Baking Quality of Triticale Flours[1]

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ABSTRACT

The farinograph properties and baking performance of three Triticale flours of different protein content were studied. The Triticale dough developed readily with a low stability toward mixing, indicating deficient gluten quantity and quality. Prolonged fermentation deleteriously affected Triticale dough. It could readily rupture the weak dough structure and also reduce reactants for the browning reaction during baking. Accordingly, the finished Triticale bread had a broken top and pale crust. By eliminating bulk fermentation and adding 0.5% sodium stearoyl-2 lactylate, 0.25% sucrose tallowate, or 0.25% ethoxylated monoglycerides, acceptable bread was made from Triticale flour (13.6% protein) without supplementing wheat flour. However, the low protein (11.1%) Triticale flour required wheat-flour supplements to produce acceptable bread. Triticale bread staled almost twice as rapidly as wheat bread.

Triticale, an artificial genus created by plant breeders and geneticists, is an important potential food and feed crop (1). Two types of Triticales are now available: The hexaploid Triticales (AABBRR) are produced from crossing durum wheat (tetraploid, AABB) with rye (diploid, RR); the octaploid Triticales (AABBDDRR) are from crossing bread wheat (hexaploid AABBDD) with rye. At present, the hexaploid Triticales, simply referred to as Triticales, are commonly used. To evaluate food uses of Triticales, their milling and baking properties warrant investigation in view of the scarcity of information regarding these properties (2).

This study was designed to examine the rheological properties and baking quality of Triticale flour and its potential for making acceptable bread.

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[1]Presented at the 56th Annual Meeting, Dallas, October 1971. Contribution 1247, Department of Grain Science and Industry, Kansas Agricultural Experiment Station, Kansas State University, Manhattan 66506

MATERIALS AND METHODS

Triticale and Wheat Flours

Three Triticales with different but relatively low protein contents were selected to see if acceptable bread could be made from them. They were milled in a Miag Multomat mill. Milling properties will be reported subsequently (3). Wheat flour used as a supplement was a blend of hard red spring and hard red winter flours milled by a commercial mill. The protein (N X 5.7) and ash contents (14% m.b.) of the experimental flours were:

	Protein	*Ash*
Triticale flour I	11.1	0.51
Triticale flour II	13.6	0.59
Triticale flour III	12.8	0.47
Wheat flour	12.7	0.48

Amino acid compositions of Triticale flours I and II and wheat flour were analyzed by an automatic analyzer. Results presented in Table I, in general, parallel those reported from other laboratories (4–8).

Farinograms

Farinograms were obtained by the constant-dough weight method, using 50 g. of sample with a farinograph (9).

Baking Tests

Two baking methods were used: a sponge-dough method of AACC with several modifications as described previously (10) and the K-State Process (no-time dough

TABLE I. AMINO ACID COMPOSITION IN FLOURS FROM TRITICALE AND WHEAT (g. AMINO ACID PER 100 g. PROTEIN (KJELDAHL))

Amino Acids	Triticale I	Triticale II	Wheat
Lysine	2.627	2.848	2.161
Histidine	2.026	2.226	2.238
Ammonia	3.821	3.761	4.331
Arginine	4.131	4.389	3.875
Aspartic acid	5.729	6.450	4.537
Threonine	2.976	3.355	3.062
Serine	4.703	5.252	5.578
Glutamic acid	32.028	37.224	45.847
Proline	10.770	12.506	12.239
Glycine	3.615	3.907	4.086
Alanine	3.403	3.806	3.515
Half-cystine[a]	3.265	2.736	3.556
Valine	4.428	4.861	5.167
Methionine[a]	1.600	1.442	1.078
Isoleucine	3.368	3.828	4.264
Leucine	6.764	7.448	8.158
Tyrosine	3.070	3.354	4.005
Phenylalanine	4.772	5.112	5.988

[a]By oxidation.

method) (11). The latter was used except when otherwise stated. Loaf weight and volume were measured within 10 min. after removal from oven. Crumb grain was scored about 18 hr. after baking. Finished bread with a score under 5 was regarded as unsatisfactory. Specific loaf volume was averaged from duplicates. Most of the baking tests were repeated at least once on a different day to substantiate results.

