BREAD FLAVOR WITHOUT PREFERMENTATION

by

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INTRODUCTION AND REVIEW OF LITERATURE

It has long been a normal practice in breadmaking to mix flour, water, sugar, salt and yeast into a dough and allow 4 to 24 hours of fermentation before moulding, proofing and baking. A lengthy fermentation time has been thought necessary so that the gluten could develop to retain carbon dioxide and to produce the desired flavor. It has been recognized that both fermentation and baking of the dough are required to produce a desirable bread flavor (1,2,3,4,5).

Much research on bread flavor has been reported during the past decade. Extensive reviews are available (1,2,3,6,7,8,9,10,11,12,13,14,15). This review is presented to summarize the most recent advances for control of bread flavor.

Bread Processing Today

The consumer of bread is concerned about bread quality. A large, well-piled loaf with a golden brown crust and a smooth, soft but not sticky crumb and acceptable flavor is desired. Today's methods of bread production, generally achieve these bread characteristics.

Several procedures are in common use. These include the sponge-dough procedures using high speed dough mixers. The customary fermentation time for a sponge is 4 hours. A more recent procedure is the continuous mix process in which a liquid pre-ferment fermented for 3 hours, with or without flour, is used. This procedure accounts for 35% of the bread production in the United States. Another procedure developed in Great Britain involves a rapid dough development using a straight-dough procedure (16,17). Generally, bread made by these processes has good volume, crust and crumb characteristics. Crust characteristics are highly related to flavor of bread. The importance of having residual reducing sugars to react with amino groups during baking is recognized. In certain types of continuous mix bread, the acceptability of the flavor has been questioned (18,19,20,21,22).

Fermentation and Bread Flavor

More than 60 aromatic compounds are produced by dough fermentation (9) but many of them are dissipated during later stages of fermentation or in baking process. Some compounds undergo further reaction during baking to produce new flavor stimuli (1,23). Among the compounds formed during dough fermentation are alcohols, acids, ethyl esters, carbonyl compounds, maltose and free amino acids (24,25,26,27,28).

Ethyl alcohol and carbon dioxide are the main end-products of yeast fermentation but the amount of ethyl alcohol remaining in the bread is not great (23,29). It has been found that the oven vapors contain large quantities of ethyl alcohol (30). Other alcohols are found in fermenting dough in trace amounts. These include propanol, butanol, iso-butanol, pentanol and isopentanol. Some of the higher molecular weight alcohols are found in bread in trace amounts presumably because of their higher boiling points (7).

The organic acids are produced during fermentation mainly because of bacteria associated with flour and yeast (28). As fermentation time is extended, the pH of the dough is lowered even though flour proteins are efficient buffer systems. The titratable acidity increases as a function of fermentation time (20). Acetic and lactic acids are produced in greatest amounts but traces of pyruric, butyric, isobutyric, valeric and iso-valeric are found (18). Organic acids in normal white bread have a subtle effect on flavor (8) but this may be more pronounced in "sour French bread." The organic acids react with ethyl alcohol to form the corresponding volatile esters which are found only in minor amounts (31,27).

A series of carbonyl compounds are produced during fermentation in minor concentrations (32). It is likely they arise from amino acids by a metabolic process (26,33). However, it would appear that the concentration of the carbonyl compounds produced during fermentation is insignificant compared to the concentration of these compounds found in the bread crust (4,10,20). The type of carbonyl compounds found in bread will vary with the availability of certain amino acids (5,20,32,34). The addition of any one amino acid will alter the aroma but it cannot be classified as a typical bread aroma. It has become evident that bread aroma and flavor are due to a combination of different compounds. A mixture of carbonyl compounds play a dominant role in the total flavor picture.

Maltose is produced in dough as a result of damaged starch hydrolysis by amylase enzymes. If the baker uses a limited amount of sugar in the formula, much of the maltose will be used by yeast in fermentation. Little sugar will be present during the baking process and therefore the reactions with free amino groups will be limited. It is customary for the baker to add sufficient sugar to assure an excess when the dough is placed in the oven.

Free amino groups which react with reducing sugars are normally provided by partial proteolysis (33,35) of the gluten protein during fermentation. Yeast is also known to provide some free amino groups (26). If fermentation is extensive, the yeast and bacteria may utilize free amino groups in metabolism (26,36,37). However, it would appear that a long fermentation period of the dough provides a major amount of free amino groups which react with sugars to create flavor by the non-enzymatic browning reaction (26).

The Future

Presently, our knowledge of the effects of dough fermentation may make it possible to provide a synthetic mixture of the compounds produced in fermentation. With such knowledge, it may be possible to make bread with elimination of the lengthy fermentation period and at the same time control the intensity of bread flavor. It can be predicted that methods of bread production will soon change using new knowledge available today.

Summary

Bread flavor is due to a complex group of chemical stimuli which are produced through dough fermentation and further modified during the baking process. Yeast produces ethyl alcohol and carbon dioxide as primary products of anerobic fermentation but amino acids may be utilized in metabolism and the end-products are a complex series of carbonyl compounds. Bacteria associated with the flour and yeast produce organic acids during fermentation. These may equilibrate with ethyl alcohol to create ethyl

esters. Maltose and free amino acids are produced during fermentation by hydrolysis of the starch and protein, respectively. The free amino acids react with reducing sugars during the baking process to create a complex series of carbonyl compounds which complete the flavor profile of fresh bread.

Today's knowledge of the function of dough fermentation should permit the production of white bread with elimination of the lengthy fermentation period while at the same time controlling the flavor intensity.

CONCLUSION

Many attempts have been made to enhance bread flavor. Among these are the addition to dough of aroma condensates, synthetic condensates, condensed vapors, enzymes (proteases), amino acids, and organic acids. The condensates are not practical for flavor enhancement of bread because extremely large quantities of bread are necessary for their recovery. Moreover, most condensates are not effective (2,3,30,38,39).

Protease enzymes which also modify dough properties, are the only present practical means for flavor enhancement of bread; however, the use of high levels in a fermenting dough may lead to difficulties since they are sensitive to pH change, temperature, and other processing variations (33,40,41).

Amino acids added to dough will affect the resulting bread aroma. A single amino acid will alter the aroma, sometimes to non-typical bread aromas. It would appear that a complex ratio of amino acids is needed for complete bread flavor enhancement. On the other hand, organic acids, produced during dough fermentation have only a subtle effect on flavor but may affect the properties of dough, making it more resilient for machine operation (12,34,42,43).

In view of the foregoing, it is the purpose of this study to determine the effect of particular protein hydrolysates and particular ratio of organic acids on final loaf characteristics, bread flavor, and consumer acceptance. A sponge-dough procedure was used as the usual standard for comparing other procedures of baking bread.

MATERIALS AND METHODS

BAKING TESTS

A commercially milled, bakers' patent flour having protein and ash contents of 12.00 and 0.4%, respectively (14 M.B.) was used for the baking tests.

Sponge-Dough Process

In the baking tests a sponge-dough process was employed, based on the following formula:

Ingredients	Sponge %	Dough %
Flour[a]	70.0	30
Water[b]		
Yeast	2.0	
Yeast Food[b]		
Salt		2.0
Sucrose		6.0
Malted Wheat Flour		0.5
Shortening (Crisco)		3.5

[a]Total of 700 g. flour (14% moisture basis) was used.

[b]Optimum as determined by preliminary baking tests for the flour used. Arkady consisting of $(NH_4)_2PO_4$, $CaSO_4$, and $KBrO_3$.

Using two identical Hobart A-200 mixers with McDuffee bowls and forks, the sponges were mixed 3 minutes in speed 1; doughs were mixed

2 minutes on speed 1 and to optimum consistency as determined by visual observation on speed 2.

Sponge temperature after mixing was 76°F. Sponges were fermented for four hours at 86°F in fermentation pans. Dough with temperatures ranging from 81 to 84°F after mixing was given a floor time of 40 minutes. Two 539 g pieces were scaled from each dough, hand-rounded and given an intermediate proof of 20 minutes. Those dough pieces were machine-molded and pan-proofed at 110°F and 75% r.h. to a height of 1.5 cm above the pan. The loaves were baked 25 minutes at 425°F on a Reed reel oven. The volumes were measured by rapeseed displacement as soon as the loaves were taken from the oven. After cooling one hour at 80°F, the loaves were placed in polyethylene bags and stored overnight at 80°F. They were then scored and analyzed organolepically fresh.

No-Time Dough Process

A no-time dough process was employed in the baking tests, according to the following formula and procedure:

Ingredients	Per Cent
Flour[a]	100
Water[b]	
Yeast	3
Salt	2
Sucrose	5
Malted Wheat Flour	0.5

Ingredients	Per Cent (continued)
Shortening (Crisco)	3
Potassium Bromate[b]	48 p.p.m.
Potassium Iodate[b]	12 p.p.m.

[a]Total of 700 g flour (14% moisture basis) was used.

[b]Optimum as determined by preliminary baking tests for the flour.

Two Hobart A-200 Mixers were used, with McDuffee bowls and forks. Doughs were mixed 30 seconds on speed 1 and to optimum consistency determined by visual observation and dough feel on speed 2.

Dough with temperatures ranging from 85° to 87°F after mixing was divided into two 539 g pieces. Those dough pieces were hand-rounded, given a floor time of 20 minutes, machine-molded and pan-proofed at 110°F and 75% r.h. to a height of 1.5 cm. above the pan. The loaves were baked 25 minutes at 425°F on a Reed reel oven. The volumes were measured by rapeseed displacement as soon as the loaves were taken from the oven. After cooling one hour at 80°F, the loaves were placed in polyethylene bags and stored overnight at 80°F. They were then scored and analyzed organoleptically fresh.

Straight Dough Process

A straight dough process was employed in the baking tests, according to the following formula and procedure:

Ingredients	Per Cent
Flour[a]	100
Water[b]	
Yeast	2.0
Yeast Food[b]	
Salt	2.0
Sucrose	6.0
Malted Wheat Flour	0.5
Shortening (Crisco)	3.0

[a]Total of 700 g flour (14% moisture basis) was used.

