Iodoacetic Acid as a Flour-Improving Reagent[1,2]

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ABSTRACT

Baking, extensigraph, and farinograph studies were carried out on doughs containing various amounts of iodoacetic acid. Increasing the dosage of iodoacetic acid caused at first an increase and then a decrease in loaf volume, with optimum loaf volumes being obtained at approximately 0.03 μeq. iodoacetic acid per g. flour. At levels of 0.08 μeq. per g. flour, iodoacetic acid caused a larger increase in consistency and extension resistance than that caused by the addition of an equivalent amount of bromate or iodate. These studies indicate that iodoacetic acid is an effective and efficient flour-improving reagent which should be particularly useful in investigational studies of the improver reaction.

It has long been a goal of cereal chemists to understand the mechanism of the improver effect (or improver reaction) in dough. The improver effect, caused by the addition of minute amounts of agents such as bromates, iodates, persulfates, chlorites, chlorine, chlorine dioxide, formamide, 1-1′-azobis (diazocarbonamide), or organic peroxides, is that phenomenon which improves the handling and baking characteristics of dough and also results in superior-quality bread. In a study of the improving effect, employment of the commonly used improvers mentioned above does not offer much information—other than rate constants—on the mechanism involved, since the improvers do not become attached to any flour constituents. For example, bromate and iodate are reduced to bromide (1) and iodide (2).

Many current theories on the improver reaction agree that reactions of sulfhydryl (SH) groups of either proteins or peptides are somehow involved. In her acceptance of the Osborne Medal in 1948, Betty Sullivan (3) noted that iodoacetic acid can act as a good improver, presumably acting by alkylation of an SH group. Since iodoacetic acid forms stable S-carboxymethyl derivatives with SH groups, and C^{14}-labeled iodoacetic acid is now available which would allow the detection of the stable S-carboxymethyl derivatives even if they are present in very minute amounts, it is suggested that iodoacetic acid-C^{14} would be a very useful reagent in a study of the improver reaction. However, before one can embark on a full-scale investigation with iodoacetic acid-C^{14} it is necessary to be certain that iodoacetate can act as an improving reagent. Published details on the behavior of iodoacetic acid in dough are very scanty; accordingly, the present work was undertaken to examine some of the effects that iodoacetic acid has on the rheological and baking properties of dough.

MATERIALS AND METHODS

The hard red spring flours used in this study were straight-grade, untreated, commercially milled samples from blends of sound Canadian wheat. A description of the flours is given in Table I.

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[2]Presented in part at the 55th Annual Meeting, Minneapolis, October 1970.

TABLE I. DESCRIPTION OF FLOURS STUDIED

Flour	Protein[a] %	Moisture %	Ash[b] %	Farinograph Absorption[c] %
A	13.5	14.0	0.43	63.0
B	13.6	14.6	0.41	68.1

[a]N X 5.7; 14% moisture basis.

[b]14% moisture basis.

[c]14% moisture basis; 500 B.U. consistency on a 1:1 sensitivity ratio.

Two separate studies were carried out: one in 1960 with flour A, and the other in 1968 with flour B. All of the results described in this manuscript were taken from the first study. Similar results were obtained in the second study, even though a different baking test (Remix) was used.

Iodoacetic acid was recrystallized from diethylether and hexane. Solutions of iodoacetic acid were made up just before use.

Baking Procedures

The doughs were mixed for 2.5 min. in a Grain Research Laboratory (GRL) pin mixer (4) at 30°C. For flour A, the AACC baking formula was used with 3% yeast and an absorption of 59%; for flour B, the "Remix baking test" was used (5) at an absorption of 63%.

Extensigraph Methods

Doughs were mixed in a GRL mixer at 68 r.p.m. for 2.5 min. at 30°C. An absorption of 65% (14% m.b.) and 1% NaCl (flour basis) was used for all samples. Reaction times of 5 min. and 3 hr. were used, with rest periods of 15 min., the doughs being kept in a conditioning cabinet at 30°C. and 95% r.h. Extensigrams were obtained with a Brabender Extensigraph.