Staleness Evaluation

Staleness was tested by following changes in crumb firmness with a Bloom gelometer with a 1-in. plunger during 5 day storage at about 25°C. Three 1-in. slices were cut from the middle part of each loaf. Two loaves were used for each test. Three (top, center, and bottom) compressimeter readings (g.) were taken on each slice.

RESULTS AND DISCUSSION

Farinographic Properties of Triticale Dough

As shown in Fig. 1, Triticale flour dough developed much faster, with a substantially low absorption and shorter stability toward mixing than wheat-flour

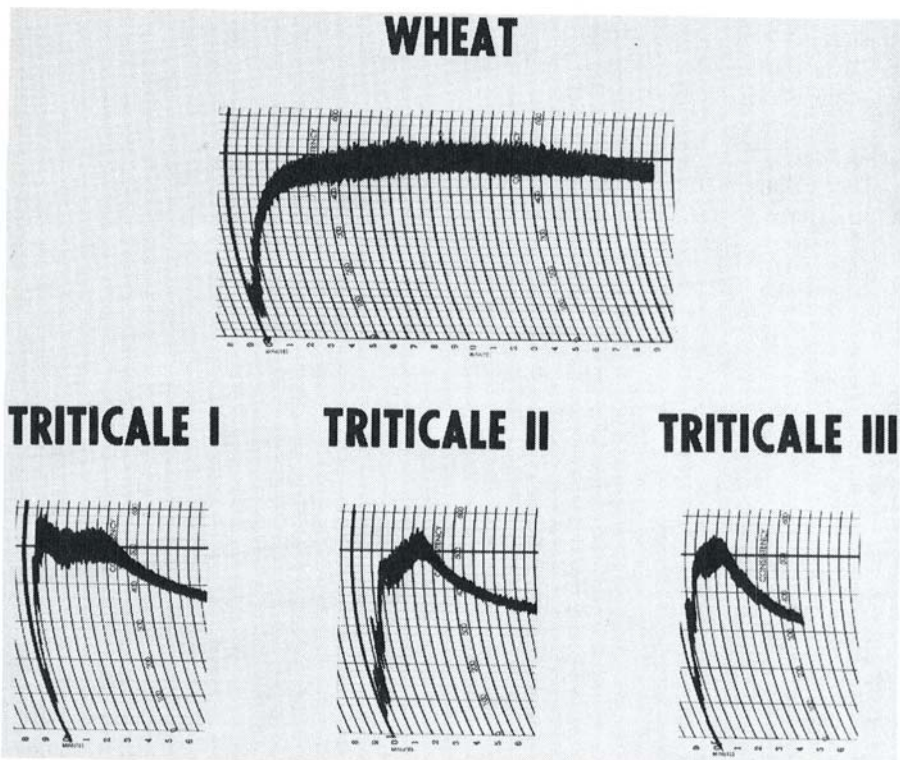

Fig. 1. Farinograms of wheat flour-water dough and Triticale flour-water dough absorptions for wheat flour, Triticale flours I, II, and III were 65, 48.6, 60.6, and 56.0%, respectively.

dough. Since Triticale flours II and III contained more protein than wheat flour, the short development time and low absorption and stability all suggest that the two Triticale flours, although rich in other protein fractions, may have less gluten for dough structure. Alternatively, these flours may contain more reducing agents or proteases which can weaken dough structure than the wheat flour.

Of the three Triticale flours, Triticale flour I had less protein content, lower absorption, and poorer baking quality than the others. However, the farinogram of Triticale flour I showed two peaks which made its stability appear longer than the other Triticale flours. Such a double-peaked farinogram was observed not only for Triticale flour I but also for several other Triticale flours (not shown). Therefore, caution should be taken when farinograph mixing stability is used as a criterion for assessing Triticale quality. Only occasionally some wheat flours also give farinograms with two peaks. The bake-mix time correlates much better with the second peak than the first one (12). However, from such a farinogram, as shown in Fig. 1, mixing stability cannot be accurately estimated.

