Effect of Fermentation on the Do-Corder and Bread-Making Properties of a Dough

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ABSTRACT

The Do-Corder of a fermenting leavened dough showed two peaks (at 75 and 85° C) and was similar to the curve for a bromated dough. The addition of prefermented dough to a freshly prepared one produced a Do-Corder curve with two peaks and improved the baking performance as evaluated by the sponge-dough baking procedure. Substances produced by yeast during fermentation appeared to play a major role in modifying the physical properties of a dough. The change in the Do-Corder curve and the improvement in bread-making potential associated with the fermentation step were not due solely to the change in dough pH; the addition of acetic acid to an unleavened dough to lower its pH to the level of a leavened one showed little effect on its properties. The fermentation step was indispensable in the bread-making process; when this step was eliminated, none of the bread was satisfactory even in the presence of bromate.

In previous studies (Nagao et al 1981, Tanaka et al 1980) the rheological characteristics of dough were examined using the Do-Corder to mix flour and water at high temperatures in the presence of oxidants and other compounds such as amino and organic acids. The Do-Corder shows promise as a possible tool for predicting the baking performance of a dough. Little study of Do-Corder performance has been made, however, in relation to the fermentation step of baking. Yeast and other microorganisms affect dough properties during panary fermentation. For sour ryebread, where overnight sponges are used, bacterial fermentation is of utmost importance. In such doughs, Beccard (1921) isolated a large number of species of lactic acid bacteria. Kent-Jones and Amos (1967) studied the effect of bacteria and molds in wheat flour on panary fermentation. In the present work, the effects of yeast fermentation on the baking and Do-Corder characteristics of leavened dough were studied.

MATERIALS AND METHODS

Flour

The flour used for this study was described previously (Tanaka et al 1980).

All chemicals used were of standard reagent grade.

Operation of Brabender Do-Corder

A Brabender Do-Corder was operated as described previously (Tanaka et al 1980).

Baking Test

Breads were baked according to the procedures described previously (Nagao et al 1981) unless otherwise stated.

Determination of Sulfhydryl Contents

The sulfhydryl (SH) contents of the samples were determined by amperometric titration, using the method developed by Sokol et al (1959) and modified by Tsen and Anderson (1963).

Determination of pH Value

A sample (10 g) of dough or bread crumb was homogenized with 90 ml of water for 2 min. The homogenate was subjected to pH measurement using a pH meter.

Experiments

Fermentation Period. Doughs having the composition shown in Table I were mixed in the Farinograph with a 300-g mixing bowl at 72 rpm for 6 min. The resulting doughs (120 g) were examined in the Do-Corder after standing for various periods of fermentation at 29° C with 90% rh.

Prefermented Dough. A dough, prefermented in a refrigerator at 5° C for 20 hr, was incorporated at various proportions in the formula for doughs used in the Do-Corder investigations. The composition is shown in Table II. All ingredients were mixed by Farinograph in a 300-g mixing bowl for 6 min at 30° C. In the subsequent Do-Corder investigation, 120 g of dough was used.

Test baking of sponge-doughs was performed to investigate the effect on baking performance of the addition of prefermented dough. Procedures and formulas were described in a previous article (Nagao et al 1981). The prefermented dough was prepared by refrigerating a leavened dough (Table I) overnight. The ratio of fresh and prefermented doughs is shown in Table III. Prefermented dough was incorporated at levels of 7 and 14% in the sponge or at 7% in the dough. The pH value of prefermented dough was 5.0.

Effect of pH. Sulfuric and acetic acids were employed to investigate the effect of acidification on Do-Corder characteristics. Dough composition was the same as in Table I except that a predetermined amount of acid was incorporated with up to 40 ml of the water. The dough was mixed in a Farinograph 300-g mixing bowl for 6 min at 72 rpm. The Do-Corder operation was performed on 120 g of the dough.

