INFLUENCE OF SMALL QUANTITIES OF THIAMINE ON BAKING QUALITY OF WHEAT FLOUR

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INFLUENCE OF SMALL QUANTITIES OF THIAMINE ON BAKING QUALITY OF WHEAT FLOUR [1]

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ABSTRACT

The influence of small quantities of thiamine on the baking quality of flour was investigated with the aid of extensograph, fermentograph, and baking experiments, using flours differing both in extraction and in the composition of the grist from which they were milled.

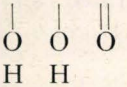
Thiamine added in concentrations up to 12 mg. per kg. of flour had no influence on the elastic properties of dough. In concentrations up to 10 mg. per kg. of flour it, apparently, exercised a slight stimulating action on the fermentation.

Even when variations were made in the type of flour, yeast concentration, dough consistency, and fermentation time, it was not possible to reproduce the improvement in the bread volume of 6.8% and 15.7% claimed in Dutch patent No. 55774 for the addition of 3 and 6 mg. respectively of thiamine per kg. of flour.

In the concentrations used, it is concluded that thiamine does not possess any improving action in breadmaking.

It is well known that very small concentrations of various oxidizing substances, such as potassium bromate, potassium iodate, and ammonium persulfate, exercise an improving influence on the baking quality of wheat flour. The extensive investigations and the many theories evolved to explain the behavior of these substances have been summarized by Sullivan *et al.* (8) and by Shen and Geddes (7). The thesis of Holger Jørgensen (3) is also a worth-while contribution to the elucidation of this problem.

Certain organic reducing agents such as ascorbic acid, reductic acid, and related substances, which, together with the oxidized form, constitute a redox-system can exercise a similar action to the above-mentioned oxidizers. From experiments in which ascorbic acid and a number of substances of analogous structure were compared as to their effect on the baking quality of wheat flour, Elion (1) was of the opinion that the group



performs an essential function in the improvement of baking quality. Sandstedt and Hites (6) showed that the presence of the specific reducing group only fulfills one requirement.

[1] Manuscript received May 12, 1948.
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A second condition is that the oxidases in the flour must be able to form a redox-system from the reducing substance and its oxidized form. This system catalyzes the transfer of oxygen contained in the dough to the oxidizable groups in the protein components of the flour, where the oxidation by bromate and similar substances also takes place. Thus the action of both groups of substances can be reduced to the same principle. Maltha (4) has arrived at a similar point of view.

Regarded in this light, it is rather surprising to find in a patent by Hoffmann-La Roche (2) an improvement of baking quality attributed to thiamine, a chemically different type of substance, which does not possess the above-mentioned characteristic properties. According to the specification the addition of 3 and 6 mg. thiamine per kg. of flour exerts a volume improvement of 6.8 and 15.7% respectively.

Moran and Drummond (5), investigating the properties of white flour enriched with thiamine, did not notice any influence on the dough, the volume of the loaf, or the crumb character of the bread.

Because of the importance of the patent from a social and economic point of view the author has tried to reproduce the claimed improvement. Although comparison is made in the patent to an action such as that of bromate and ascorbic acid—in other words, the influencing of the protein-proteinase system—attention was paid in the present studies to the possible activation of fermentation by the added thiamine, which could likewise cause an increase in bread volume.

Materials and Methods

A rather wide choice of flours was employed in case some types would be more susceptible than others to any effect produced by the thiamine.

a. A flour milled in a Dutch flour-mill from a grist consisting of 40% home-grown wheat, 40% foreign wheat, and 20% rye,[3] from which were separated the fractions 0–30% (patent flour A_1) and 30–67% (clear flour B_1). By mixing the fraction 0–30% with that of 30–67% in the proportion of 3:3.7, a flour (AB_1) was obtained having an extraction of 67%, which is not far short of the prewar standard in Holland.

b. A flour milled by the same mill, from a mixture consisting of 50% foreign wheat, 30% home-grown wheat, and 20% rye. The same fractions 0–30% (A_2) and 30–67% (B_2) were separated, and by mixing these fractions in the proportion 3:3.7, a flour (AB_2) of 67% extraction was compounded.

c. A flour milled exclusively from soft home-grown wheat to an extraction of about 75%.

[3] In the present situation of world wheat-shortage the millers are bound by the government to admix a certain amount of rye, mostly home-grown, to the grist.

d. A national bread-flour: "Type 10 November 1946." Composition: 50% foreign wheat, 30% home-grown wheat, and 20% rye, and extraction of 85%.

The yeast used was furnished by the Ned. Gist en Spiritusfabriek (Koningsgist).