Dough conditioners such as sodium stearoyl-2 lactylate (SSL) are known to increase the mixing tolerance of dough (13,14). As all the Triticale doughs had low stability with mixing, SSL was tried to improve stability of dough prepared from Triticale flour III. Adding 0.5% SSL increased stability from 1.75 min. (control dough) to 4.35 min. (SSL-treated dough). The increase suggests that a dough conditioner like SSL may improve baking quality of Triticale flour.

Baking Quality of Triticale Flours I and II Evaluated by Sponge-Dough Method

Triticale flours I and II were unsuitable for breadmaking by the sponge-dough method as reflected by very low specific volume and grain score (Table II).

Poor baking performance was largely because dough made from Triticale flour I or II was too weak to stand the stress of mixing, fermenting, and particularly oven-spring during baking through the sponge-dough process. Weakness was manifested by the dough surface (top) rupturing during fermentation and proofing. Consequently, the finished bread had a broken top. Two typical examples are shown in Fig. 2.

In view of the improving action of SSL on high-protein breads (10,11,13,14,15), and other bakery products (16), we added it to improve the baking performance of Triticale flour with the sponge-dough method. Resulting data (Table II) showed the improving effect by increasing specific volume and grain score from adding 0.5% SSL. However, the increase was too small to make the finished Triticale bread acceptable.

TABLE II. BAKING QUALITY OF TRITICALE FLOURS I AND II BY SPONGE-DOUGH METHOD

Triticale Flour	Absorption %	Dough Mix Time sec.	Bromate p.p.m.	SSL %	Avg. Specific Loaf Volume cc./g.	Grain Score
I	57	60	10	0	2.99	2
	57	60	10	0.5	3.61	3
II	61	45	30	0.5	4.56	3
	61	45	50	0.5	4.58	3

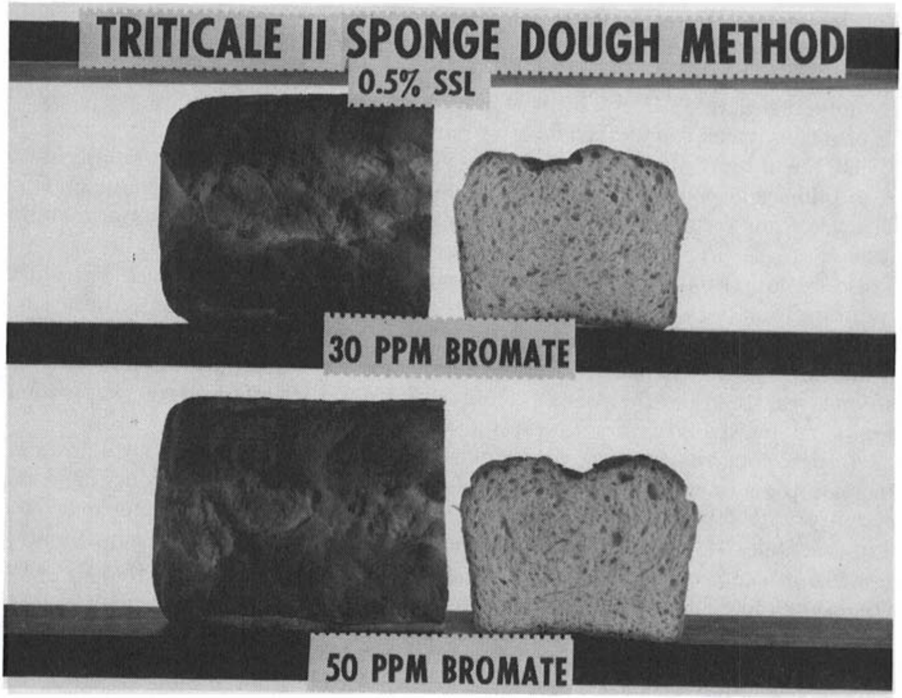

Fig. 2. Triticale breads made from Triticale flour II by sponge-dough method.

Because sucroesters and ethoxylated monoglycerides (EM) improve baking performance of wheat flour fortified with soy flour (17)[2], further tests were conducted with other dough conditioners including EM, sucrose tallowate (ST), sucrose monopalmitate (SMP), and sucrose mono- and distearate (SMS). All, like SSL, failed to bring the specific loaf volume of the Triticale bread over 4.60 by the sponge-dough method.