Effect of Fermentation. The role of fermentation in baking was studied by eliminating the fermentation step from the straight-dough baking procedure. Instead, sulfuric and acetic acids were

TABLE I
Formulas for Doughs

	Leavened	Unleavened
Ingredients (g)		
Flour (g)	500	500
Yeast (g)	16	···
Yeast food (g)	0.7	0.7
Salt (g)	3.6	3.6
Water (ml)	355	355

TABLE II
Formulas for Incorporation of Prefermented Dough

Prefermented Dough[a]			
Amount (g)	Proportion (%)[b]	Flour (g)	Water (ml)[c]
0	0	300	213
15	3	285	204
30	6	270	193
60	13	240	171
90	20	210	150
120	28	180	129

[a]Prefermented for 20 hrs at 5° C.
[b]Based on the total mass of water, flour, and prefermented dough.
[c]The water absorption for the resulting dough is 71%.

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used to acidify the doughs. The dough formula was as follows: flour, 300 g; yeast, 6 g; sugar, 9 g; salt, 4.5 g; shortening, 6 g; water, 219 ml. The amount of acid was predetermined to adjust the pH of the dough (5.6) to the level in a fermented dough (5.3).

RESULTS

Effect of Fermentation Period on the Do-Corder Properties of Dough

For yeasted dough, the pH value decreased by 0.7 units during a fermentation period of 7 hr, whereas for the control dough, little change in pH value was seen (Fig. 1). This trend has been observed by many workers, among them Micka (1955) and Faridi and Johnson (1978).

The Do-Corder curve for a yeasted dough also changed with prolonged fermentation. This may be related to the changes in pH value. As shown in Fig. 1, the Do-Corder curve for yeasted dough without fermentation had a single peak at 85° C with a shoulder at 75° C. This was very similar to the curve for the control dough in previous work (Tanaka et al 1980). As fermentation proceeded, a peak between 70 and 75° C became evident in the curve, which is also observed for bromated dough (Tanaka et al 1980).

The control dough however, showed little change in its Do-Corder curve during a fermentation period of up to 7 hr (Fig. 1).

These results suggested that the shift in the pH value of the dough caused by yeast fermentation might be related to the change in Do-Corder curve.

Effect of Prefermented Dough on the Do-Corder Characteristics

Prefermented dough was incorporated into the formula at various proportions. Incorporation of prefermented dough at a level of 3% had little effect on the curve. As the amount of the prefermented dough increased, a peak between 70 and 75° C appeared in the Do-Corder curve (Fig. 2), similar to that observed in the curve for leavened dough (Fig. 1).

Effect of Prefermented Dough on the Baking Quality of Sponge

The similarity in the Do-Corder curves for bromated dough and for doughs containing prefermented dough may indicate that the shape of the curve is related to bread-making performance. Therefore, test-baking was done on sponge-doughs containing prefermented dough. Results are summarized in Table III, in which baking quality is expressed as loaf volume. Addition of prefermented dough did not alter the pH of baked bread; all loaves had almost the same pH (either 5.6 or 5.7). The load volume of bread baked from bromated dough was the highest, and that from the control dough was the lowest, Any bread baked from doughs containing prefermented dough had a greater volume than the control did. Of these samples, sample C (14% prefermented dough in the sponge) was almost as good as the loaf baked from bromated dough. Because sample A (7% prefermented dough in the sponge) had a greater volume than sample B (7% prefermented dough in the dough), we concluded that incorporating prefermented dough at the sponge stage is preferable to doing so at the dough stage.

As reported in the previous study (Nagao et al 1981), a Do-Corder curve having peaks at 75 and 85° C was found to be associated with superior baking performance.

TABLE III
Effect on Baking Performance of Incorporation of Prefermented Dough into Sponge or Dough in Sponge-Dough Baking

Sample	Sponge (%) Fresh	Sponge (%) Prefermented	Dough (%) Fresh	Dough (%) Prefermented	Loaf Volume (cc)	pH
Untreated	70	0	30	0	1,960	5.7
Bromated[a]	70	0	30	0	2,170	5.6
A	63	7	30	0	2,120	5.6
B	70	0	23	7	2,080	5.7
C	56	14	30	0	2,150	5.6

[a] Potassium bromate added at 9.6 ppm.

