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Quality Characteristics of Bread Using Sour Dough

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Abstract

In this study, we examined the changes in loaf weight, loaf volume and specific volume, moisture content and water absorption, pH and titrable acidity, shape, texture profile and sensory evaluation using sour dough instead of dough conditioner in bread making. The weight and volume of bread tended to increase in the sour dough bread, compared to the control. The pH of bread tended to be lower in the sour dough bread. The control bread had large irregular pores that were fewer in number, while the sour dough bread had small spots and was very dense and even throughout the whole surface. The texture profile of bread such as hardness, cohesiveness, chewiness and brittleness was lower in the sour dough bread. There were no significant differences in the sensory characteristics of the breads, except for the shape of bread. However, the sour dough A bread was better in color, texture, flavor, touch, moistness, taste and overall acceptability, and the sour dough B bread was better in flavor, touch and taste than the control.

Key words: quality characteristics, bread, sour dough, ferment, texture

INTRODUCTION

Recently, the bakery industry has been increasingly concerned about development of new breads. As a result, the interest in naturally fermented bread has increased. Naturally fermented bread contains natural yeast or is naturally fermented using only a little yeast. Although baking using natural yeast is the most common and original form of baking bread, development of naturally fermented products for baking seems more realistic, considering the real situation of the bakery industry, especially when taking productivity and workability into consideration. Of the naturally fermented products, one kind of microorganism which greatly influences flavor is sour dough and it is widely used in bread fermentation. Fermentation of sour dough increases the amount of nutrients and the rate of digestion, improving the nutritive value of food. Sour dough inhibits the growth of pathogenic bacteria and pathogens, synthesizes antimicrobial compounds such as lactic acid, acetic acid, benzoic acid and hydrogen peroxide, extends the shelf life for fermented products, inhibits strong pathogenic bacteria, and prevents diseases. Furthermore, organic acids produced by sour dough not only have good effects on the flavor of bread, but also help the swelling of gluten and increase gas retention, producing products with good texture and massive volume. Since it is largely accepted that it inhibits degradation and improves shelf life, it may function as a natural dough conditioner (1). During fermentation, sour dough secretes a mucilaginous polysaccharide which is not attached to a cell wall other than lactic acid this polysaccharide was revealed to have anticancer properties (2). Because its effect as a bioactive substance is generally accepted, using sour dough may greatly contribute to improving the functional quality of bread. Quality of bread products depends on flavor, volume, taste and texture. As time goes by, products age and lose their commercial value through sensory changes which adversely affects the unique flavor of the products as well as physical and chemical changes (3). Accordingly, in order to prevent the decrease in product quality, many studies using chemical additives (3-5) have been conducted. However, since customers prefer healthy and eco-friendly products recently, it is very desirable to improve quality using natural ingredients. In order to improve product quality using natural ingredients, Chamberlain et al. (6) investigated using α-amylase and a non-traditional fermenting method using sour dough, which improved bread quality, and isolated and identified the microorganisms from the sour dough (7). Among microorganisms which ferment bread and influence the

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flavor of bread, the most important one from sour dough is *Lactobacillus*. Bread using bifidobacteria, which is an entero anaerobic sour dough, is very flavorful because, in the process of fermentation, both sour dough and yeast are fermented together in the dough. Sour dough inhibits the action of yeast, acting as a natural dough conditioner, changing the strong acidity caused by over fermentation to a softer taste. It also reduces the pH of bread dough, increasing springiness, making bread dense, reducing staleness and increasing the mechanics and fermentation of swelling, so raising bread volume. Bread prepared by bifidobacteria is generally high in biological value.

The objective of study was to provide basic materials for a health bread by developing naturally fermented bread by substituting sour for a dough conditioner in the bread making.

MATERIALS AND METHODS

Materials

Two kinds of commonly available commercial yogurts were used as sour dough starters. Other ingredients included wheat flour (1st class, the Korea Flour Mills Co., Ltd.), raw yeast (Jenico Co., Ltd.), sugar (TS Corp.), shortening (Mokdong Gold), milk (Seoul Milk) and salt (Baekjo Salt).

