MEASUREMENT OF THE IMPROVER RESPONSE IN DOUGH[1]

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ABSTRACT

Structural relaxation data were obtained for doughs containing initially 0, 10, 15, and 20 p.p.m. bromate and allowed reaction times of 1, 2, and 3 hours. When the semiaxis constant for the bromate effect was plotted against reaction time, linear plots were obtained. Analogous linear plots were also obtained when the amount of bromate reacted in dough as determined chemically was plotted against reaction time. The amount of change in the semiaxis constant per unit amount of bromate reacted was taken as a definition of bromate response. The response was evaluated for several flours. Improver response was also obtained from similar data with iodate.

When bromate or iodate reacts with dough a change in the physical properties of the dough results. If our knowledge of dough chemistry and rheology were adequate, it should be possible to predict from the bromate treatment the corresponding change in the physical properties of dough, and conversely.

There have been two attempts made to evaluate the bromate response of dough from physical measurements. Munz and Brabender (6) derived an "oxy-number" based on the area under the extensigram, and the ratio of its height to length. Merritt and Bailey (5) also included the protein content of flour as a factor in a similar expression to obtain an "age index."

In a recent paper (3) the writers presented preliminary evidence suggesting that the semiaxis constant of the structural relaxation curve offered certain advantages as a measure of the bromate response in dough; a simple linear relation was obtained between this rheological parameter and the initial concentration of the bromate added to dough. The present paper is an extension of this study. On the one hand, rheological data in terms of the semiaxis constant were obtained for a series of doughs at several levels of bromate, and after different reaction times. On the other hand, parallel chemical determinations were made on similar doughs and the amount of bromate reacted after different reaction times was obtained. Supplementary data were also obtained with iodate. These data are presented and discussed in terms of the physical response of the dough in relation to the amount of improver reacted.

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[1] Manuscript received March 17, 1960. Paper No. 188 of the Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg 2, Manitoba.

Materials and Methods

Four flours designated A, B, C, and D, all commercially milled from Canadian hard red spring wheat, were used for this study. Flours A and B were straight grade; flour C, termed "baker's special," was the first 70% and flour D, termed "baker's strong," was the remaining 30% of the total yield of flour. All flours were unbleached and improver-free. The particulars are listed in Table I.

TABLE I
DESCRIPTION OF FLOURS

	Flour			
	A	B	C	D
Protein content, %	12.2	13.2	12.2	14.9
Ash content, %	0.47	0.46	0.34	0.66
Farinograph absorption[a]	59.6	64.5	62.3	66.7
Optimum bromate requirement, p.p.m.[b]	5.0	10.0	5.0	17.5

[a] A uniform absorption of 55% (14% basis) was used for all flours.
[b] AACC baking test.

A uniform absorption of 55% (14% flour basis) was used for all ours so as to keep the total water-to-dry-flour ratio constant and in this way to make comparisons of the different flours on an equal basis.

Doughs were prepared by mixing 200 g. of flour (14% moisture basis), salt solution, and varying amounts of bromate or iodate solution in an atmosphere of nitrogen for 2.5 minutes in a GRL mixer (2). Temperature was controlled so that the dough came out of the mixer at 30°C., and it was maintained at this temperature in a humidified cabinet during reaction time and rest period.

Structural relaxation curves were obtained for doughs containing 0, 10, 15, and 20 p.p.m. potassium bromate and allowed reaction times of 1, 2, and 3 hours, and for doughs containing 0, 5, 10, and 15 p.p.m. iodate and allowed reaction time of 1 hour. The methods used in obtaining the curves, in evaluating the relaxation constant C and the semiaxis constant *a* were those described in the previous study (3).

In the present study a simple linear relation was found between the semiaxis constant and reaction time by the following modification. The relaxation curve for the control dough was subtracted from the curve for the bromated or iodated dough to give a new curve which represented the rheological change due to the action of the improver. The semiaxis constant for the new curve was then obtained. In practice this was evaluated from the relation

$$a = \sqrt{2\,(C_{\text{bromated}} - C_{\text{control}})}$$

where the symbols C and *a* have the usual meaning. The procedure for doughs treated with iodate was the same.

A set of bromate-treated doughs entirely similar to those used for the extensigraph tests was used to obtain parallel chemical data. The bromate loss in dough for each bromate concentration and reaction time was determined by the method of Cunningham and Anderson (1), and the results were plotted as the amount of bromate reacted against given reaction time.

Results

Variation of the Semiaxis Constant a *with Reaction Time.* The first set of experiments was designed to provide structural relaxation data for doughs containing initially 0, 10, 15, and 20 p.p.m. bromate and allowed reaction times of 1, 2, and 3 hours. Data on four different flours were obtained.