Effect of Fermentation Time

Because Triticale dough deteriorated with fermentation and proof through the sponge-dough process, further experiments were undertaken to trace more closely the deleterious effect of fermentation on Triticale dough with a straight-dough process.

The dough was processed according to the K-State method. After resting for 40 min. (floor time) at 86°F. and 85% r.h., it was allowed to ferment for 1, 2, or 4 hr. It then was moulded, proofed, and baked as described by the method.

The results (Table III) showed that specific loaf volume and grain score of bread made from Triticale flour II decreased substantially with increasing fermentation time from 0 to 4 hr.

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[2]Tsen, C. C., and Hoover, W. J. Announcement made at KSU high-protein bread news conference at Kansas City, Mo., Oct. 6, 1970.

TABLE III. EFFECTS OF FERMENTATION TIME AND SSL ON BAKING QUALITY OF TRITICALE FLOURS II AND III[a]

Triticale Flour	Fermentation hr.	SSL %	Avg. Specific Loaf Volume cc./g.	Grain Score
	0	0.5	6.21	7
	1	0.5	5.98	6
II	2	0.5	4.20	4
	4	0.5	2.97	3
	4	1.0	3.29	3
	0	0	5.39	6
	1	0	4.00	5
	2	0	3.00	3
	4	0	2.56	3
III	0	0.5	6.02	7
	1	0.5	5.61	6
	2	0.5	3.72	4
	4	0.5	3.05	3
	4	1.0	3.42	3

[a]Breadmaking conditions for Triticale flour II: absorption, 61%; bromate, 80 p.p.m.; mix time, 2.0 min.; those for Triticale flour III: absorption, 59%; bromate, 70 p.p.m.; mix time, 1.5 min.

As shown in Fig. 3, dark color of the bread's crust lightened with fermentation. Fermentation of Triticale dough appears to be very effective in reducing reactants for the browning reaction. Vigorous fermentation suggests that the Triticale dough provides the yeast with many nutrients, including sugars and soluble nitrogenous compounds, to boost the yeast activity. The fermentation difference between Triticale and wheat-flour doughs may result from the higher activity of amylases and proteases[3] and more soluble proteins (8) in Triticale flour.

The major deleterious effect of fermentation observed so far was the rupture of Triticale dough structure, presumably because Triticale dough has a weak gluten network and a high proteolytic activity so the dough cannot stand prolonged fermentation. Additional studies are required to verify this presumption.

Acceptable Triticale bread, however, was made from Triticale flour II by eliminating bulk fermentation and adding 0.5% SSL to strengthen the dough, as shown in Table III. Further tests were conducted with Triticale flour III. The results (Table III) confirmed the deleterious effect of prolonged fermentation on the Triticale dough. With the no-time dough process, acceptable bread also could be made from Triticale flour III treated with 0.5% SSL.

Although SSL could effectively improve the baking performance of Triticale flour, it did not erase the deleterious action of fermentation. Loaf volumes and grain scores of Triticale breads steadily decreased with increased fermentation despite the addition of 0.5 or 1.0% SSL, as shown in Table III.

Effect of Various Additives on Baking Quality of Triticale Flour

Because SSL improved the baking quality of Triticale flour, further experiments, with Triticale II flour, were made to evaluate the improving effect of various additives such as EM, ST, added at 0.25, 0.50, and 1.00%, and lard (texturated for bakery use) at 1.0, 2.0, and 3.0%.

[3]Madl, R., and Tsen, C. C. Unpublished data.

All additives improved the baking quality of Triticale flour (Table IV). Lard was the least effective; SSL, EM, and ST exhibited no significant differences in improving effects. In general, adding EM gave a slightly larger loaf, and SSL produced a slightly better grain and texture (as shown in Table IV and Fig. 4). All three dough conditioners could strengthen Triticale dough enough to produce acceptable Triticale bread.