Sour dough and bread making

The sour dough was prepared by mixing 100 g wheat flour, and 145 mL distilled water. Five mL yogurt was inoculated into the mixture at 37°C for 10 hr after a preliminary test. According to kinds of yogurt, sour dough A-added bread and sour dough B-added bread were made by adding 20% sour dough to the flour.

Bread was prepared using the straight dough procedure. The baking formula based on the flour weight is presented in Table 1. First, all materials were mixed in the mixer bowl (Jungang Industry, JAM-2030, Korea) in the order of low (5 min)−middle (11 min)−low (1 min) speed.

After the first fermentation for 1 hr in 75% humidity and 27°C, the dough was divided into 180 g portions. The second fermentation was conducted, allowing the dough to rise to 1 cm higher above the pan height in 85% humidity at 38°C after 20 min intermediate proof and finally three loaves were formed. After fermentation, the bread was baked in an electric oven (Dae Yung Machinery Co., Ltd.) at 150°C upper heat and 180°C lower heat for 30 min. The baked bread was then removed from the pan and cooled for 2 hr at room temperature on a cooling rack.

Table 1. Basic baking formula for straight dough method

Ingredients	Ratio (%)	Control	Sour dough addition group
Wheat flour	100 (92)[1)]	660	607.2
Water	63 (51)	416	336.8
Yeast	2	13.2	13.2
Sugar	6	39.6	39.6
Shortening	4	26.4	26.4
Powdered milk	3	19.8	19.8
Salt	2	13.2	13.2
Sour dough	0 (20)	0	132

[1)]Ratio of sour dough addition group.

Measurement of loaf weight, loaf volume and specific volume

Loaf volume was determined through the rapeseed displacement method (8). After their volumes were measured by rapeseed displacement, their weights were determined, and specific volumes were calculated as loaf volume (cc)/baked loaf weight (g).

Measurement of moisture content and water absorption

Moisture content was measured by an infrared moisture determination balance (FD-600, Kett Electric Laboratory, Japan) for 15 min at 105°C using 2.5 g of bread. In order to measure water absorption, 20 mL of distilled water was added to 1 g of bread, stirred for 30 min, centrifuged for 10 min at 15,000 rpm, and weighed.

Measurement of pH and titrable acidity

The pH was measured with a pH meter (Suntex SP-2200, USA) after mixing 100 mL of distilled water with 15 g of bread for 30 min at room temperature. In order to measure titrable acidity, 100 mL of distilled water was mixed with 15 g of bread for 30 min at room temperature. We added two or three drops of 0.1% phenolphthalein (indicator), and 0.1 N NaOH was used for titration. Titrable acidity was calculated from the dilution ratio at the end point when a pink color appeared lactic acid was converted and content % was indicated on samples.

Observation of shape

Bread was dried for 24 hrs in a freeze dryer and its surface was plated with gold in order to give conductivity. Then, the shape of the bread was observed by scanning electron microscope (JSM-5400, JEOL, Japan) in 15 kV of acceleration voltage, 8 seconds of phototime, and 1,000 time binoculars.

Texture profile analysis

Texture was measured using a Rheometer (Sun Rheometer compac-100, Sun Sci. Co., Japan) by cutting bread crumb to the size of $3\times3\times3$ cm^3. Each sample was repeatedly measured ten times by texture profile analysis (TPA) to obtain hardness, adhesiveness, cohesiveness, springiness, chewiness and brittleness. Measurement conditions were 1) type: two bite mastication test, 2) adaptor: No. 25 (ϕ20.00 mm), 3) load cell: 1 kg, 4) deformation: 50%, 5) table speed: 50.00 (mm/min) and 6) chart speed: 50.00 (mm/min).

Sensory evaluation

Twenty students from the Department of Food & Nutrition were selected as panelists and trained to assess the sensory characteristics of the bread (color, shape, texture, flavor, touch, moistness, taste and overall acceptability) using 9-point hedonic scoring. Samples cut to $1\times1\times1$ cm^3 size after baking were offered on white polyethylene dishes with water.