[b]Optimum as determined by preliminary baking tests for the flour used. Arkady consisting of $(NH_4)_2PO_4$, $CaSO_4$ and $KBrO_3$.

Using two identical Hobart A-200 Mixers with McDuffee bowls and forks, the doughs were mixed 1 minute on speed 1 and to optimum consistency as determined by visual observation on speed 2.

Dough with temperatures ranging from 80° to 82°F after mixing was given a fermentation period of three hours. Two 539 g pieces were scaled from each dough, hand-rounded and given an intermediate proof of 20 minutes. Those dough pieces were machine-molded and pan-proofed at 110°F and 75% r.h. to a height of 1.5 cm. above the pan. The loaves were baked 25 minutes at 425°F on a Reed reel oven. The volumes were measured by rapeseed displacement as soon as the loaves were taken from the oven. After cooling one hour at 80°F, the loaves were placed in polyethylene bags and stored overnight at 80°F. They were then scored and analyzed organoleptically fresh.

Bread for Chemical Analysis

For chemical analysis, 50 gram pieces were scaled from each dough under process. Those dough pieces (otherwise handled as previously described) were hand-rounded, hand-molded, pan-proofed 50 minutes, and baked 13 minutes at 425^{o}F.

Bread Scoring Procedure

A scoring system was designed that included five loaf quality characteristics. The maximum score possible with this system was 60. Loaf volume was considered as a separate entity and was measured in cubic centimeters. The characteristics scored included break and shred, symmetry, crust color, texture, crumb grain and crumb color. All characteristics were 10 points maximum.

ORGANOLEPTIC TESTS

Flavor Rating

A Flavor Rating System was used for preliminary determination of bread flavor intensity. The baked bread was allowed to cool for one hour after baking and was then sliced one-half inch by a commercial slicing machine. Samples of two adjacent slices were placed immediately into polyethylene bags equipped with seals. The number of judges was 6 semi-trained people (44). The six different samples of bread representing the sponge and straight dough controls and other treatments were given to the judges about one and a half hour after lunch. The judges were advised to rank in order of intensity. The degrees to express intensity were based on this scale: + very low, ++ low, +++ medium and ++++ high.

The judges were also asked to comment whether the flavor was "bread-like" or "unbread-like."

Consumer Preference Test.

The baked bread was allowed to cool for one hour after baking and was then sliced one-half inch by a commercial slicing machine. Samples of two adjacent slices were placed immediately into polyethylene bags equipped with seals. The samples were randomized to insure statistical comparison when needed. The number of judges was 13 or 14 semi-trained people (45). The three different samples of bread representing the sponge control and other treatments were given to the judges about one and a half hour after lunch (46). The judges were advised to determine over-all aroma and flavor first, then sweetness and sourness. They were asked to arrange over-all flavor and aroma in order of preference with the number 3 the most, 2 in-between and 1 the least preferred; and sweetness and sourness in order of intensity with 3 the most, 2 in-between and 1 the least intense. The test was repeated at least twice when the data indicated a statistical analysis was needed.

PREPARATION OF HYDROLYZATES

Laboratory

Ten pounds of flour (same flour used for baking tests) was formed into a dough. The gluten was washed out and dispersed in 4N HCl by placing small pieces of gluten in a Waring Blendor totaling to 300 g per 1000 ml acid (300 g sample was used of soy protein concentrate obtained from Archer, Daniels, Midland Company). After blending, the suspension was diluted to 2000 ml with more acid. The suspension was heated 6-8 hours in an autoclave at 121°C and 15 pounds pressure. The hydrolysate was steam-distilled until thick, diluted 3 times with water and steam-distilled until most of the HCL was evaporated. Neutralization of the remaining acid was accomplished by addition of 1N NaOH to a pH of 5.4. Neutralization with out removal of HCl by distillation was also attempted. The thick suspension was diluted with water and decolorized with carbon (Darco G-60) and filtered through suction. Several batches of carbon were used to achieve clarity. Sodium hydroxide pellets were used to neutralize the remaining acid to a pH of 6.5. At this point, carbon was added again for further decoloration after which solution was lyophilized and subjected to protein and amino acid analysis.

Commercial

Vital Wheat Gluten hydrolysate (Promate 200) was obtained from the Griffith Laboratories, Chicago, Illinois. A blend of gluten, soy and other plant protein hydrolysates (Vegamine) was also obtained from Griffith.

Autolyzed yeast was obtained from Universal Foods.

AMINO ACID ANALYSIS OF HYDROLYSATES

Qualitative and quantitative determinations of amino acids were made by use of a Beckman Amino Acid Analyzer Model 120B (47,48). One ml aliquots were used on each of the 150-cm columns for analysis of acids and neutral amino acids and on the 15-cm column for basic amino acid analysis. The area under each curve of the amino acid chromatogram was calculated and compared with that of the corresponding amino acid in a standard chromatogram of known quantity. The results were expressed as g amino acid per 100 g dry basis of hydrolysate.

PREPARATION OF ORGANIC ACID AND SALT SOLUTIONS

Free Organic Acids

The following total quantity of organic acids was diluted to 1000 ml.

Acids	Mg.	M Moles
Lactic	1081.0	12.0
Acetic	240.2	4.0
Butyric	35.2	0.4
IsoButyric	35.2	0.4
Valeric	14.3	0.14
IsoValeric	14.3	0.14
Caproic	16.3	0.14
Total	1436.5	17.22

This solution approximates the ratio of significant organic acids which have been isolated and identified in a sponge of a sponge and dough process with 4 hour prefermentation (49,50,51).

Organic Acid Salts

The sodium salt of acetic acid and calcium salt of lactic acid (sodium lactate is liquid at room temperature) were obtained from Fisher Scientific. The other sodium salts of butyric, isobutyric, valeric, isovaleric and caproic acids, were synthesized by neutralizing them with concentrated sodium hydroxide followed by freeze drying to obtain them in solid form. The following total quantity of organic acid salts was diluted to 1000 ml.

Acid Salt	Mg.	M Moles
Calcium Lactate	1309.3	6.0
Sodium Acetate	328.1	4.0
Sodium Butyrate	44.0	0.4
Sodium isoButyrate	44.0	0.4
Sodium Valerate	17.4	0.14
Sodium isoValerate	17.4	0.14
Sodium Caproate	19.3	0.14
Total	1779.2	11.22

CHEMICAL ANALYSIS

Determination of Total Carbonyl Compounds

Total carbonyl compounds were determined by a slight modification of the method of Lappin and Clark (52). A 40 g sample loaf of bread was cut in to 8 pieces immediately after baking and put into a pint Mason jar. A 200 ml portion of carbonyl free chloroform was added and the sample extracted for 30 minutes using an Everbach shaker. The extract was filtered through filter paper and the filtrate analyzed for total carbonyl compound content. Aliquots of 0.0, 0.1, 0.2, 0.3, 0.4, 0.5, and 0.6 ml were taken of the filtrate and diluted to 1 ml with the chloroform.

One ml of saturated 2,4-dinitrophenylhydrazine in methanol was added to each aliquot with one drop of concentrated hydrochloric acid. The aliquots in test tubes were then heated in boiling water for five minutes which formed the 2,4-dinitrophenylhydrazones. The test tubes were cooled and 5 ml of 10% potassium hydroxide in methanol was added. The optical density was read at 480 nm.

Headspace Analysis

The breads were cut in half and 1 ml vapor samples taken directly out of the center of the loaf and from headspace of loaves placed in bottles equipped with rubber septums on the lids. These vapor samples were immediately injected into a gas chromatograph. Triplicates were run on each bread sample and repeated at least two days. A Hewlett-Packard Model 5750 gas chromatograph equipped with a dual column hydrogen flame ionization detector was used. A 500 ft. long capillary column was used packed with Carbowax 2M. Injection port was 210°C, column temperature 85°C isothermal and the flame 260°C. The carrier gas was nitrogen, with a flow rate of 9 ml/minute.

RESULTS AND DISCUSSION

AMINO ACID ANALYSIS OF PROTEIN HYDROLYZATES

For analysis of most amino acids, a protein is usually hydrolyzed with 6N HCl at 110°C for 20 hours or longer in an anaerobic atmosphere. The time is usually varied, both to estimate the rate of destruction of labile amino acids, e.g., serine, threonine and tyrosine and to insure complete hydrolysis of more stable peptide bonds. Particularly those involving isoleucine and valine residues. Acidic hydrolysis destroys tryptophan and glutamine and asparagine are converted to their respective dicarboxylic acids (53). The interest in this study was to obtain protein hydrolysates disregarding the above effects of acid hydrolysis in order to obtain a simple means for their recovery.

The amino acid analysis of Gluten, Soy, Yeast, Vegamine, and Promate 200 are shown on Table 1. The per cent glutamic acid is highest in the hydrolysates. Half cystine was lowest and was detected only in Gluten, Soy, and Promate 200. The hydrolysates varied in their ratio of amino acids indicating that reaction of each with reducing sugars may produce different ratios of carbonyl compounds (54,55,56).

EFFECT OF HYDROLYSATES AND ORGANIC ACIDS ON BREAD FLAVOR AND QUALITY

Bread flavor can be affected by the grain and texture which are tactual factors, while sweetness, sourness, bitterness, and saltiness are influenced mainly by formulation. Sourness and bitterness may also develop as a result of fermentation. Many organic compounds produced during fermentation are olfactory factors which influence aroma; however, those produced during baking may modify the aroma to a greater extent (4.10.20).