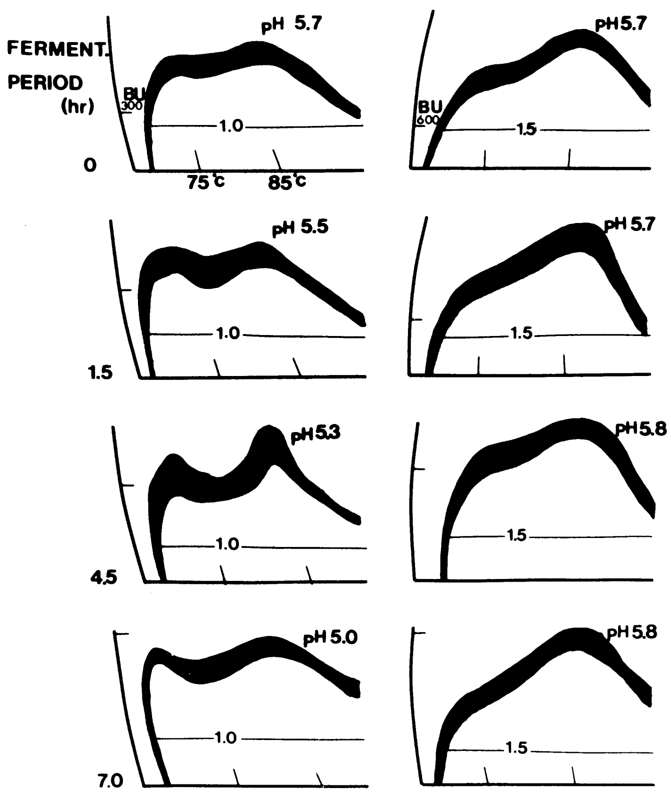

Fig. 1. Do-Corder curves for leavened (left) and unleavened (right) dough after various periods of fermentation. The number under each curve stands for the lever position of the instrument.

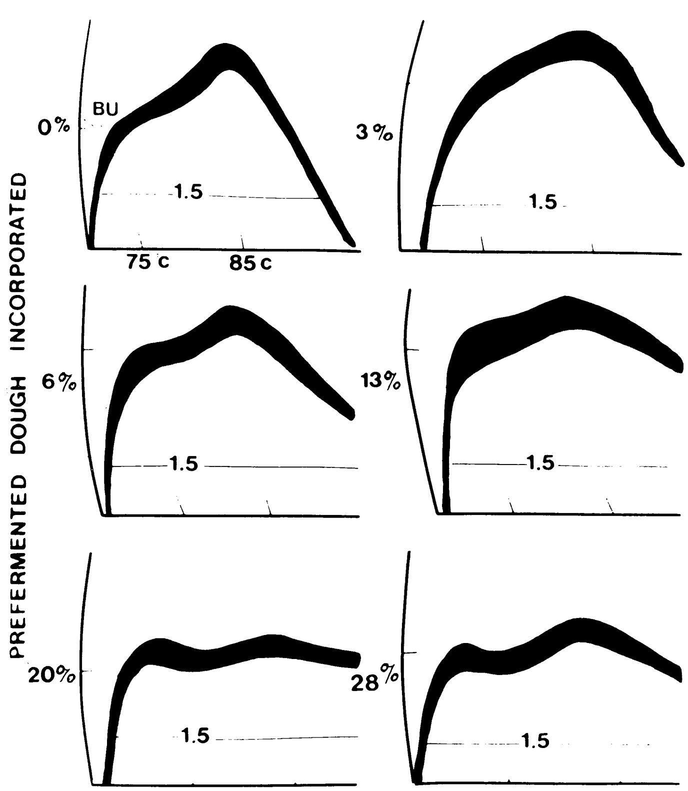

Fig. 2. Effects on the Do-Corder curves of incorporation of various percentages of prefermented dough. The number under each curve stands for the lever position of the instrument.