Figure 1 summarizes the rheological data. The semiaxis constant *a* for the bromate effect is plotted against reaction time for three bro-

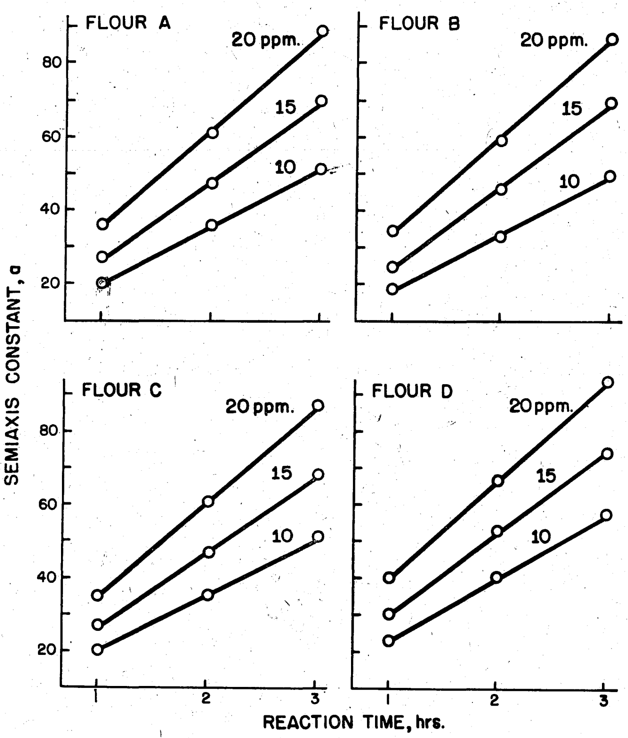

Fig. 1. Plots of the semiaxis constant *a* against reaction times for doughs initially containing 10, 15, and 20 p.p.m. bromate.

mate levels. The linearity of the plots is immediately apparent for all four flours. This contrasts with the curvilinear plots obtained by the method described in the previous paper (3). The data in the present form have the important advantage that they can be compared with analogous chemical data to be presented in the next section.

Although the flours used in this study differed appreciably, the bromate effect as measured by *a* was very nearly the same. This similarity in the physical response of the flours to bromate is better

TABLE II

CHANGE OF THE SEMIAXIS CONSTANT *a* WITH REACTION TIME OR SLOPE

Initial Bromate	Slope			
	Flour A	Flour B	Flour C	Flour D
ppm				
10	15.6	15.3	15.6	17.2
15	21.0	22.1	20.5	21.9
20	26.3	26.2	25.9	26.6

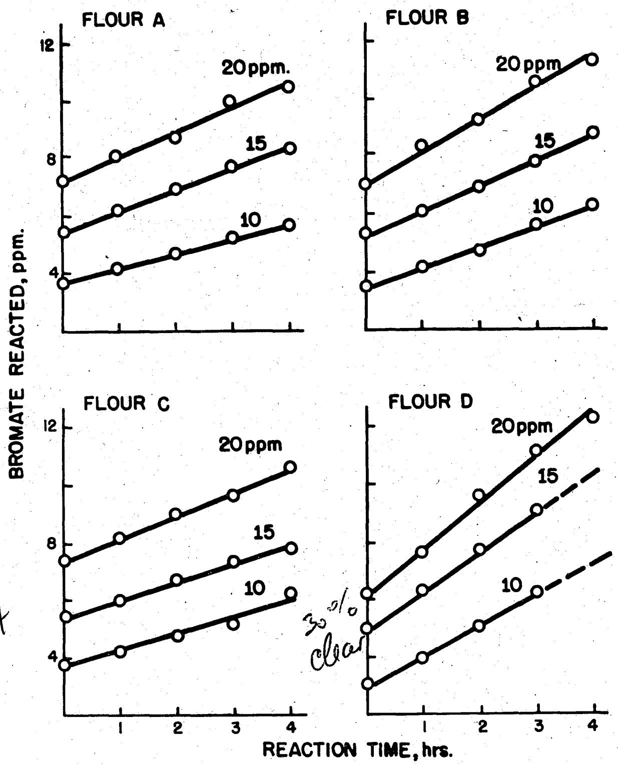

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Fig. 2. Plots of the amount of bromate reacted in dough against reaction time for doughs initially containing 10, 15, and 20 p.p.m. bromate.

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shown by the slopes of the *a* vs. reaction time plots summarized in Table II.

Variation of the Amount of Bromate Reacted in Dough with Time. Parallel with the rheological study, doughs for the chemical analysis of bromate were prepared in the same manner with the same initial bromate concentrations and given reaction times of 0, 1, 2, 3, and 4 hours. Figure 2 summarizes the results. The amount of bromate reacted is plotted against reaction time.

The linearity of these plots is in accordance with the previous finding that the rate of loss of bromate is constant for a given initial concentration (4,1). The rates of bromate loss for each of the flours obtained as the slope of the individual graphs are summarized in Table III.