TABLE 1. AMINO ACID CONTENT OF HYDROLYSATES, g/100 g HYDROLYSATE DRY BASIS

Constituent	Gluten	Soy	Yeast	Vegamine	Promate 200
Lysine	0.344	3.759	2.417	0.551	0.683
Histidine	0.364	1.426	0.743	0.451	0.646
Ammonia	0.862	0.950	0.335	0.443	1.039
Arginine	0.677	4.559	1.900	0.982	1.303
Aspartic acid	0.713	6.926	2.476	2.786	1.504
Threonine	0.570	1.675	1.975	1.195	1.090
Serine	1.119	2.513	3.514	2.231	2.048
Glutamic acid	10.543	11.974	5.377	7.817	17.687
Proline	3.205	2.992	0.972	3.524	5.166
Glycine	0.753	2.358	1.520	1.083	1.513
Alanine	0.603	2.279	3.832	3.972	1.178
Half cystine	0.045	0.527	0.000	0.000	0.923
Valine	0.905	2.513	2.996	1.239	1.306
Methionine	0.340	0.556	0.834	0.570	0.470
Isoleucine	0.857	2.533	2.303	0.832	0.990
Leucine	1.786	4.759	3.565	4.770	2.165
Tyrosine	0.071	1.398	0.537	0.557	0.374
Phenylalanine	0.355	2.407	2.296	1.552	0.837
Protein content	45.000	44.300	63.200	31.400	40.600

Various levels of the hydrolysates were used in preliminary tests to obtain those desired and find if the hydrolysates produced bread like flavor.

Gluten Protein Hydrolysate

The results when using 0.0, 0.3, 0.6, and 0.9 and 1.2 per cent (flour basis) gluten hydrolysate are shown on Table 2. As the concentration increased, crust color and flavor intensity increased to a point where it seemed objectionable at 1.2 per cent. The flavor was distinctly bread-like but lacked acid notes (sourness). Grain and texture did not compare with those of the control indicating the need of a more resilient dough for processing. That property may be obtained by use of organic acids (8).

Soy Protein Hydrolysate

The results when using 0.0, 0.3, 0.6, 0.9, and 1.2 per cent (flour basis) gluten hydrolysate are shown on Table 3. As the concentration increased, crust color and flavor intensity increased to a point where it seemed objectionable at 1.2 per cent. However, the flavor was distinctly different than that produced with Gluten protein hydrolysate. This was expected, since the ratio of amino acids in the hydrolysates differed. Grain and texture did not compare with the control indicating that a more resilient dough may have been needed in this series for processing.

Vegamine

Table 4 shows the effect of increased levels of Vegamine on bread flavor and quality. Crust color scores and bread flavor ratings increased

TABLE 2. EFFECT OF GLUTEN PROTEIN HYDROLYSATE ON BREAD FLAVOR AND QUALITY

Treatment	Gluten Hydrolysate %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb color max 10	Flavor 1/ Rating
Sponge-dough	0	3025	9	10	9	9	9	10	+++
Straight dough	0	2975	8	9	8	8	9	10	+++
No-time dough	0	3025	7	8	7	6	6	10	—
No-time dough	0.3	2850	7	7	7	7	7	10	++
No-time dough	0.6	2850	8	9	8	7	8	9	+++
No-time dough	0.9	2825	8	9	8	7	7	9	+++
No-time dough	1.2	2850	8	10	8	7	8	9	++++ 2/

1/ Flavor distinctly like bread but lacking in acid notes (sourness).

2/ Highest concentration of hydrolyzed gluten very intense bread flavor which seemed objectionable.

TABLE 3. EFFECT OF SOY PROTEIN HYDROLYSATE ON BREAD FLAVOR AND QUALITY

Treatment	Gluten Hydrolysate %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flavor 1/ Rating
Sponge-dough	0	3112	9	7	9	9	9	9	+++
Straight-dough	0	3080	9	6	9	7	7	9	+++
No-time dough	0	3000	8	5	7	7	7	9	++
No-time dough	0.3	3025	8	9	8	8	7	9	++
No-time dough	0.6	2925	7	9	8	9	9	8	+++
No-time dough	0.7	3000	8	9	9	9	8	7	+++
No-time dough	1.2	2425	8	10	9	8	8	7	++++ 2/

1/ Aroma and taste intensified by soy protein hydrolysate but flavor distinctly different than that made with gluten protein hydrolysate.

2/ Highest concentration of soy protein hydrolysate very intense flavor which seemed objectionable.

TABLE 4. EFFECT OF VEGAMINE ON BREAD FLAVOR AND QUALITY

Treatment	Vegamine %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flavor 1/ Rating
Sponge-dough	0	3125	9	8	9	9	9	10	+++
Straight-dough	0	2975	6	8	6	7	7	10	++
No-time dough	0	3175	6	7	6	6	6	10	+
No-time dough	0.3	3025	7	8	7	6	7	9	++
No-time dough	0.6	2950	9	8	9	6	6	9	++
No-time dough	0.9	3000	8	9	8	6	7	8	+++
No-time dough	1.2	3025	6	10	6	6	7	7	++++

1/ Aroma and taste were intensified but not to a typical bread flavor.

with increase in Vegamine concentration; however, the intensified flavor was unlike that of normal bread. Other quality scores did not seem to be affected. The differences between scores given the no-time dough and control breads are probably due to procedural differences.

Promate 200

Table 5 shows the results when using 0.0, 0.3, 0.6, 0.9, and 1.2 per cent (flour basis) Promate 200. As the concentration increased, crust color and flavor intensity increased to a point where it seemed objectionable at 1.2 per cent. The flavor was comparable to that produced by Gluten protein hydrolysate and was distinctly "bread like" but lacked acid notes (sourness). Grain and texture did not compare with the control indicating the need for a more resilient dough for processing.

Autolyzed Yeast

Table 6 shows the results when using 0.0, 0.3, 0.6, 0.9, and 1.2 per cent (flour basis) autolyzed yeast. Again as the concentration increased crust color and flavor intensity increased to a point where it seemed objectionable at 1.2 percent. The flavor was distinctly different than that produced with either Gluten or Soy hydrolysate. The effect of autolyzed yeast on grain, texture and crumb color was similar to that of the other hydroysates.

Organic Acids

The effects of the increase of organic acid concentration on bread flavor and quality are shown on Table 7. Increase in the acid concentration

TABLE 5. EFFECT OF PROMATE 200 ON BREAD FLAVOR AND QUALITY

Treatment	Promate 200 %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flavor 1/ Rating
Sponge-dough	0	3100	9	10	9	9	9	10	+++
Straight-dough	0	2900	7	9	7	7	8	10	+++
No-time dough	0	3025	8	8	8	7	6	10	--
No-time dough	0.3	2975	8	8	8	7	7	10	++
No-time dough	0.6	3000	7	9	7	7	7	9	+++
No-time dough	0.4	2900	9	9	9	7	8	9	+++
No-time dough	1.2	3000	7	10	7	7	7	8	++++ 2/

1/ Flavor distinctly like bread but lacking in acid notes.

2/ Highest concentration of Promate 200 very intense bread flavor which seemed objectionable.

TABLE 6. EFFECT OF AUTOLYZED YEAST ON BREAD FLAVOR AND QUALITY

Treatment	Autolyzed Yeast %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flavor 1/ Rating
Sponge-dough	0	3100	9	9	9	9	9	9	++++
Straight-dough	0	2925	8	9	8	8	8	9	++++
No-time dough	0	2975	8	7	8	7	7	9	++
No-time dough	0.3	3000	9	8	9	7	7	8	+++
No-time dough	0.6	3050	9	9	9	8	8	8	+++
No-time dough	0.9	2950	8	9	8	7	7	7	++++
No-time dough	1.2	2900	7	9	7	7	7	7	++++ 2/

1/ Aroma and taste intensified by autolyzed yeast but flavor distinctly different than that made with gluten hydrolysate.

2/ Highest concentration of autolyzed yeast very intense flavor which was objectionable.

TABLE 7. EFFECT OF ORGANIC ACIDS ON BREAD FLAVOR AND QUALITY

Treatment	Organic Acids mole/700 g. flour	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb max 10	Flavor 1/ Rating
Sponge-dough	0	3100	9	8	10	9	9	9	+++
Straight-dough	0	2950	9	8	10	5	7	9	+++
No-time dough	0	3000	8	7	9	5	7	9	++
No-time dough	8.6×10^{-5}	3000	8	8	8	9	7	9	++
No-time dough	1.7×10^{-4}	3075	9	8	9	8	8	9	++
No-time dough	2.6×10^{-4}	3175	7	9	7	9	9	9	+++
No-time dough	3.4×10^{-4}	3075	9	8	9	9	9	9	+++ 2/

1/ Aroma of the no-time series did not compare with the control.

2/ Acid note was apparent in the taste of bread by no-time dough with organic acids added.

had a subtle effect on bread flavor as indicated by the flavor ratings. Grain and texture scores increased with increase of acid concentration. This was expected since a beneficial effect on grain and texture by organic acids produced during fermentation has been suggested. Organic acids did not seem to affect other bread quality characteristics.

All the published work on different amino acids relating to bread flavor indicates that the amino acids react with reducing sugars and create carbonyl compounds with one less carbon atom than the amino acid from which it originates (8,18,27,28). The published literature also suggests that bread aroma and taste are a result of a complex mixture of organic acids and carbonyl compounds. Also, it would appear that organic acids reach an equilibrium with alcohols present in a fermented dough to create low concentrations of esters; acids and alcohols are necessary reactants that create the volatile esters (27,31).

Since free amino acids are created as a result of proteolysis with extended fermentation (33,35), the fermentation process produces bread flavor compounds. Bread aroma and taste appear to be due to presence of a particular ratio of free amino acids which react with free reducing sugars to supply a mixture of carbonyl compounds (4,10,20). Since wheat protein is the natural subtrate for formation of free amino acids in a fermentating dough, it should provide a given ratio of amino acids when hydrolyzed. The data in the present work indicated that to be the case.

The data indicated that hydrolyzed wheat Gluten and Promate 200 seemingly provided an intensified bread flavor. This flavor closely approached that of normal bread produced by fermentation procedures. The data also indicated that the organic acids approximated the ratio of those produced in normal fermentation. They appeared to give a good bread from the view point of volume, grain and texture.

A syntetic mixture has not been prepared that replicates "bread flavor," when added to dough. In perspective, it would appear that a combination of Promate 200 and organic acids could provide a mixture which could closely replicate "bread flavor" and provide optimum bread quality characteristics, respectively.