Effect of pH on the Do-Corder Curve

Sulfuric acid exerted quite a different effect on Do-Corder curves than did acetic acid. Sulfuric acid (at pH 5.3) caused a slight peak at 75° C (Fig. 3). This is somewhat similar to the curve for a bromated dough. Upon addition of more sulfuric acid, the peak at 75° C disappeared. The pH-5.3 Do-Corder curve for acetic acid had a shoulder at 75° C. This shoulder progressively disappeared as the pH was lowered to 4.0 (Fig. 3). Various effects on dough properties due to acids were observed by Tanaka et al (1967), and the results obtained in this study coincide with their results, namely that sulfuric acid showed a farinogram with two peaks and acetic acid with one peak when acid was added at a fixed water absorption to give a pH of 4.2. Bennett and Ewart (1962) considered the main effect of acid on dough to be caused by the action of the hydrogen ions on the flour protein. Later Bennett and Ewart (1965) also showed the importance of the anion of the acid when they compared the effects of salts of various aliphatic and aromatic acids with that of sodium chloride. Thus, the differences between sulfuric and acetic acids in their effects on dough properties could be attributed to the influence of the different anions involved.

Although the Do-Corder characteristics of a fermenting yeasted dough were quite different from those of a dough whose pH value was simply altered by the addition of an acid, as seen by comparison of Figs. 1 and 3, these differences may be due to the many by-products of yeast fermentation. This possibility was studied next.

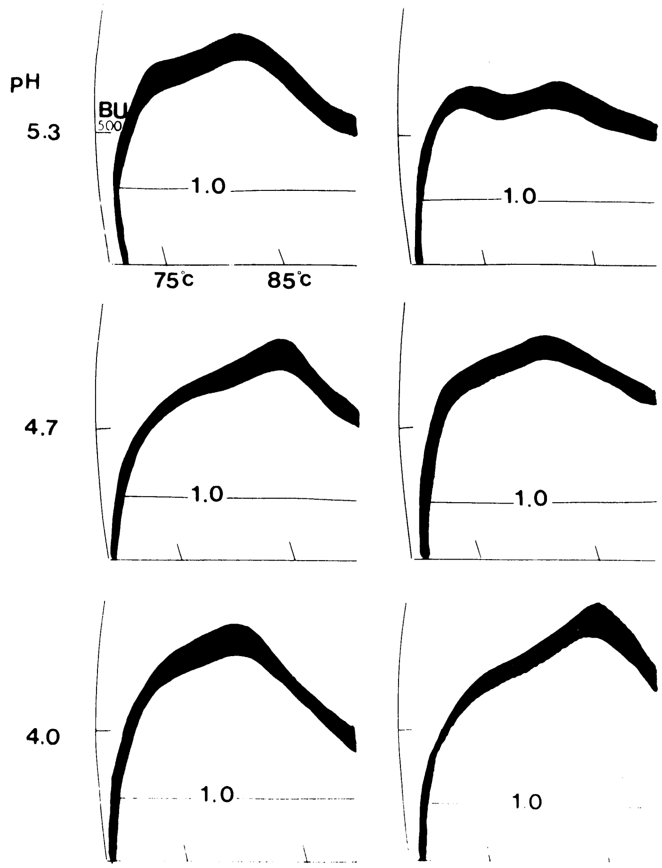

Fig. 3. Effects of acetic **(left)** and sulfuric **(right)** acids on the Do-Corder curves. The number under each curve stands for the lever position of the instrument.

Effect of Fermentation on Breadmaking

During prolonged fermentation, the pH value of dough gradually decreased. To study the role of fermentation in baking, we eliminated the fermentation step and acidified the doughs with sulfuric or acetic acid. Results are shown in Table IV. Sample A (fermented and bromated) had the best quality and the control the second best. Any loaf of bread baked from nonfermented dough had a very small volume regardless of the addition of potassium bromate or acid. Bromate at the level used in the study had no improving effect on a loaf baked without a fermentation. This is one of the reasons why bread-making processes without a fermentation stage require a high level of oxidizing agent.