Farinograph Methods

A Brabender Farinograph was used with a 50-g. stainless-steel mixing bowl. The mixing speed was 63 r.p.m., with a 1:1 lever sensitivity linkage setting.

Gassing Power

The modified AACC pressuremeter method was used to determine gassing power (6).

RESULTS AND DISCUSSION

Farinograph Studies

It is seen in Fig. 1 that iodoacetic acid at 0.4 μeq. per g. flour shows a slightly higher consistency in comparison to an equivalent amount of potassium bromate and potassium iodate. It should be recalled that the farinograph is a relatively insensitive instrument as far as indicating an improver response.

Extensigraph Studies

Extensigraph studies are also illustrated in Fig. 1, where it is seen that iodoacetic acid is a very effective reagent in changing the resistance to extension of dough, particularly at the 3-hr. reaction time. At the 3-hr. reaction time, iodoacetic acid at a dosage of 0.05 μeq. per g. flour is more efficient in altering the extension properties of flour than 20 and 10 times that amount of potassium bromate or potassium iodate.

Baking Studies

Bread was baked with various added increments of iodoacetic acid, potassium iodate, and potassium bromate. All of the reagents produced a good response in loaf volume, giving a maximum loaf volume of approximately 700 cc. per 100-g.-flour loaf (Fig. 2).

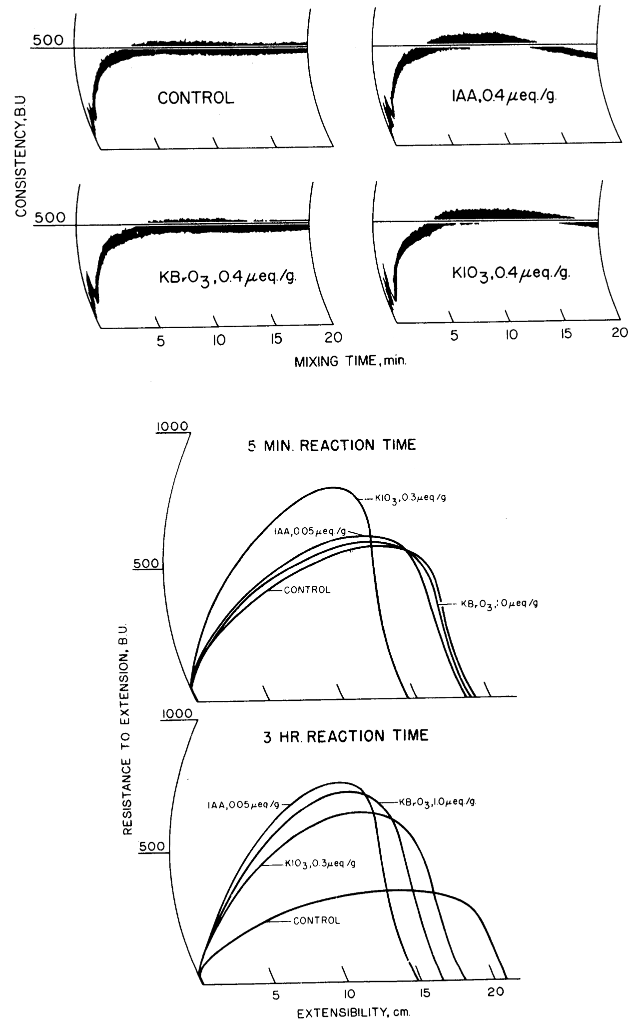
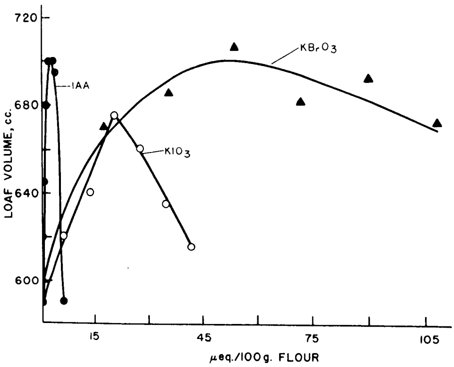


Fig. 1. Effect of iodoacetic acid, potassium bromate, and potassium iodate on farinograms (top) and extensigrams (bottom).