EFFECT OF PROMATE 200 AND ORGANIC ACIDS OR SALTS ON BREAD FLAVOR AND QUALITY.

The effect of combination of Promate 200 and organic acids are shown on Table 8. As indicated by the flavor rating and quality scores, the combination produced bread with good flavor and quality.

Since ingredients in powder form are more desirable in the baking industry, organic acids in their salt form may be handled more conveniently. Table 9 shows the results obtained using organic acid salts. It is evident from these data that the organic acids could be replaced by their salts without an unlike effect on flavor and quality.

Soy protein hydrolysate, Vegamine and Autolyzed Yeast were not suitable for "Bread-like" flavor enhancement. This is probably due to their unlike amino acid ratios relative to Gluten protein hydrolysate. Gluten protein hydrolysate and Promate 200 produced adequate flavor

TABLE 8. EFFECT OF INCREASING AMOUNTS OF PROMATE 200 WITH FREE ORGANIC ACIDS ON BREAD FLAVOR AND QUALITY.

Treatment	Organic acid moles/700 g flour	Promate 200 %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flavor 1/ Rating
Sponge-dough	0	0	3162	9	9	9	9	9	10	+++
Straight-dough	0	0	2950	9	8	9	5	7	9	+++
No-time dough	0	0	3080	8	7	9	7	7	10	+
No-time dough	3.4×10^{-4}	0.3	3150	9	8	9	7	9	10	++
No-time dough	3.4×10^{-4}	0.6	2950	7	8	9	7	9	8	+++
No-time dough	3.4×10^{-4}	0.9	2925	8	9	9	8	9	7	+++
No-time dough	3.4×10^{-4}	1.2	2950	9	10	9	8	9	7	++++ 2/

1/ Good bread flavor and quality were produced.

2/ The bread with 1.2% hydrolyzed gluten had an undesirable intense bread aroma and flavor.

TABLE 9. EFFECT OF PROMATE 200 WITH ORGANIC ACID SALTS ON BREAD FLAVOR AND QUALITY

Treatment	Organic Acid Salts moles/700 g flour	Promate 200 %	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flavor Rating
Sponge-dough	0	0	3162	9	10	9	9	9	10	+++
Straight-dough	0	0	2875	8	9	8	8	8	10	+++
No-time dough	0	0	2825	7	7	7	7	7	10	+
No-time dough	3.4×10^{-4}	0.3	3150	9	9	9	7	9	10	++
No-time dough	3.4×10^{-4}	0.6	3150	9	9	9	9	9	8	++
No-time dough	3.4×10^{-4}	0.9	3150	10	9	10	8	9	10	+++
No-time dough	3.4×10^{-4}	1.2	2975	10	9	10	9	9	7	++++

and could be interchanged. Both were obtained from wheat flour and therefore had similar amino acid ratios. Organic acids and organic acid salts improved bread quality and could be interchanged. This improvement may be due to change in pH of the dough. Acid pH affects the colloidal structure of dough, a process which the baker calls "mellowing." The combination of organic acid salts and Promate 200 improved bread flavor and quality.

The foregoing showed that a synthetic mixture that should replicate "bread flavor" when added to dough with elimination of prefermentation is possible. That mixture could consist of organic acids or organic acid salts with Promate 200. To substantiate this, a wide range of concentrations of Promate 200, organic acids and organic acid salts was studied. The combination of Promate 200 with either organic acids or organic acid salts was also tried. Consumer preference type test was used instead of flavor rating.

EFFECT OF ORGANIC ACIDS, ORGANIC ACID SALTS, AND PROMATE 200 ON BREAD FLAVOR AND QUALITY

Promate 200

The effect of Promate 200 on bread flavor and quality is shown on Table 10. As indicated previously, Promate 200 affected flavor; however, at high levels it also affected crust and crumb color. Symmetry, texture, grain, and volume were not affected relative to 0.0 per cent Promate 200. Sweetness, flavor, and aroma decreased while sourness increased with increased levels of Promate 200; however, an optimum response was apparent at 0.2 and 0.4 per cent Promate 200.

TABLE 10. EFFECT OF PROMATE 200 ON BREAD FLAVOR AND QUALITY

Promate 200	% Max.	Sponge dough	0.0	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Break & Shred	(10)	9	6	6	8	8	7	7	7	7
Symmetry	(10)	9	7	7	8	8	7	7	8	8
Crust color	(10)	9	6	8	10	10	8	8	7*	6*
Texture	(10)	9	7	7	7	7	7	7	7	6
Grain	(10)	8	7	7	7	6	7	7	7	6
Crumb color	(10)	10	10	10	7	6	8	8	8	8
Volume	(cc)	3163	3150	3163	3200	3185	3137	3125	3052	3000
Total	(60)	54	43	45	47	45	44	44	44	43
Sweetness	(3)	2.29	2.00	2.00	1.71	1.77	1.71	1.35	1.88	1.35
Sourness	(3)	2.06	1.75	1.71	1.94	1.65	2.06	2.41	2.12	2.53
Flavor	(3)	2.18	1.88	1.97	1.97	1.49**	1.82**	1.52**	1.94**	1.47**
Aroma	(3)	2.18	1.94	1.95	1.68	1.59**	1.88**	1.82**	1.76**	1.59**

* Too dark

** Bitter-Cheesy aroma and flavor.

Promate 200 and Organic Acids

Table 11 shows the effect of the combination of 0.2 per cent Promate 200 and various levels of organic acids. As indicated by total bread score, bread quality characteristics improved with the addition of organic acids. Flavor and aroma increased substantially with the increase of organic acid concentration. The variability in data of sweetness and sourness made it difficult to find a trend; however, it appeared that both were adequate relative to the control. Considering flavor and quality data, optimum was apparent at 0.2 percent Promate 200 and from 5.1×10^{-4} to 8.5×10^{-4} moles organic acids per 700 gram flour.

Promate 200 and Organic Acid Salts.

The effect of Promate 200 and various organic acid salt concentrations is shown on Table 12. Optimum range for flavor and quality could easily be seen between 2.4×10^{-4} and 8.5×10^{-4} moles organic acid salts. Table 13 shows the effect of 6.8×10^{-4} moles organic acid salts with various levels of Promate 200. The data indicated that 0.2 and 0.3 per cent Promate 200 combined with 6.8×10^{-4} moles organic acid salts per 700 g flour were optimum.

Using the no-time dough process the following observations were made: Good bread flavor was detected in bread made with 0.2 and 0.4 per cent Promate 200. When promate 200 was used at 0.2 per cent, a range from 5.1×10^{-4} to 8.5×10^{-4} moles organic acids increased bread quality. Organic acid salts at a range from 7.4×10^{-4} to 8.5×10^{-4} moles with 0.2 per cent Promate 200 gave bread with excellent flavor and quality.

TABLE 11. EFFECT OF PROMATE 200 AND ORGANIC ACID CONCENTRATION ON BREAD FLAVOR AND QUALITY.

Acid Conc.	Moles/700 g flour	Sponge dough	Promate 200 0.2%					
	Max.		$1.7x10^{-4}$	$3.4x10^{-4}$	$5.1x10^{-4}$	$6.8x10^{-4}$	$8.5x10^{-4}$	$1.0x10^{-3}$
Break & Shred	(10)	10	9	9	9	8	10	9
Symmetry	(10)	10	9	9	9	9	10	9
Crust color	(10)	8	9	9	9	9	10	9
Texture	(10)	8	7	8	8	7	9	7
Grain	(10)	8	7	8	8	8	9	7
Crumb color	(10)	10	10	10	10	10	10	8
Volume	(cc)	3100	3025	2900	3000	2950	3025	3125
Total	(60)	54	51	53	53	51	58	49
Sweetness	(3)	1.94	1.94	2.18	2.12	1.65	2.25	1.65
Sourness	(3)	1.94	2.12	1.65	1.88	1.82	1.50	2.12
Flavor	(3)	1.82	1.88	1.82	2.06	2.00	2.19	2.06
Aroma	(3)	1.82	1.94	1.65	2.12	1.95	1.94	2.06

TABLE 12. EFFECT OF PROMATE 200 AND ORGANIC ACID SALT CONCENTRATION ON BREAD FLAVOR AND QUALITY.

Organic acid Salts Conc.	Moles		Promate 200 0.2%								
		Sponge dough	$8.5x10^{-5}$	$1.7x10^{-4}$	$2.4x10^{-4}$	$5.1x10^{-4}$	$6.8x10^{-4}$	$8.5x10^{-4}$	$1.0x10^{-3}$	$1.2x10^{-3}$	$1.4x10^{-3}$
	Max.										
Break & Shred	(10)	10	9	8	10	10	10	9	9	8	8
Symmetry	(10)	10	8	8	10	10	10	10	10	8	8
Crust color	(10)	8	9	9	9	9	10	10	10	7	7
Texture	(10)	9	7	6	8	8	10	9	9	7	7
Grain	(10)	8	8	7	8	8	10	9	9	7	7
Crumb color	(10)	10	10	9	10	10	10	10	10	10	10
Volume	(cc)	2925	3075	2925	3200	3225	3250	3200	3000	3100	3000
Total	(60)	55	51	47	55	55	60	57	57	56	47
Sweetness	(3)	2.06	1.94	2.00	2.12	2.00	2.24	2.29	1.82	1.88	1.71
Sourness	(3)	2.18	1.88	2.18	2.18	1.88	1.59	1.82	1.94	2.19	1.68
Flavor	(3)	2.06	2.18	2.18	2.20	2.24	2.47	2.06	1.88	2.00	2.00
Aroma	(3)	2.24	2.08	1.88	2.29	2.06	2.18	2.00	2.12	1.75	1.94

TABLE 13. EFFECT OF PROMATE 200 AND 6.8 x 10^{-4} ORGANIC ACID SALTS ON BREAD PROPERTIES

Promate 200	% Max.	0.05	0.1	0.2	0.3	0.4	0.6
Break and Shred	(10)	9	9	9	8	10	10
Symmetry	(10)	10	10	10	8	10	10
Crust color	(10)	8	9	10	10	9	9
Texture	(10)	8	8	9	9	8	8
Grain	(10)	7	8	9	9	7	7
Crumb color	(10)	10	10	10	10	10	10
Volume	(cc)	3100	3125	3000	3150	3100	3150
Total	(60)	52	54	57	54	54	54
Sweetness	(3)	1.77	1.94	1.82	1.59	1.53	1.82
Sourness	(3)	1.82	1.82	1.94	2.47	2.12	1.24
Flavor	(3)	2.06	1.71	1.88	1.77	1.77	1.77
Aroma	(3)	2.06	1.88	2.12	2.00	1.77	1.77

Promate 200 at 0.2 and 0.3 per cent showed excellent bread flavor and quality with 6.8×10^{-4} moles organic acid salts. Therefore, a synthetic mixture which provided 0.2 per cent Promate 200 and 6.8×10^{-4} moles organic acid salts produced excellent bread flavor and quality when added to dough without prefermentation.