Sodium chloride (a highly purified product) was supplied by Brocades Stheemann and Pharmacia, Meppel, and thiamine (synthetic) by the "Chemo Puro Manufacturing Company," New York.

The effect of thiamine on the protein- (gluten-) system was studied with the aid of the Brabender Extensograph, since the nature of the extensogram is known to be markedly influenced by small concentrations of such improving agents as potassium bromate and ascorbic acid. The procedure was as follows: 300 g. flour plus 6 g. sodium chloride and the thiamine, when used, were kneaded with water in the Brabender Farinograph to the normal consistency of dough (500 Brabender units). Each piece of dough was divided into two parts of 150 g. These were worked and rolled into the desired shape and set aside at a temperature of 27°C. At intervals of 45 minutes four extensograph curves were made for each piece of dough.

The influence of fermentation activity was examined with the aid of the Brabender Fermentograph as follows: The dough, prepared from flour, 2% yeast, 2% common salt, and the thiamine when used, was kneaded in the farinograph to a consistency of 450 to 500 Brabender units. Immediately after preparation an accurately weighed quantity (400 g.) was placed in the fermentograph at a temperature of 27°C. At intervals of one hour the piece of dough was well punched in accordance with the process in the bakery. The total duration of the experiment was from 4 to 5 hours; that is, about the time when the fermentation begins to weaken. With only a few exceptions, each experiment was carried out in duplicate.

The influence of thiamine on the properties of the bread was investigated by several series of baking tests. Six tinned loaves of 400 g. (each containing about 240 g. of dry substance) were baked from each dough. A dough temperature of 26° to 27°C., a proofing temperature of about 30°C., and an oven temperature of 260° to 270°C. were always maintained. Ingredients to promote diastatic power were not added, since the composition of the grain mixtures insured sufficient enzyme activity. Thiamine was added to the dough-liquor in the form of a concentrated solution by means of a pipette. Variations were introduced in the percentage of yeast, consistency of the dough, and the length of fermentation to discover the conditions most favorable to the action of thiamine on the baking behavior. The volumes of the loaves

were determined immediately after baking, and the remaining properties were estimated after about 18 hours.

Results and Discussion

The extensograph data for the 45- and 180-minute curves are summarized in Table I. Besides the highest concentration of thiamine mentioned in the patent, i.e., 6 mg. per kg. flour, an addition of 12 mg. was also examined, the greater amount thus giving a possibly vague influence of 6 mg. a chance to become evident.

For the same reason, concentrations of 10 mg. thiamine per kg. flour, as well as those of 6 mg. per kg. were examined in the fermentation experiments. Variations were also made in dough consistency and percentage of yeast. The results are summarized in Table II.

Finally the results of the different series of baking tests are collected in Table III.

The extensograms (Table I) show in a striking manner that thiamine has no effect upon the stretching properties of the dough. The curves with and without the addition of thiamine are the same at each of the

TABLE I

EFFECT OF THIAMINE ON EXTENSOGRAM MEASUREMENTS

Property measured	After 45 minutes			After 180 minutes		
	Thiamine, mg./kg. flour			Thiamine mg./kg. flour		
	0	6	12	0	6	12
FLOUR A_2 (0–30% EXTRACTION)						
Water absorption—%	52.5	52.5	52.5	52.5	52.5	52.5
Extensogram area—cm.^{2}	90.5	90.6	83.2	103.0	109.8	107.4
Max. stretching power—B. U.	370.0	365.0	340.0	540.0	545.0	540.0
Extensibility—cm.	17.5	16.6	17.0	14.4	14.7	14.5
FLOUR B_2 (30–67% EXTRACTION)						
Water absorption—%	53.5	53.5	53.5	53.5	53.5	53.5
Extensogram area—cm.^{2}	73.7	77.1	67.0	83.7	88.7	75.5
Max. stretching power—B. U.	310.0	310.0	300.0	420.0	420.0	385.0
Extensibility—cm.	16.5	16.5	16.2	14.2	14.5	14.2
FLOUR AB_2 (0–67% EXTRACTION)						
Water absorption—%	52.5	52.5	52.5	52.5	52.5	52.5
Extensogram area—cm.^{2}	82.1	84.1	83.5	100.3	103.6	99.8
Max. stretching power—B. U.	340.0	340.0	335.0	490.0	505.0	495.0
Extensibility—cm.	16.5	17.0	17.1	14.1	13.3	14.2

TABLE II

EFFECT OF THIAMINE ON THE GAS PRODUCTION OF DOUGHS OF VARYING CONSISTENCY AND YEAST CONTENT, MADE WITH FLOURS OF DIFFERENT COMPOSITION AND EXTRACTION [1]