In addition to ST, the two other sucroesters, SMP and SMS, were tested. Volume of Triticale bread treated with 0.5% SMP or SMS was smaller than that of 0.5%

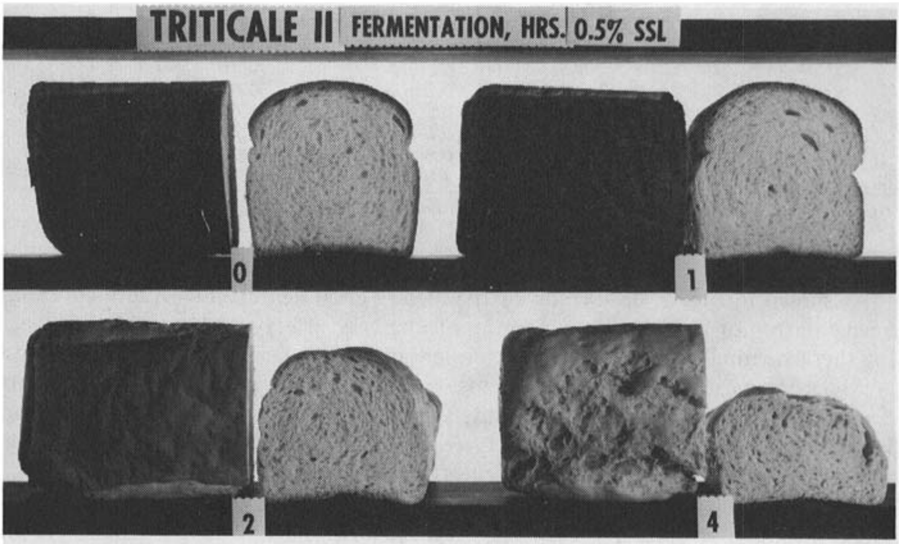

Fig. 3. Effect of fermentation on Triticale bread.

TABLE IV. EFFECTS OF INDICATED ADDITIVES ON THE BAKING QUALITY OF TRITICALE FLOUR II[a]

Additive	Avg. Specific Loaf Volume cc./g.	Grain Score
0	4.94	6
0.25% SSL	5.76	8
0.50% SSL	6.19	9
1.00% SSL	6.21	8
0.25% EM	6.11	7
0.50% EM	6.05	7
1.00% EM	6.28	7
0.25% ST	6.15	7
0.50% ST	5.82	7 (open)
1.00% ST	6.19	7
1.00% Lard	5.43	7
2.00% Lard	5.58	7
3.00% Lard	5.61	7
0.50% SMS	5.64	8
0.50% SMP	5.69	8

[a]Breadmaking conditions for Triticale flour II the same as in Table III.

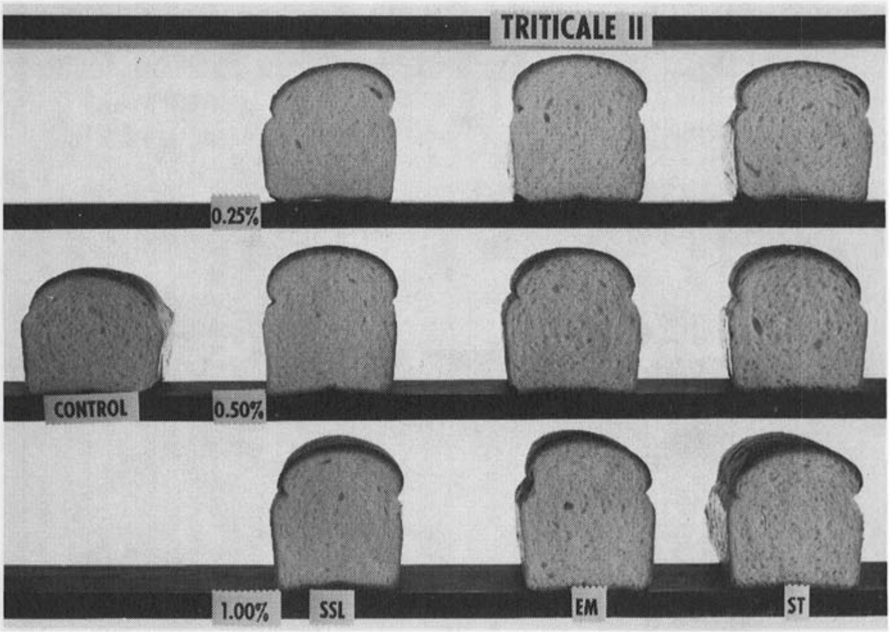

Fig. 4. Effects of different levels of SSL, EM, and ST on the baking performance of Triticale flour II.