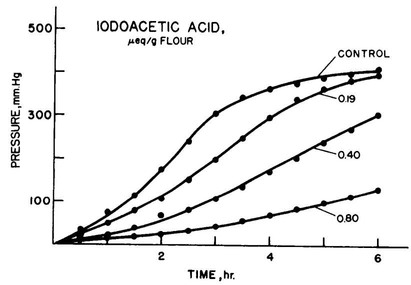


Fig. 2 (left). Effect of iodoacetic acid, potassium bromate, and potassium iodate on loaf volume.

Fig. 3 (right). Effect of iodoacetic acid on the gassing power of yeasted doughs.

Scoring of the bread indicated that the untreated bread, or bread containing low levels of the reagents, showed typical green characteristics of underoxidized dough (low loaf volumes, sharp corners, and smooth biscuity crust). At high levels of the reagents, a loaf volume depressant action was observed, accompanied by typical old characteristics of dough (rough appearance, gas holes). At intermediate reagent levels, bread was produced with a higher loaf volume, and better appearance and crumb texture. However, there are striking differences in the efficiencies of the various reagents in achieving optimum loaf volumes, since optimum volumes were produced at approximately 0.03, 0.22, and 0.60 μeq. per g. flour for iodoacetic acid, potassium iodate, and potassium bromate. These results indicate that iodoacetic acid is a very effective and efficient baking improving reagent, being approximately 7 and 20 times more effective than potassium iodate or potassium bromate.

Gassing-Power Studies

Iodoacetic acid is a well-known yeast inhibitor and, accordingly, its effect was determined on the gassing power of yeast. The results are shown in Fig. 3. While iodoacetic acid does depress gassing power at the higher concentrations, at concentrations of approximately 0.05 μeq. per g. flour, it would have virtually no effect on gassing power.

CONCLUSION

The effect of adding various increments of iodoacetic acid, potassium bromate, and potassium iodate to dough was studied by some rheological and baking techniques.

Farinograph studies showed that iodoacetic acid produced a slightly higher consistency than equivalent amounts of potassium bromate or potassium iodate.

Extensigraph studies showed that iodoacetic acid is very effective in increasing the resistance to extension of doughs. Extension resistance increases caused by normal dosages of potassium bromate or potassium iodate can be realized by much smaller dosages (1/10 to 1/20) of iodoacetic acid.

Baking studies showed that iodoacetic acid produced effects on loaf volume and crumb characteristics similar to those of potassium bromate or potassium iodate. At intermediate dosages of iodoacetic acid, increased loaf volumes and improved loaf and crumb appearances were obtained. At higher dosages, loaf volumes were depressed and crumb appearances deteriorated. However, iodoacetic acid was strikingly more efficient in producing the effects: for example, maximum loaf volumes with iodoacetic acid were obtained by one-twentieth of the dosage of potassium bromate.

The reason for the superior efficiency of iodoacetic acid as a flour-improving reagent could be that it reacts most readily with those SH flour constituents which are concerned most directly with the improver effect. It is known that some of these constituents are low-molecular-weight SH peptides (7) which can react with iodoacetic acid or potassium bromate (8). This concept agrees with that of rheologically effective thiols proposed by Bloksma in a recent very thorough study which showed that there is no unequivocal relation between total SH content and rheological effects or between the rheological effect and amount of improving reagent added.

These findings indicate that iodoacetic acid can produce responses in dough similar to those caused by other commonly used improvers (10,11), and at much lower dosages. These observations, added to the knowledge that iodoacetic acid can form reaction products which can be isolated and identified, indicate that iodoacetic acid should prove to be a valuable reagent for the investigation of the improver reaction.

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