Flour	Extractions	Yeast	Thiamine	Absorption	Farinograph consistency	Total gas production [2]	
						4 hours	5 hours
	%	%	*mg./kg.*	%	*B. U.*	*ml.*	*ml.*
A_1	0–30	2	Control	50	500	1400	—
		2	10	50	500	1440	—
AB_1	0–67	2	Control	52	450	1480	—
		2	6	52	450	1540	—
AB_1	0–67	2	Control	51	500	1475	—
		2	10	51	500	1515	—
AB_1	0–67	1	Control	53	450	765	1075
		1	6	53	450	900	1180
AB_2	0–67	2	Control	53	450	1505	1955
		2	6	53	450	1525	1980
AB_2	0–67	1	Control	53	450	790	1110
		1	6	53	450	835	1165

[1] All dough contained 2.0% of salt (flour basis). Mean values of duplicate determinations.
[2] The mean error of the mean values is about 80 ml.

testing times so that an action similar to that of bromate, ascorbic acid, or similar improvers cannot be ascribed to thiamine.

The figures derived from the fermentographic investigation (Table II) are inconclusive. The indicated influence of the thiamine on the fermentation is slight and of the same magnitude as the mean error of the mean of the duplicate determinations, but the fact that in all six series of experiments the addition of thiamine gave an increased gas-production suggests that thiamine has a positive influence on the fermentation. However, statistical calculations indicate that this influence is so slight that no definite conclusions can be drawn from it.

The question arises whether the bakers' yeast used in Switzerland, with which the experiments described in the patent in question were probably carried out, contained less thiamine than the Dutch yeast and in consequence was more sensitive to additions of this substance. However, the manufacture of bakers' yeast in West European countries is essentially the same, thus making important differences in composition very unlikely.

The baking experiments confirm the results of the dough investigation. The differences in volume of the loaves made with and without thiamine were at the most 1.5%, thus falling within the limits of experimental error. An apparent decrease in volume due to the addition of thiamine appeared in the series with the flour milled from Dutch soft wheat.

To conclude the investigation, a commercial baking test was carried out, to determine whether any differences could be obtained in the commercial bakery which uses sacks of 50 kg. of flour. Bread baked from a sack of government flour (50% foreign wheat, 30% home-grown wheat, 20% rye: 85% extraction) with thiamine added at the rate of 6 mg. per kg. flour gave similar loaves to that baked without thiamine.

TABLE III

EFFECT OF THIAMINE ON THE BAKING BEHAVIOR OF DIFFERENT FLOURS WITH VARIATIONS IN PERCENTAGE OF YEAST AND FERMENTATION TIME [1]

Procedure					Baking results				
Thiamine added per kg. flour	Yeast	Absorption	Total fermentation time	Total proof time	Shape	Texture	Loaf volume (mean)	Volume per kg. flour	Volume increase
mg.	%	%	*min.*	*min.*			*cc.*	*cc.*	%
FLOUR A_2 (0–30% EXTRACTION)									
Control	2	55	43	83	Good	Good	1720	6005	—
3	2	55	43	83	Good	Fair	1740	6070	+1.1
6	2	55	43	83	Good	Satisfactory	1740	6070	+1.1
Control	1	55	53	98	Satisfactory	Satisfactory	1530	5330	—
3	1	55	53	98	Satisfactory	Satisfactory	1530	5330	0
6	1	55	53	98	Satisfactory	Satisfactory	1530	5330	0
12	1	55	53	98	Satisfactory	Satisfactory	1550	5370	+0.8
FLOUR AB_2 (0–67% EXTRACTION)									
Control	2	55	40	93	Good	Fair	1590	5540	—
3	2	56	40	93	Good	Fair	1590	5540	0
6	2	56	40	93	Good	Fair	1590	5540	0
Control	1	56	50	103	Satisfactory	Satisfactory	1390	4810	—
3	1	56	50	103	Satisfactory	Satisfactory	1390	4810	0
6	1	56	50	103	Satisfactory	Satisfactory	1410	4880	+1.4
SOFT DUTCH FLOUR (75% EXTRACTION)									
Control	2	57.5	40	82	Moderate	Fair	1100	3760	—
3	2	57.5	40	82	Moderate	Fair	1080	3690	−2
6	2	57.5	40	82	Moderate	Fair	1095	3745	−0.5
12	2	57.5	40	82	Moderate	Fair	1085	3710	−1.5

[1] Added sodium chloride 2% (flour basis); baking time 30 minutes.

The experimental results given here show that it has not been possible to reproduce the improvement in volume of 6.8 and 15.7% respectively, on addition of 3 and 6 mg. thiamine per kg. flour, claimed in the patent in question. This applies to flour made from different grists, milled to different extractions, and baked by different formulas.

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