Statistical analysis

The mean and standard deviation of data were calculated using SAS software. Significance of differences were determined by ANOVA and Duncan's multiple range test at the level of $p<0.05$ (9).

RESULTS AND DISCUSSION

Loaf weight, loaf volume and specific volume

The loaf weight, loaf volume and specific volume of breads are shown in Table 2. The loaf weights of the breads were 485 g, 489 g and 489 g in the control, sour dough A-added bread and sour dough B-added bread, respectively. The results suggest that the addtion of sour dough to the bread a little increased the weight, compared to the control. This agrees with Park and Hong's (10) findings that Japanese apricot flesh containing rich organic acid added to bread increased the loaf volume when addition increased, compared to the control group. It was also similar to Hong and Kim's (11) barley bread made by *Enterococcus* sp.- and *Lactobacillus* sp.- sour dough addition. It is well accepted that size distribution, gas collection and water absorption are greatly involved in the loaf weight of sour dough bread. The volume of bread was 2,300 cc, 2,305 cc and 2,306 cc in the control, sour dough A-added bread and sour dough-added B bread, respectively. The results suggest that the sour dough bread had almost the same volume as the control. The results were similar to Hong and Kim's (11) results, Cho et al.' (12) bread prepared by *Bifidobacterium bifidumflour* brew, and Chang and Ahn's (13) bread prepared by sour liquid ferments. It is also similar to Shin and Jung's (1) results that the addition of lactic acid bactria & yeast isolated from Kimchi increased the volume. The specific volumes of the breads were 4.742 cc/g, 4.713 cc/g and 4.715 cc/g in the control, sour dough A bread and sour dough B bread, respectively.

Table 2. Loaf weight, loaf volume and specific volume of bread

Sample	Loaf weight (g)	Loaf volume (cc)	Specific volume (cc/g)
Control	$485^{b1)}$	$2,300^{a}$	4.742^{a}
Sour dough A-added bread	489^{a}	$2,305^{a}$	4.713^{a}
Sour dough B-added bread	489^{a}	$2,306^{a}$	4.715^{a}

1)Values with different superscripts within a column are significantly different by Duncan's multiple range test at $p<0.05$.

Moisture content and water absorption

The moisture contents and water absorptions are shown in Table 3. The moisture content was 43.9%, 42.3% and 42.7% in the control, sour dough A bread and sour dough B bread, respectively, suggesting almost the same trend. It was similar to Hong and Kim's (11) results. Water absorptions were 185.3%, 185.0% and 201.9% in the control, sour dough A bread and sour dough B bread, respectively.

pH and titrable acidity

The pH and titrable acidity are shown in Table 4. The pHs were 5.36, 5.17 and 5.11 in the control, sour dough A bread and sour dough B bread, respectively. It was similar to Cho et al.'s (12) results of the decrease in the pH of bread prepared by *Bifidobacterium bifidum*-added flour brew, the decrease in the pH of bread using sour liquid ferments (13), the decrease in the pH of ferment liquid-added bread by Kook (14), and the decrease in the pH of *Enterococcus* sp. and *Lactobacillus* sp. added-bread by Hong and Kim (11).

The titrable acidities were 0.39%, 0.39% and 0.41% in the control, sour dough A bread and sour dough B bread,

Table 3. Moisture content and water absorption of bread

Sample	Moisture content (%)	Water absorption (%)
Control	$43.9^{a1)}$	185.3^{b}
Sour dough A-added bread	42.3^{a}	185.0^{b}
Sour dough B-added bread	42.7^{a}	201.9^{a}

1)Values with different superscripts within a column are significantly different by Duncan's multiple range test at $p<0.05$.

Table 4. pH and titrable acidity of bread

Sample	pH	Titrable acidity (%)
Control	$5.36^{a1)}$	0.39^{a}
Sour dough A-added bread	5.17^{ab}	0.39^{a}
Sour dough B-added bread	5.11^{b}	0.41^{a}

1)Values with different superscripts within a column are significantly different by Duncan's multiple range test at $p<0.05$.

respectively. This suggests that sour dough bread had a higher titrable acidity than the control. This is considered natural because the addition of sour dough causes a decrease in the pH.