ST-treated bread; their grain and texture, however, were superior to those of ST-treated breads (Table IV and Fig. 5).

Supplementing Triticale Flour with Wheat Flour

There are obviously two ways to improve the baking quality of Triticale flour. One is to use an additive; the other is to supplement the Triticale flour with wheat flour, as Unrau and Jenkins (2) previously recommended.

Because we had made acceptable bread from Triticale flours II and III but not from Triticale flour I, we selected Triticale flour I for the supplementation study.

Acceptable bread was prepared from Triticale flour I supplemented with 20% wheat flour and 0.5% SSL (Table V and Fig. 6). Without SSL, wheat flour had to be raised to 60% to produce acceptable bread.

Staleness Evaluation

Table VI shows average compressimeter readings for loaves containing 0.5% EM, ST, or SSL, and 3.0% lard made from Triticale flour II and loaves made from wheat or Triticale flour with no additive. Crumb softness was greatly enhanced by a dough conditioner or lard. Of dough conditioners tested, SSL most effectively retarded staling rate, while EM was least effective. Lard was less effective than the dough conditioner used as an antistaling agent. However, despite the additives, Triticale breads staled quite rapidly (Table VI).

For comparison, average compressimeter readings were found in an additional test to be 181.5 and 115.8 g., respectively, for wheat bread and wheat bread treated with 0.5% SSL, prepared by the same method and stored 5 days at the same

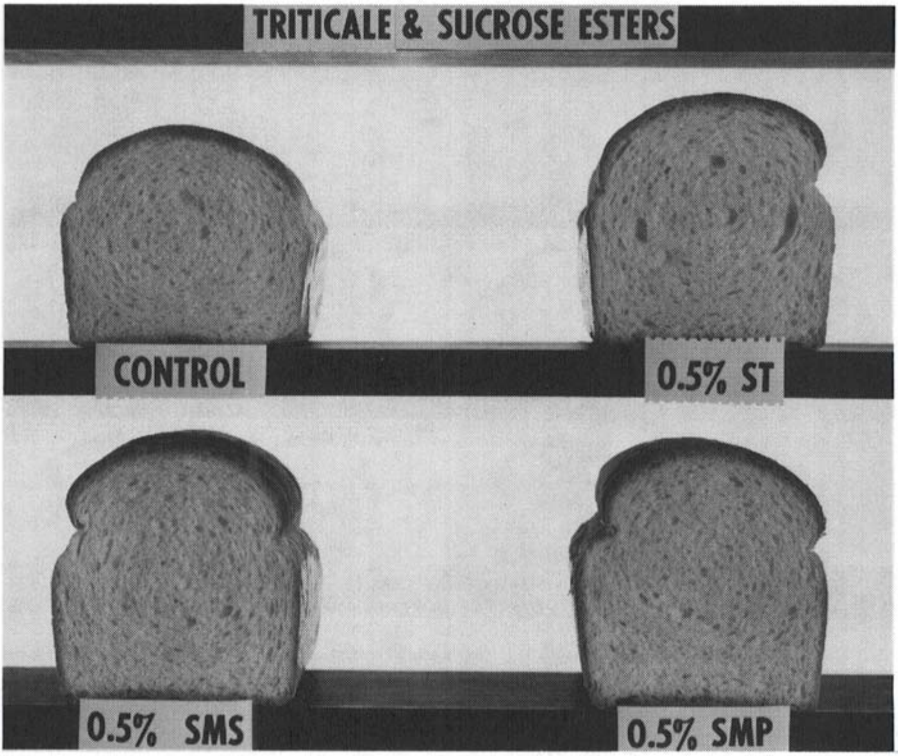

Fig. 5. The improving effect of sucrose esters on the baking performance on Triticale II.