A blend (Flavol) of 147 parts wheat starch, 1400 parts Promate 200, and 98 parts organic acid salts was made and used in the insuing experiments. The composition of Flavol at different percentages relative to 700 g flour is shown on Table 14.

EFFECT OF FLAVOL ON FLAVOR AND QUALITY OF BREAD BY CONTINUOUS MIX AND CONVENTIONAL PROCESSES

Continuous Mix Process

About 35 per cent of the bread production in the United States is by the Continuous Mix Process (11,16). Presently in this process a liquid preferment is used. About 3 hours fermentation is used usually in the presence of about 30 per cent flour. The purpose of the preferment has been to condition the dough and create flavor precursors such as organic and amino acids (contained in Flavol) that contribute to the flavor of bread.

After prefermentation the liquid ferment is metered into a stream carrying other formula ingredients. Flour is metered at a given rate and an incorporator mixes all ingredients. A dough pump transfers the mixture to a dough mixing head from which it is deposited in bread pans. Thereafter the process is the same as for conventional bread production (57). The

TABLE 14. FLAVOL COMPOSITION

Flavol % 700 g flour	Promate 200 g	Organic acid g	Salts moles	Starch g	Amino Acids g
0.41	2.4714	0.1730	1.2×10^{-3}	0.2595	1.0034
0.35	2.0600	0.1442	1.0×10^{-3}	0.2163	0.8364
0.30	1.7571	0.1230	8.5×10^{-4}	0.1845	0.7134
0.24	1.4000	0.0980	6.8×10^{-4}	0.1470	0.5684
0.18	1.0500	0.0735	5.1×10^{-4}	0.1103	0.4253
0.08	0.4943	0.0346	2.4×10^{-4}	0.0519	0.2011
0.06	0.3500	0.0245	1.7×10^{-4}	0.0368	0.1421

objective of this experiment was to eliminate the customary preferment and replace it with a yeast suspension and Flavol. Thus, in the process a dough was mixed continuously with various levels of Flavol but with the elimination of prefermentation. A control using three hours prefermentation was also run.

Table 15 shows that bread production with Flavol by Continuous Mix Process produced an almost perfect bread without prefermentation. Flavor of crumb and crust of the bread appeared proportional to the amount of Flavol used. Grain, texture, crumb color and crust color were equal in all treatments.

Conventional Breadmaking

Since the conventional breadmaking process is dominant in the baking industry, the use of Flavol to eliminate the lengthy prefermentation period in this process with retention of bread quality and flavor is advantageous. No longer would it be necessary to set sponges and allow 3-4 hours for the flavorful compounds to be produced. No longer would it be necessary to be concerned with losses of dough weight and biological variation associated with sponges. The baker could easily control the intensity of bread flavor. To substantiate this role of Flavol, a statistical analysis with emphasis on flavor characteristics was undertaken. A randomized complete block design was used (58).

Three experiments were run to determine the effect of Flavol on flavor characteristics as follows:

Experiment 1. Sponge, No-Time with 0.2 and 0.3% Flavol

Experiment 2. Sponge, No-Time with 0.3 and 0.4% Flavol

TABLE 15. EFFECT OF FLAVOL ON BREAD FLAVOR AND QUALITY BY CONTINUOUS MIX PROCESS

Treatment	Flavol % flour basis	Loaf Volume cc	Break & Shred max 10	Crust Color max 10	Symmetry max 10	Grain max 10	Texture max 10	Crumb Color max 10	Flour
Control	0	2765	10	7	6	10	10	10	++
No-time dough	0	2850	8	7	8	10	10	10	-
No-time dough	0.1	2800	10	6	10	10	10	10	+
No-time dough	0.3	2750	10	7	10	10	10	10	++
No-time dough	0.5	2915	10	8	10	10	10	10	++++

Experiment 3. Sponge, No-Time with 0.4 and 0.5% Flavol

The analyses of variance of the data obtained from the 3 experiments are shown on Tables 16, 17, and 18, respectively. The interest was on the main effect, procedure. On experiment 1, the F-ratios under procedure were not significant except in sourness. The F-ratios on experiment 2 were significant under sweetness and flavor but not significant under sourness. On experiment 3, the F-ratios under procedure for all flavor characteristics were not significant.

Table 19 shows the means obtained from the statistical analyses. On experiment 1 under sweetness, flavor and aroma, the procedures were nonsignificant; however, under sourness 0.3 and 0.2 were significant. On experiment 2 under sweetness, flavor and aroma 0.2 and 0.4 were nonsignificant from sponge. Under sourness: sponge and 0.4 were nonsignificant and each was significantly different from 0.3. On experiment 3 the procedures were nonsignificant under all flavor characteristics.

EFFECT OF FLAVOL ON HEADSPACE VALATILES AND CARBONYL COMPOUND CONTENT

<u>Headspace Analysis</u>

Bread was made from sponge-dough and no-time dough with 0.0, 0.3, and 0.6 per cent Flavol. One milliliter samples were taken from the internal portion of the loaves and the headspace of loaves placed in containers. Figure 1 shows the chromatograms of gas obtained from headspace of the bread. Each corresponding peak on the chromotograms has the same retention times. It can easily be seen that sponge and 0.0 per cent Flavol have identical peaks except for peak heights. This indicates that

Table 16 Analysis of Variance (Experiment 1)

	Panelist	Procedure	Panelist x Procedure	Error	Total
			Sweetness		
DF	10	2	20	33	65
SS	1.4849	1.5758	20.4242	17.4910	40.9898
MS	0.1485	0.7899	1.0212	0.5303	-
F-ratio	0.2710ns	1.4851ns	1.9257*	-	-
			Sourness		
DF	10	2	20	33	65
SS	1.7879	5.1212	17.2121	18.4997	42.6209
MS	0.1788	2.5606	0.8606	0.5606	-
F-ratio	0.3184ns	4.5676*	1.5352ns	-	-
			Flavor		
DF	10	2	20	33	65
SS	0.8182	0.8485	22.8181	18.4910	42.9848
MS	0.0882	0.4242	1.1409	0.5606	-
F-ratio	0.1410ns	0.7568ns	2.0341*	-	-
			Aroma		
DF	10	2	20	33	65
SS	0.3333	3.9091	16.7576	21.0000	42.0000
MS	0.3333	1.9545	0.8379	0.6364	-
F-ratio	0.0524ns	3.0714ns	1.3167ns	-	-

* significant at 5%

ns = nonsignificant at 5%

Table 17 Analysis of Variance (Experiment 2)

Sweetness

	Panelist	Procedure	Panelist x Procedure	Error	Total
DF	13	2	26	42	83
SS	3.9048	5.4286	24.2380	21.9994	55.5707
MS	0.3004	2.7143	0.9322	0.5238	--
F-ratio	0.5734ns	5.1820*	1.7798*	--	--

Sourness

	Panelist	Procedure	Panelist x Procedure	Error	Total
DS	13	2	26	42	83
SS	0.0	3.5000	27.4999	23.0001	54.0000
MS	0.0	1.7500	1.0577	0.5476	--
F-ratio	0.0ns	3.1957ns	1.9314*	-	-

Flavor

	Panelist	Procedure	Panelist x Procedure	Error	Total
DF	13	2	26	42	83
SS	1.9524	11.0238	20.9762	19.9999	53.9522
MS	0.1502	5.5119	0.8068	0.4762	-
F-ratio	0.3154ns	11.5751*	1.6942ns	-	-

Aroma

	Panelist	Procedure	Panelist x Procedure	Error	Total
DF	13	2	26	42	83
SS	0.7262	3.5000	29.1666	21.4995	54.8923
MS	0.0559	1.7500	1.1218	0.5119	-
F-ratio	0.1091ns	3.4187*	2.1915*	-	-

---

* Significant at 5%

ns = Nonsignificant at 5%

Table 18 Analysis of Variance (Experiment 3)

	Panelist	Procedure	Panelist x Procedure	Error	Total
Sweetness					
DF	12	2	24	39	77
SS	2.8462	0.9487	21.3846	23.4998	48.6792
MS	0.2372	0.4744	0.8910	0.6026	-
F-ratio	0.3936ns	0.7872ns	1.4787ns	-	-
Sourness					
DF	12	2	24	39	77
SS	3.1538	2.0256	22.3077	27.4996	54.9896
MS	0.2628	1.0128	0.9295	0.7051	-
F-ratio	0.3727ns	1.4364ns	1.3182ns	-	-
Flavor					
DF	12	2	24	39	77
SS	1.6154	0.4872	31.8461	19.9997	53.9484
MS	0.1346	0.2436	1.3269	0.5128	-
F-ratio	0.2625ns	0.4750ns	2.5875ns	-	-
Aroma					
DF	12	2	24	39	77
SS	0.9487	1.8718	23.1281	29.9997	55.9484
MS	0.0791	0.9359	0.9637	0.7692	-
F-ratio	0.1028ns	1.2167ns	1.2528ns	-	-

ns = Nonsignificant at 5%

Table 19. Effect of Flavol on Flavor Characteristics

	Sweetness	Sourness	Flavor	Aroma
	(3) 2.1363a	(2) 2.2727a	(3) 2.1364a	(3) 2.3181a
	(1) 2.0455a	(1) 1.9091ab	(1) 1.9546a	(2) 1.9546a
	(2) 1.7927a	(3) 1.5909b	(2) 1.1364a	(1) 1.7273a
$LSD_{0.05}$	-	0.4610	-	-

