 2 months' storage. However, loaf volume deterioration (Table IV) was already too marked at 120° F to be related to loss of bromate activity.

GENERAL DISCUSSION

The present formulation for Blend A, including potassium bromate and the low moisture content, may be the most suitable for obtaining a stable product for use overseas. In the study reported here, loaf volume decrease in blends stored at 90° F was about 15% after 4 months and 20–22% at 6 months, when fat or SSL was added at mixing. The decrease was about 18% at 4 months and 33% at 6 months when SSL was present in the mix during storage. In a previous study (6), upon which the present purchase specifications are based, a different Blend A stored at 90° F and 13.2% moisture showed a 13% loss in loaf volume by 4 months in blends baked with 3% fat. When that blend was dried to 9.0% moisture and stored at 90° F, loaf volume loss was limited to 5% at 4 months and 9% at 6 months. At a higher storage temperature (100° F), the low-moisture sample showed volume losses of 8% at 4 months and 14% by 6 months. Thus, more stability of Blend A destined for hot climates can be provided by reducing moisture content than by adding SSL.

In this study, the blends baked with SSL were compared with blends baked with and without fat to ensure that the results could be related to a range of applications. Recipients of Blend A may not have fat available or may use oil. Alternatively, they may prefer the more dense breads obtained without fat, similar to bread from the zero time sample (no fat-no SSL) shown in Fig. 1. The loaf volume for this blend at the beginning of storage was 557 cc (7.8 cu in./oz). The volume loss was slow initially, decreasing 9% by 4 months. Losses increased to 15 and 25% at 5 and 6 months, respectively. Decreasing moisture content of this blend would retard deterioration, substantially improving loaf volume potential.

Flat breads, such as the unleavened chapatties in India and the yeast-leavened Arabic-type bread of the Middle East, are also made from Blend A and do not normally contain fat. Some unpublished work from this laboratory indicated Indian chapatties made from the stored blends were unaffected by storage deterioration. They rolled out and browned satisfactorily on the griddle and puffed when placed in a hot oven. Addition of SSL did not affect the dough handling or baking properties. No off-flavors or odors were detectable in the stored samples.

Although SSL did not maintain baking performance of Blend A as well as had been hoped, other types of dough conditioners are available and may provide the necessary functional stability. For example, in another study, soy-fortified flour blends containing ethoxylated monoglycerides were more stable than those containing SSL (12). It should be noted that SSL was more stable in the soy-fortified flour blends than in Blend A. A conditioner better able to maintain its effectiveness under conditions of higher moisture levels, enzymatic activities, and microorganism growth (within the limits of food safety and acceptability) could have potential for use in government export flours.

Acknowledgments

The authors wish to acknowledge the technical assistance of Mrs. Viola Ashby and Miss Geraldine Secor, and the advice offered by David A. Fellers throughout this study.

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[Received November 22, 1974. Accepted August 8, 1975]