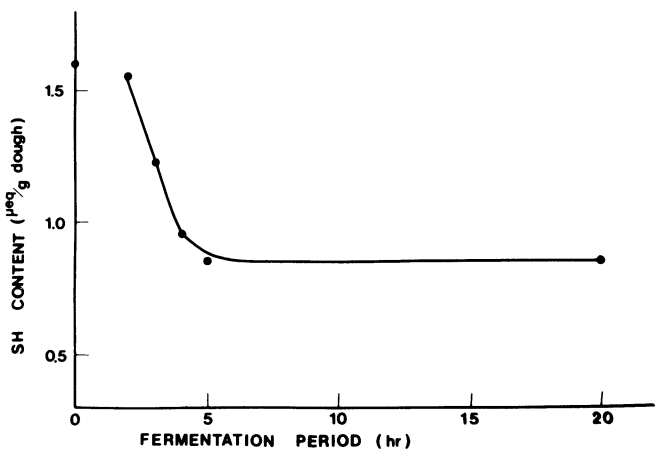

Fig. 4. Decrease in the sulfhydryl (SH) content of a leavened dough during fermentation at 29° C.

TABLE IV
Effects[a] of pH and Fermentation on the Bread-Making Performance of a Dough

	Doughs							
Sample	**Control**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Addition								
Bromate (10 ppm)	···	+	···	+	···	+	···	+
Acid[b]	···	···	···	···	Acetic	Acetic	Sulfuric	Sulfuric
Operation								
Fermentation, punch, and intermediate proof	+	+	−	−	−	−	−	−
Panning, proof, and oven	+	+	+	+	+	+	+	+
pH								
Dough[c]	5.6	5.6	5.7	5.3	5.3	5.3	5.3	5.3
Bread	5.4	5.3	5.4	5.5	5.2	5.2	5.1	5.1
Loaf Volume (cc)	1,810	1,900	1,460	1,480	1,560	1,510	1,500	1,540

[a]+ = Operation performed or addition made, − = operation not performed or addition not made.
[b]Added after dilution with water to 219 ml.
[c]At mixing stage.

Change in SH Content of a Fermenting Dough

The SH content of the leavened (Table I) dough was determined during a 20-hr fermentation. A rapid decrease in SH content was observed in the first 5 hr, as shown in Fig. 4. Then the decrease leveled off at half of the initial content. The initial loss of SH content may be due to oxidation of SH to disulfide groups because fermentation of yeast proceeds initially under oxidative conditions, according to Atkin et al (1946).

DISCUSSION

Fermentation is one of the important steps in the conventional bread-making process. During 7 hr of fermentation, leavened dough changed in both Do-Corder characteristcs and pH, a decrease from 5.7 to 5.0 (Fig. 1). An unleavened dough, however, did not show any change in either its Do-Corder curve or its pH value during the 7 hr after mixing (Fig. 1).

The addition of acetic acid to an unleavened dough to reduce its pH to the level of a leaved one did not produce any marked effect on Do-Corder characteristics. Therefore, substances other than acidity are produced by yeast fermentation, and these play a major role in modifying the physical properties of a dough. This is supported by the observation that the incorporation of prefermented dough into an unleavened dough caused similar changes in the Do-Corder curve (Fig. 2). Cole et al (1966) and Faridi and Johnson (1978) reported that yeast produced several organic acids, amines, and amino acids during fermentation. Some of them are closely related to intermediates of the tricarboxylic acid cycle, a major metabolic pathway in yeast. Some compounds that showed an effect on the Do-Corder curve in previous work (Nagao et al 1981) are also related to intermediates of the tricarboxylic acid cycle. The addition of these compounds (ie, glutamate, aspartate, α-keto glutarate, alanine, and cystine) plus L-ascorbic acid to a dough caused an effect on the Do-Corder curve similar to that produced by fermentation, a shoulder or peak at 75°C in addition to the peak at 85°C (Nagao et al 1981). The addition of a prefermented dough to the sponge or dough in the sponge-dough bread-making system improved the resulting bread to some extent. This may be the result of the combined effect of those compounds produced by yeast. Oxidation of SH to disulfide groups during fermentation (Fig. 4) may also play an important role in determining the physical properties of leavened dough. Thus the fermentation step is indispensable in conventional breadmaking with either the straight-dough or the sponge-dough system. This was particularly shown by the finding that, following the elimination of fermentation from a baking system, none of the bread was satisfactory even in the presence of bromate.

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