TABLE V. EFFECT OF SUPPLEMENTING TRITICALE FLOUR I WITH WHEAT FLOUR FOR BREADMAKING

Triticale Flour I %	Wheat Flour %	Absorption %	Mix Time min.	Bromate p.p.m.	SSL %	Avg. Specific Loaf Volume cc./g.	Grain Score
100	0	57	2.5	80	0	3.86	3
100	0	57	2.5	80	0.5	5.19	6
80	20	60	2.5	80	0	5.24	6
80	20	60	2.5	80	0.5	6.05	7
60	40	61	2.5	80	0	5.70	6
60	40	61	3.0	80	0.5	6.41	8
40	60	62	3.0	80	0	6.19	8
40	60	62	3.0	80	0.5	6.89	9
0	100	64	6.0	40	0	6.77	9
0	100	64	6.0	40	0.5	7.25	9

temperature. Respective readings after 1 day's storage had been 101.2 and 68.1. Data from wheat breads and corresponding Triticale breads (Table VI) indicate that Triticale bread stales about twice as rapidly as wheat bread.

Why Triticale bread stales rapidly is not completely understood. Its small loaf volume with dense structure is one reason. Another reason could be the difference

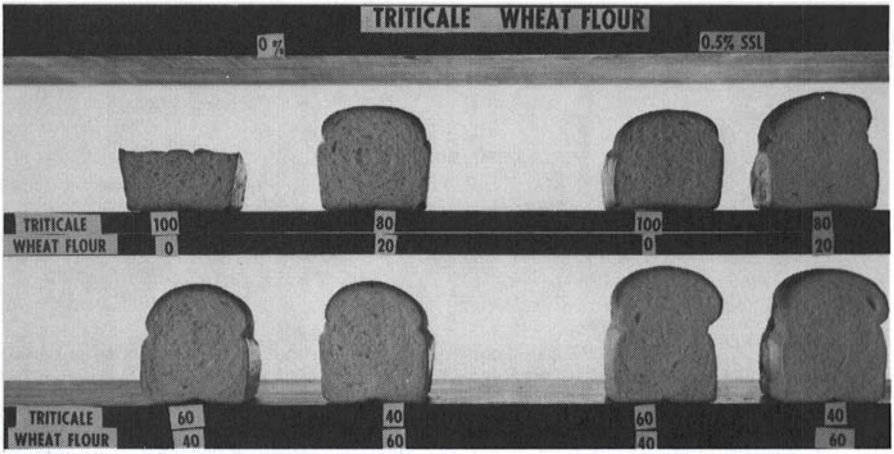

Fig. 6. Supplementation of Triticale flour I with wheat flour for making Triticale bread with and without the addition of SSL.

TABLE VI. AVERAGE COMPRESSIMETER READINGS (g.) OF STORED TRITICALE BREADS TREATED WITH INDICATED ADDITIVES[a]

Additive	Days Stored		
	1	3	5
0	159.9	296.4	432.6
0.5% SSL	101.6	150.6	269.6
0.5% EM	110.3	190.1	309.4
0.5% ST	116.3	199.1	285.9
3.0% Lard	124.3	229.8	342.3

[a]Breadmaking conditions for Triticale flour II the same as in Table III.

in compositions and properties of wheat and Triticale flours. Hill (18) found that Triticale starch resembled its rye, rather than its wheat, parent. Berry et al. (19) reported only small differences among the starches of Triticale, rye, hard red spring, and durum wheats in protein, fat, phosphorus, and ash contents. However, the different starches varied somewhat in physicochemical properties.

Chen and Bushuk (8,20) reported that quantitative distribution of protein fractions varied with rye, Triticale, durum, and HRS wheats. For each fraction the amount for Triticale was intermediate between the amounts for the parental species. Such limited information is not sufficient to explain staling. Further research is needed to elucidate why Triticale bread stales much faster than wheat bread.