(1) Sponge, (2) 0.2% Flavol, and (3) 0.3% Flavol

	Sweetness	Sourness	Flavor	Aroma
	(2) 2.1429a	(1) 2.2857a	(2) 2.2500a	(2) 2.2143a
	(3) 2.0714a	(3) 1.8929a	(3) 2.2143a	(3) 1.9643ab
	(1) 1.5714	(2) 1.8214	(1) 1.4643	(1) 1.7143b
$LSD_{0.05}$	0.3909	-	0.3727	0.3864

(1) Sponge, (2) 0.3% Flavol, (3) 0.4% Flavol

	Sweetness	Sourness	Flavor	Aroma
	(1) 2.0769a	(1) 2.1539a	(3) 2.0769a	(3) 2.1923a
	(3) 1.9231a	(3) 2.0385a	(2) 1.9615a	(2) 1.8846a
	(2) 1.8077a	(2) 1.7692a	(1) 1.8846a	(1) 1.8462a
$LDS_{0.05}$	-	-	-	-

(1) sponge, (2) 0.4% Flavol, (3) 0.5% Flavol

The means containing the same lower case letter are non-significant.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

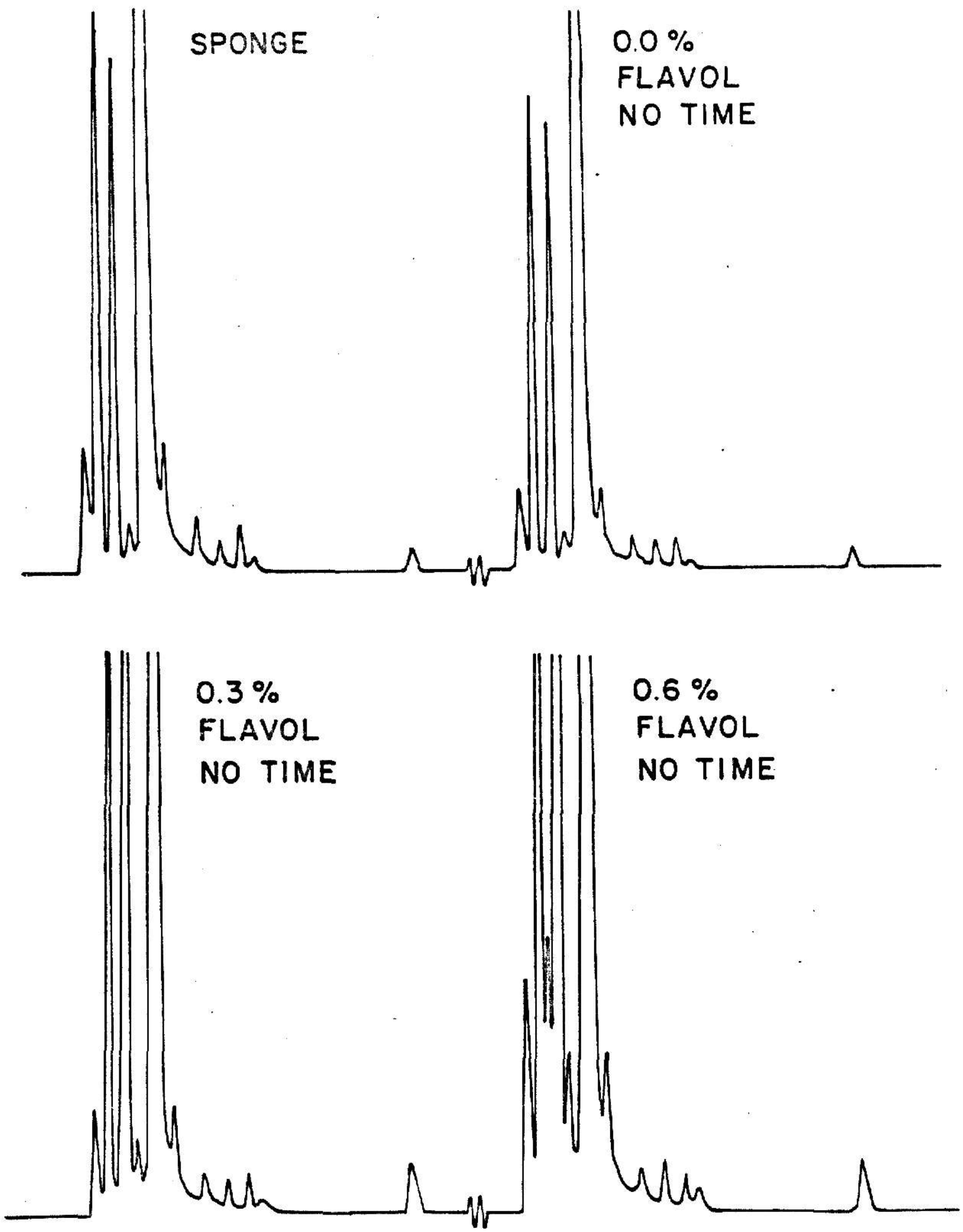

FIGURE 1

the same recorder response was obtained from bread by both procedures; however, that of sponge was more intense. The chromotograms with 0.3 and 0.6 per cent showed an increase in response indicating more flavor compound production. Moreover, 0.6 per cent Flavol developed an additional peak (number 3) than the others. This confirms the organoleptic test; that Flavol definitely enhanced flavor in no-time dough bread.

Figure 2 shows chromatograms obtained from the internal portion of the loaves. Each corresponding peak on the chromatograms was obtained with the same retention time. It can easily be seen that sponge and 0.0 per cent Flavol no-time bread produced identical peaks except for peak heights. This indicates that the same compounds were produced by both procedures; however, sponge bread showed more intense response. The chromatograms with 0.3 and 0.6 per cent showed an accentuated recorder response indicating a more intense flavor. This confirms the organoleptic test; that Flavol definitely enhanced flavor in no-time dough bread.

Carbonyl Compound Content

Since carbonyl compounds have been shown to be important to bread flavor, the bread baked was analyzed for total carbonyl compound content. The analytical procedure uses 3,4-dinitrophenylhydrazine derivatives in a basic solution at a concentration low enough to prevent their precipitation. The standard curve obtained by using n-butylaladehyde as a standard is shown on Figure 3. The concentration range is from 10^{-4} to 10^{-5} molar. Bread by sponge and no-time dough with 1 and 3 per cent Flavol was extracted with methyl alcohol and the extract at 0.1, 0.2,

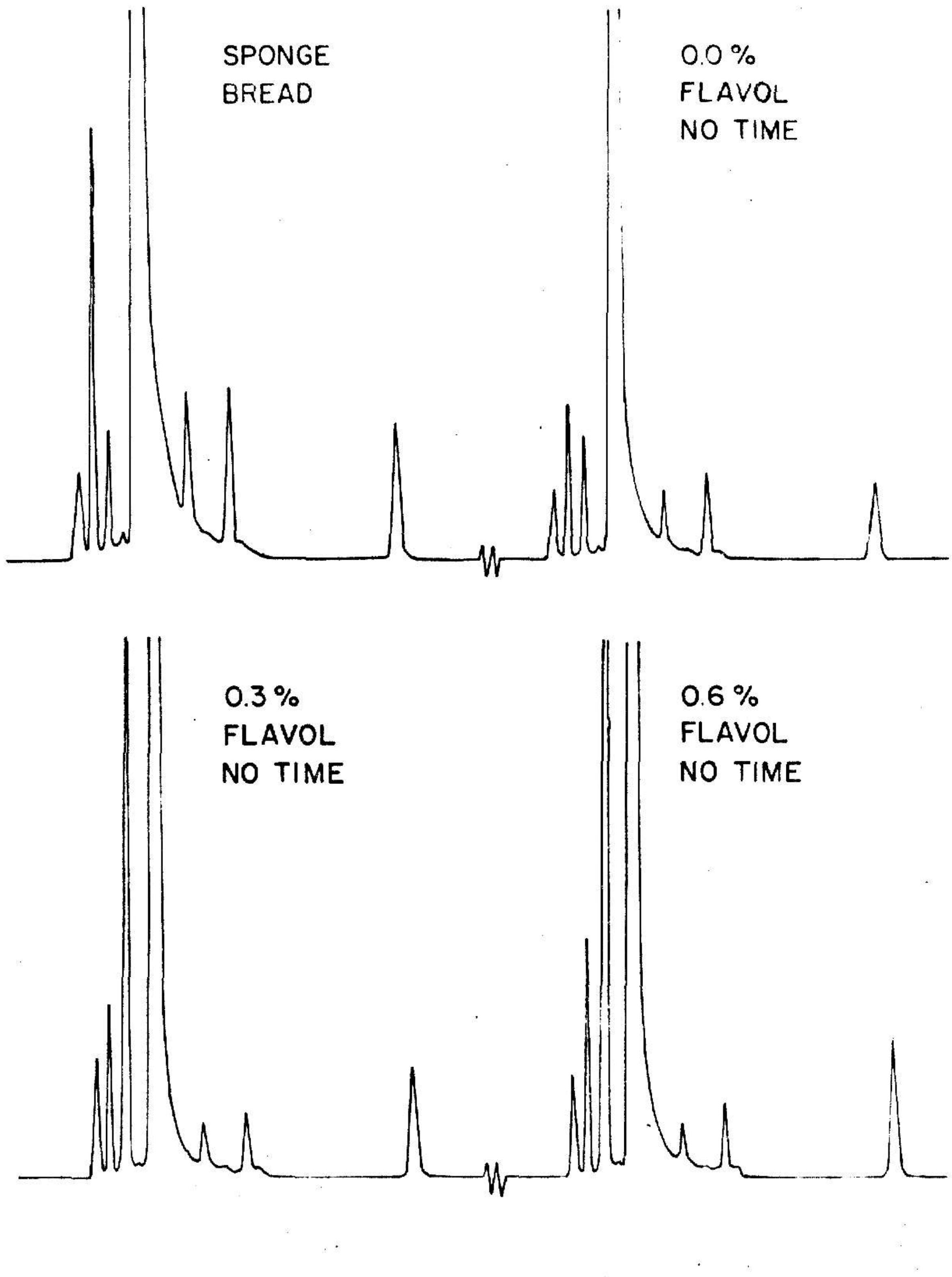
SPONGE
BREAD
0.0 %
FLAVOL
NO TIME
0.3 %
FLAVOL
NO TIME
0.6 %
FLAVOL
NO TIME