TABLE III
Rates of Bromate Loss in Dough

Initial Bromate	Rate of Loss			
	Flour A	Flour B	Flour C	Flour D
ppm	*ppm/hr*	*ppm/hr*	*ppm/hr*	*ppm/hr*
10	0.51	0.65	0.50	1.08
15	0.71	0.84	0.65	1.38
20	0.87	1.11	0.81	1.64

Variation of Semiaxis Constant a *with Bromate Concentration* c. There is a striking similarity between Figs. 1 and 2 in that the rheological and chemical data, both plotted against reaction time, are linear. This similarity makes it possible to study these data further.

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The amount of change in the rheological parameter per unit amount of bromate reacted may be looked upon as a measure of bromate response (a/c) of the dough. Figure 3 (left) presents a plot of the semiaxis constant *a* against the amount of bromate reacted *c*. The initial amount of bromate in the dough was 20 p.p.m. and the data plotted were obtained after reaction times of 1, 2, and 3 hours. Other initial levels of bromate gave essentially similar results and are not shown.

The response (a/c) of each of the flours to bromate may be seen from the slopes of the graphs in Fig. 3 (left). The highest response or slope is given by flour C, a baker's special or a patent type. The lowest response is given by the baker's strong flour D which was a clear type and was of lowest quality. It may be of interest to add that the flours giving the highest response had (consequently) the lowest optimum bromate requirement in the baking test (Table I),

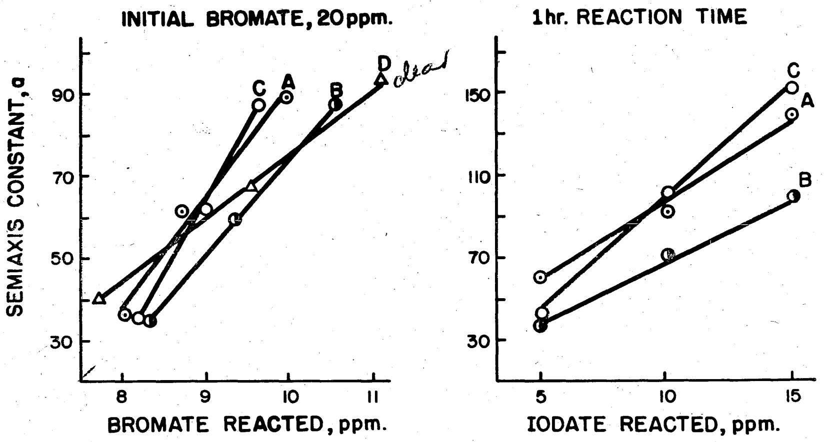

Fig. 3. The improver response of several flours as shown by plots of the semiaxis constant against bromate reacted in doughs containing initially 20 p.p.m. bromate (left); and the semiaxis constant against iodate reacted in doughs after a reaction time of 1 hour (right).

while the flour giving the lowest response had the highest bromate requirement.

Two main factors appear to determine the bromate response as defined here. Of these the semiaxis constant *a* does not show a large variation for the flours tested here. The rate of bromate loss in dough appears, therefore, to be the major factor. The bromate response (*a/c*) includes both of these.

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Variation of Semiaxis Constant a *with Iodate Concentration* c. The use of iodate rather than bromate as a reagent for assessing the improver response of flour or dough is somewhat simpler. The reason for this is that the amount of bromate reacted in dough depends upon the reaction time and must be determined chemically. For iodate, because of its fast reaction, the amount reacted can be simply taken as the amount of iodate initially added to dough.

Data on the response of flours A, B, and C to iodate are shown in the right half of Fig. 3. (No more flour D was available at this time.) The initial amounts of iodate added (assumed to be the same as the amount of iodate reacted) were 0, 5, 10, and 15 p.p.m. A uniform reaction time of 1 hour was given for all doughs. It will be seen that the response to iodate was the highest for flour C, followed by A and B. This order is the same as that obtained in experiments with bromate and shown in the left half of Fig. 3.

Discussion

The primary aim of the present investigation was to look into the feasibility of describing the improver response of flour or dough from a more fundamental point of view than has been possible thus far. To this end, additional support has been presented for the validity of the assumption that the semiaxis constant is a basic rheological parameter. This support is based on the analogous linearity between the semiaxis constant against reaction time, on the one hand, and the bromate reacted against reaction time, on the other. The improver response was then examined as the change in the semiaxis constant per unit amount of improver reacted in the dough. While bromate and iodate may react somewhat differently in dough, either may be used in evaluating the improver response. On the basis of data obtained for four different flours, the rate of bromate reaction in dough and the protein content of flour appear to be strongly related to the improver response. Moreover, those flours that showed a high bromate response had also a low optimum improver requirement in the baking test, and conversely.

One is, of course, tempted to speculate on the practical implications of the results obtained in this study, and there are interesting implications. However, the experimental work was done with simplified flour-water-salt doughs mixed in nitrogen and on only a few flours. The emphasis has been on the basic aspects. This study is, therefore, more appropriately regarded as a prerequisite fundamental phase for a more practically oriented future study of improver response.

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