Acknowledgments

Competent technical assistance of Mrs. Mickey Willyard and the financial support from the International Sugar Research Foundation (ISRF299), C. J. Patterson Company, and the Agency for International Development (Contract No. 1586) are gratefully acknowledged. Thanks are also given to Archer-Daniels-Midland Company; FasGro Seeds, Inc.; and Universal Foods Corporation for kindly supplying wheat flour, Triticales, and yeast, respectively; and to C. W. Deyoe for amino acids analyses.

Literature Cited

1. ZILLINSKY, F. J., and BORLAUG, N. E. Progress in developing Triticale as an economic crop. International Maize and Wheat Improvement Center, Mexico (1971).
2. UNRAU, A. M., and JENKINS, B. C. Investigations on synthetic cereal species. Milling, baking, and some compositional characteristics of some "Triticale" and parental species. Cereal Chem. 41: 365 (1964).
3. FARRELL, E. P., and TSEN, C. C. Milling characteristics of Triticale grain. Cereal Chem. 50: (In preparation) (1973).
4. FOX, S. W., and DeFONTAINE, D. Sequential assays of 4 amino acids in grains of wheat, rye and of their hybrids. Proc. Soc. Exp. Biol. Med. 92: 503 (1956).
5. KIES, C., and FOX, H. M. Protein nutritive value of wheat and triticale grain for humans, studied at two levels of protein intake. Cereal Chem. 47: 671 (1970).
6. KIES, C., and FOX, H. M. Determination of the first-limiting amino acid of wheat and triticale grain for humans. Cereal Chem. 47: 615 (1970).
7. VILLEGAS, E., McDONALD, C. E., and GILLES, K. A. Variability in the lysine content of wheat, rye, and triticale proteins. Cereal Chem. 47: 746 (1970).
8. CHEN, C. H., and BUSHUK, W. Nature of proteins in Triticale and its parental species. I. Solubility characteristics of amino acid composition of endosperm proteins. Can. J. Plant Sci. 50: 9 (1970).
9. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. AACC Approved methods (7th ed.). The Association: St. Paul, Minn. (1962).
10. TSEN, C. C., HOOVER, W. J., and PHILLIPS, D. The use of sodium stearoyl-2 lactylate and calcium stearoyl-2 lactylate for producing high-protein breads. Baker's Dig. 45(2): 20 (1971).
11. TSEN, C. C., and TANG, R. T. K-State process for making high-protein breads. I. Soy bread. Baker's Dig. 45: 26 (1971).
12. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. The farinograph handbook, ed. by L. Locken, S. Loska, and W. Shuey. The Association: St. Paul, Minn. (1960).
13. TSEN, C. C. Action of surfactants on flour protein in relation to their dough-strengthening effect. (Abstr.) AACC 55th Annual Meeting, Minneapolis (1970).
14. PAPE, G. Research on the behavior of calcium stearoyl-2 lactylate and sodium stearoyl-2 lactylate in breadmaking. Bol. Tec. Divisao Tecnologia Agricola - Alimentar No. 5 Brazil (1971).
15. FINNEY, K. F., and SHOGREN, M. D. Surfactants supplement each other, make foreign proteins compatible in breadmaking. Baker's Dig 45(1): 40 (1971).
16. TENNEY, R. J., and SCHMIDT, D. M. Sodium stearoyl-2 lactylate–Its functions in yeast-leavened bakery products. Baker's Dig. 42: 38 (1968).
17. POMERANZ, Y., SHOGREN, M. D., and FINNEY, K. F. Improving breadmaking properties of glycolipids. I. Improving soy products with sucroesters. Cereal Chem. 46: 503 (1969).
18. HILL, R. D. On starch of Triticale and its parent rye and durum wheat varieties. (Abstr.) AACC 54th Annual Meeting, Chicago (1969).
19. BERRY, C. P., D'APPOLONIA, B. L., and GILLES, K. A. The characterization of Triticale starch and its comparison with starches from rye, durum, and HRS wheat. Cereal Chem. 48: 415 (1971).
20. CHEN, C. H., and BUSHUK, W. Nature of proteins in Triticale and its parental species. II. Gel filtration and disc electrophoresis results. Can. J. Plant Sci. 50: 15 (1970).

[Received February 15, 1972. Accepted July 18, 1972]