FIGURE 2

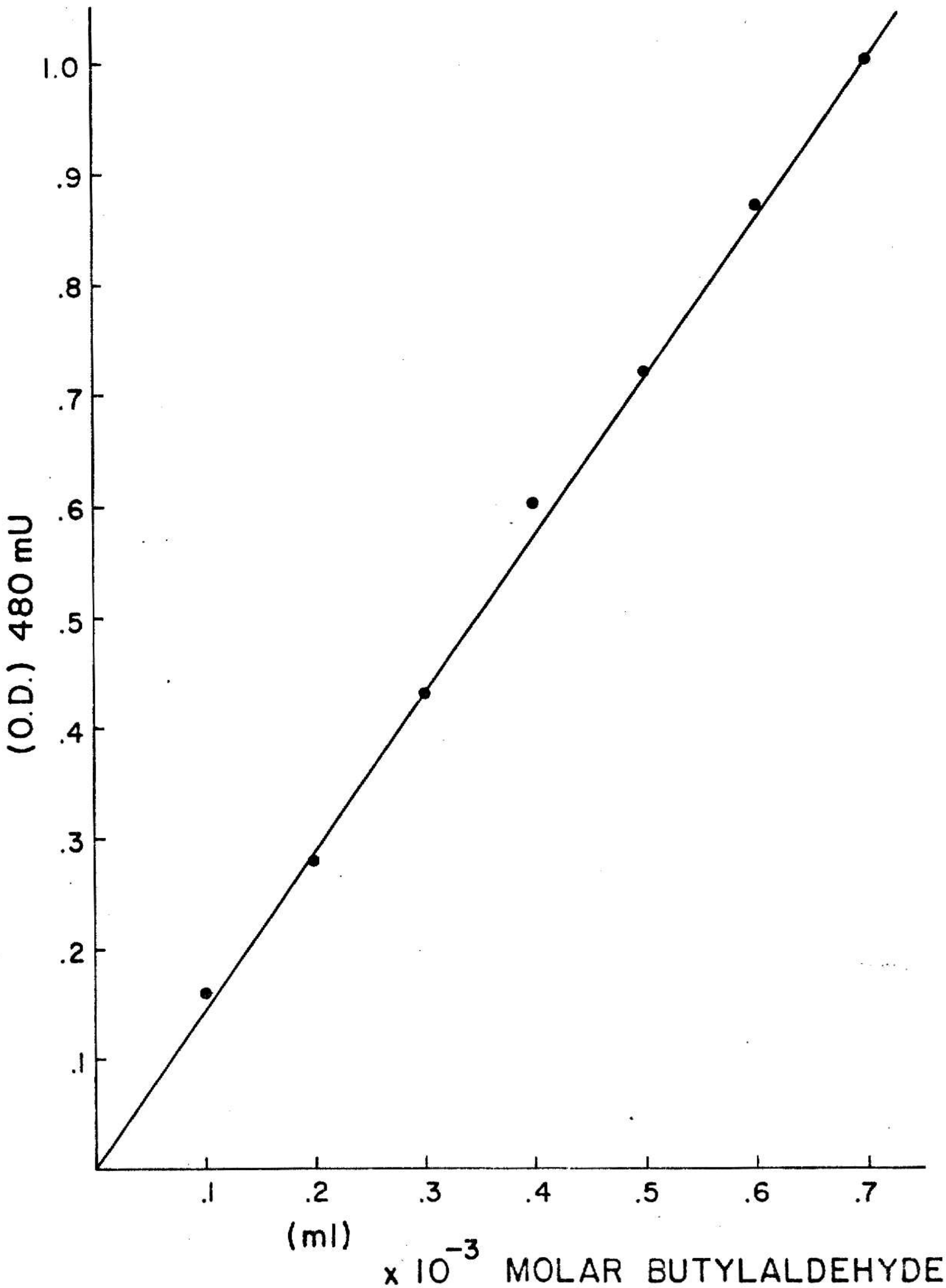

FIGURE 3

0.3, 0.4 and 0.5 ml was subjected to the test. Bread made with Flavol contained higher total carbonyl compound concentrations than did bread made by sponge dough (Figure 4). This indicated that Flavol aids in the production of carbonyl compounds in the breadmaking process.

The statistical analyses showed that no-time dough bread made with 0.2, 0.3, 0.4 or 0.5 per cent Flavol was equivalent to sponge-dough bread in flavor characteristics. Continuous-mix bread with Flavol and elimination of prefermentation (brew), was equivalent in flavor and quality characteristics to that made using a brew.

Chemical analysis of no-time dough bread revealed that total carbonyl compound concentration increased with increase in per cent Flavol. Headspace analysis showed that Flavol increased the volatile compounds internally and externally in no-time dough bread similarly to those in bread made using the conventional sponge procedure.

It was evident from the preceding that Flavol could be used in breadmaking processes with the elimination of customary prefermentation and still retain desirable flavor and quality characteristics. This initiated studies on commercial trials. The following are two examples where Flavol was used in the Baking Industry.

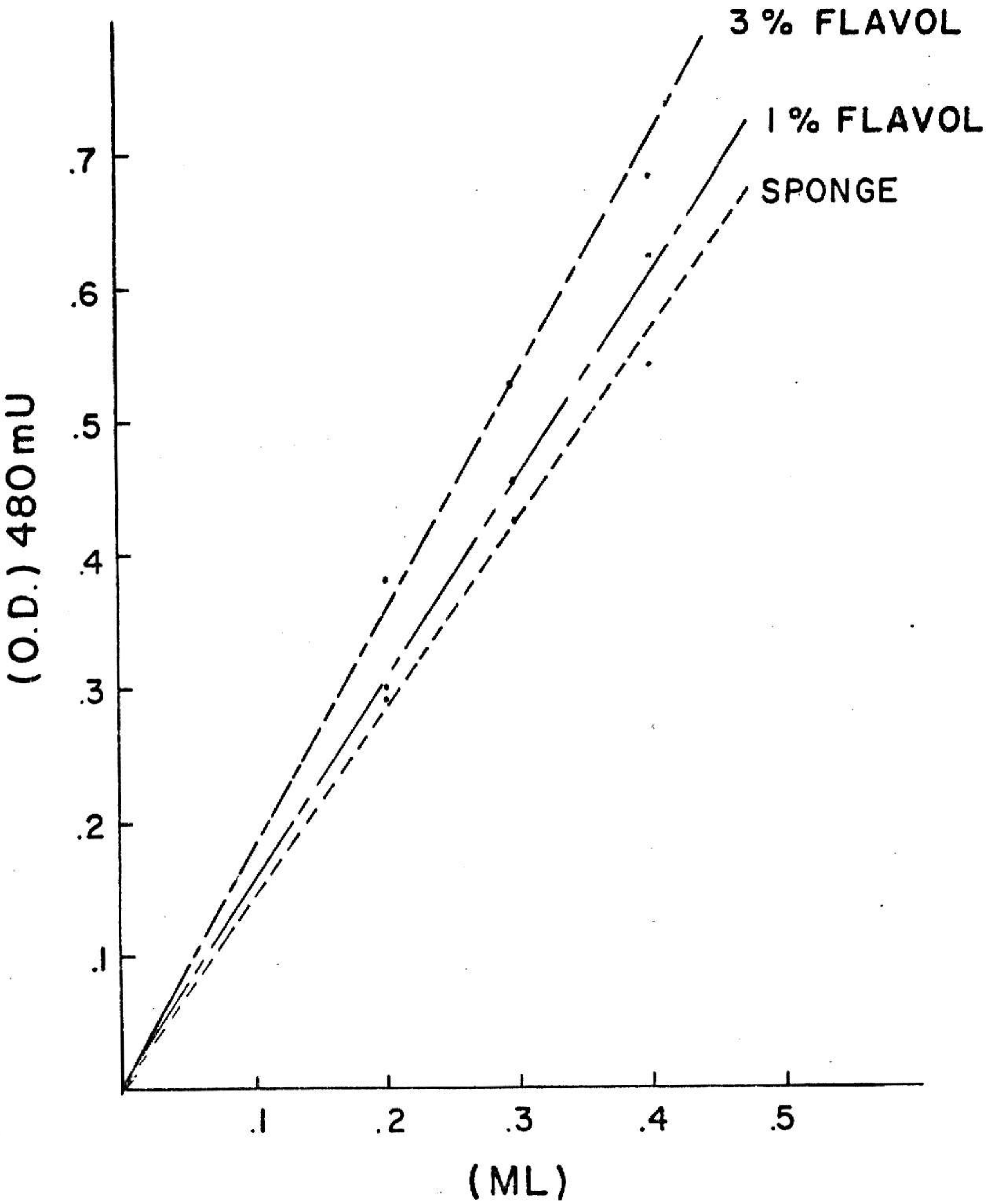

FIGURE 4

TEST BAKE AT MARHOEFFER BAKERY

ALTOONA, PENNSYLVANIA

The formulation and procedure used at Marhoeffer Bakery for making 1 1/2-pound white pan bread follows:

Ingredients	Sponge %	Dough %
Flour[a]	70.0	30.0
Water[b]	42.0	
Yeast	2.5	-
Yeast Food	0.5	
Salt		2.0
Sweetose[c]		30.0
Lard		2.5
NFDM		1.25
Emulsifier		0.5
Expando	0.31	0.31
Inhibitor		0.19
Amylase tablets	(8)	

[a] Total of 800-lbs flour was used.

[b] % Total flour.

[c] 70% water and 30% corn sugar.

Using a Baker-Perkins mixer without refrigeration, the sponges were mixed 1 minute on low and 5 minutes on high speed; doughs were mixed 1 minute on low and 9 minutes on high speed to optimum development with refrigeration.

Sponge temperature after mixing was 76°F. Sponges were fermented for 3 hours at 86°F and about 95% r.h. in fermentation troughs equipped with covers for control. Dough with temperature of 80°F was given a floor time of 20 minutes. After floor time the dough was divided, rounded, etc. and proofed for 55 minutes at 105°F and 100% r.h.; the bake time was 18 1/2 minutes at 430°F.

The formulation and procedure for Flavol No-Time dough used at Marhoeffer Bakery for making 1 1/2-pound white pan bread follows:

Ingredients	Dough %	
Flour[a]	100.0	
Water[b]	42.0	
Yeast	3.25	
Yeast Food	-	
Salt	2.0	
Sweetose[c]	30.0	
Lard	2.5	
NFDM	-	
Emulsifier	0.5	
Expando	0.31	
Inhibitor	-	
Flavol	0.2	
Oxidant	60 ppm	Potassium bromate

[a] Total of 800-lbs flour was used.

[b] % Total Flour.

[c] 70% water and 30% corn sugar.

The same procedure was used with the elimination of the sponge.

TEST BAKE AT BUNNY BAKERY

NEW ORLEANS, LOUISIANA

The formulation and procedure used at Bunny Bakery for making Variety Buns follows:

Ingredients	Sponge %	Dough %
Flour[a]	70.0	30.0
Gluten	1.0	-
Syrup[b]	-	17.5
Salt		2.0
Lard		5.0
Enrichment tablets		(4)
Calcium phosphate	0.1875	
Yeast	3.5	
N-hance (Phosphated Mono and Di-glycides)		0.625
Wytall		0.5
Yeast food	0.75	
Water[c]	31.0	28.0
Inhibitor		0.1875

[a] Total of 400-lbs flour was used.

[b] 70% water and 30% corn sugar

[c] % total flour

Using a Baker-Perkins mixer without refrigeration the sponges were mixed 1 minute on low and 6 minutes on high speed; doughs were mixed

1 minute on low and 10 minutes on high speed to optimum development with refrigeration.

Sponge temperature after mixing was 76°F. Sponges were fermented for 4 hours, at 86°F. and about 85% r.h. in fermentation troughs. Dough with temperature of 80°F was immediately dumped into a degasser. The degasser pumped the dough into a hopper of a Model-K bun machine, divided, rounded, and run through a Pan-O-Mat. After the dough pieces were sheeted and panned, the dough was proofed at 110°F and 95% r.h. for 50 minutes. Baking time was 8 1/2 minutes at 360°F lower and 420°F upper oven temperature. The baked buns were dumped, cooled and packaged.

The formulation and procedure for Flavol No-Time dough used at Bunny Bakery for making variety buns follows:

Ingredients	Dough %
Flour[a]	100.0
Gluten	1.0
Syrup[b]	17.5
Salt	2.0
Lard	5.0
Enrichment tablets	(4)
Calcium phosphate	0.1875
Yeast	4.0
N-hance	0.625
Wytan	0.5
Yeast Food	0.75
Water[c]	59.0
Inhibitor	-
Oxitabs	(5)
Flavol	0.2

[a] Total of 400-lbs flour was used.

[b] 70% water and 30% corn sugar.

[c] % total flour.

The procedure for making Flavol No-Time dough was the same with the exception of the sponge.

The major changes that were made to convert the Sponge-Dough to Flavol No-Time dough procedure were: (1) Sponge stage omitted (2) Yeast content increased (3) Oxidant added in place of yeast food (4) Sugar content decreased and (4) Inhibitor omitted.

More yeast was added mainly for increase of gas production. The sponge stage was eliminated since Flavol was shown to increase flavor and quality characteristics in No-Time dough bread. Oxidant was added for the increase of gas retention by chemical dough development. Finally, the inhibitor was omitted since Flavol contained organic acids which serve the same purpose.

Flavol No-Time doughs had excellent machineability. They produced bread and buns equivalent to conventional procedures in flavor and quality characteristics as those produced in the two bakeries.

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the effect of certain protein hydrolysates and a particular ratio of organic acids on quality characteristics, flavor and consumer acceptance of bread by a no-time dough procedure. A sponge-dough procedure was used as a control.

Several protein hydrolysates, gluten, soy, yeast, and vegamine were added to no-time dough at various levels. The bread produced was equivalent in flavor characteristics to that made by sponge-dough process only with gluten protein hydrolysate.

A particular ratio of organic acids representing those found in a sponge after 4 hours fermentation was added to no-time dough. The organic acids imparted a resilient character to the dough resulting mainly in an improved grain and texture of the bread. It was found that the organic acids could be replaced by their sodium salts without a change in effect.

A synthetic blend (Flavol) containing 147 parts starch, 1400 parts hydrolysate and 98 parts organic acid salts was made. The blend was added to no-time dough and no-brew dough in continuous mix at various levels. The bread produced was statistically analyzed for sweetness, sourness, flavor and aroma. These characteristics were found to be nonsignificantly different between Flavol no-time dough and sponge-dough bread.

Flavol No-Time dough process was used for producing buns and 1 1/2 pound white pan bread by two commercial bakeries. Six basic changes were made as follows: (1) Sponge stage was omitted (2) Yeast was increased (3) Sugar was reduced (4) Oxidant was increased (5) Yeast food omitted and (6) Inhibitor omitted. The product produced in each bakery was equivalent in flavor and quality characteristics to that made with their conventional breadmaking process.

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BREAD FLAVOR WITHOUT PREFERMENTATION

by

Carlos R. S. Sanchez

B. S., Kansas State University, 1970

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1973

The primary purpose of this study was to make a synthetic mixture which when added to dough would aid in elimination of the lengthy pre-fermentation period, used in breadmaking and still retaining acceptable bread flavor and quality characteristics.

Various protein hydrolysates and a particular ratio of organic acids or their salts were added to dough without prefermentation. The breads were judged for flavor and quality characteristics relative to bread made by the 4-hour sponge-dough process as a control.

1. Effect of the hydrolysates of gluten, soy, yeast, vegamine, at 0.0, 0.3, 0.6, 0.9, or 1.2 per cent flour basis on bread flavor and quality characteristics were determined. Crust color (increase) was the characteristic visually affected by increase of hydrolysate. Gluten was the only hydrolysate that produced "True Bread-Like" flavor in the resulting bread.

2. Effect of the solution of lactic, acetic, butyric, isobutyric, valeric, isovaleric, and caproic acids at 0.0, 8.6×10^{-4}, 1.7×10^{-4}, 2.6×10^{-4}, or 3.4×10^{-4} mole/700 g flour on bread flavor and quality characteristics were determined. The data indicated that the organic acids approximated the ratio of those produced in a normal 4-hour fermentation. They appeared to give a good bread from the view point of volume, grain, and texture.

3. The effect of the combination of Promate 200 (commercially prepared Gluten hydrolysate) and organic acids on bread flavor and quality characteristics was determined. The combination 3.4×10^{-4} moles acid/700 g flour and 0.3 percent (flour basis) of Promate 200 produced bread with good flavor and quality.

4. The foregoing showed that a synthetic mixture should replicate "bread-flavor" when added to dough with elimination of prefermentation was possible. That mixture could consist of organic acids or organic acid salts with Promate 200. To substantiate this, a wide range of concentrations of Promate 200, organic acids and organic acid salts was studied. The combination of Promate 200 with either organic acids or organic acid salts was also tried. Good bread flavor was determined in bread made with 0.2 and 0.4 per cent Promate 200. When Promate 200 was used at 0.2 per cent, a range from 5.1×10^{-4} to 8.5×10^{-4} moles organic acids/700 g flour improved bread quality. Organic acid salts at a range from 7.4×10^{-4} to 8.5×10^{-4} moles/700 g flour with 0.2 per cent Promate 200 gave bread with excellent flavor and quality. Bread with Promate 200 at 0.2 and 0.3 per cent showed excellent flavor and quality with 6.8×10^{-4} moles/700 g flour organic acid salts. Therefore, a synthetic mixture which provided 0.2 per cent Promate 200 and 6.8×10^{-4} moles/700 g flour organic acid salts produced excellent bread flavor and quality when added to dough without prefermentation.

5. A blend (Flavol) of 147 parts starch, 1400 parts Promate 200 and 98 parts organic acid salts was made. This was used in continuous mix process and conventional bread process. The bread made by the conventional bread process was analyzed statistically for flavor characteristics, chemically for total carbonyl compound content and for volatile vapors by headspace gas chromatography. The statistical analyses showed that no-time dough bread made with 0.2, 0.3, 0.4, or 0.5 per cent Flavol was equivalent to sponge-dough bread in flavor characteristics. Continuous mix bread

with Flavol and elimination of prefermentation (brew), was equivalent in flavor and quality characteristics to that made using a brew. Chemical analysis of no-time dough bread revealed that total carbonyl compound concentration increased with increase in the presence of Flavol. Headspace analysis showed that Flavol increased the volatile compounds in no-time dough bread similarly to those in bread made using the conventional sponge-dough procedure.

6. It was evident from the preceding that Flavol could be used in breadmaking processes with the elimination of customary prefermentation and still retain desirable flavor and quality. This initiated studies on commercial trials. Doughs made with Flavol no-time had excellent machineability. They produced bread and buns equivalent to conventional procedures in flavor and quality characteristics as those produce in two bakeries.