The sour dough bread had a decreased pH and increased titrable acidity and indicated strong acidity, compared to the control, suggesting identical results to Park and Hong's (10) results.

Shape

Scanning electron microphotograph pictures in the control, sour dough A and sour dough B breads are shown in Fig. 1. The control had fewer but larger and more irregular pores, than the sour dough A and sour dough B breads. While the sour dough A bread had small spots and was very dense and even throughout the whole surface, the sour dough B bread had wider pores. Pomeranz (15) indicated that when changes in starch occurred in the state of the dough, bread had changes between protein and swelled starch, resulting in a change from mostly large to mostly smaller starch grains. In other words, the regular internal shape of the bread was made by protein and swelling and changing of starch. In this experiment, adding sour dough appeared to bring about the inhibition of tangling of small starch grains, the creation of the thin films of flour protein, easy gas collection, and differences in pore distribution.

Texture profile

The texture of the bread is shown in Table 5. The sour dough bread had significantly less hardness, cohesiveness, chewiness and brittleness, compared to the control. The decrease in hardness and cohesiveness showed the same trend as Park and Hong's (10) Japanese apricot pulp-added bread. The sour dough bread was softer, and Shim et al. (16) also found that sour dough bread was softer than general bread. Lee (17) added flour ferments containing wheat flour koji and lactic acid bacteria to frozen bread and measured hardness. He found that its hardness was lower than non-added bread, thus the product was softer.

Table 5. Texture profile of bread

Item	Control	Sour dough A -added bread	Sour dough B -added bread
Hardness (dyne/cm^2)	330.53^a	301.03^c	303.87^b
Adhesiveness (g)	-1.0^a	-1.3^a	-1.3^a
Cohesiveness (%)	99.34^a	96.06^b	89.57^c
Springiness (%)	100.24^a	100.00^a	100.24^a
Chewiness (%)	238.25^a	206.71^b	197.28^c
Brittleness (g)	239.39^a	206.54^b	197.70^c

[1)]Values with different superscripts within rows are significantly different by Duncan's multiple range test at $p<0.05$.

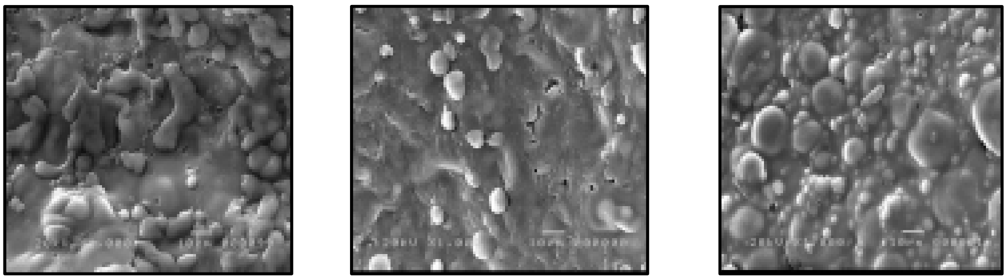
Sensory characteristics

The sensory characteristics of the breads are shown in Table 6. There was no significant difference except the shape of bread. However, the sour dough A bread had better color, texture, flavor, touch, moistness, taste and overall acceptability, and the sour dough B bread had better flavor, touch and taste, compared to the control. These results suggest that the addition of sour dough improves the quality of bread. This is similar to the results of Shim et al. (16) that the sour dough-added bread was higher in sensory tests than general bread. It was similar to Cho et al.'s (12) result of improving

Table 6. Sensory characteristics of bread

Item	Control	Sour dough A-added bread	Sour dough B-added bread	F-value
Color	5.64±1.39$^{1)a2)}$	6.14±1.29^a	5.57±1.29^a	0.20
Shape	6.39±1.28^a	6.00±1.44^{ab}	5.46±1.35^b	0.04*
Texture	5.60±1.44^a	6.00±1.65^a	5.28±1.60^a	0.24
Flavor	5.35±1.63^a	5.60±1.57^a	5.57±1.47^a	0.81
Touch	5.67±1.51^a	6.01±1.39^a	6.03±1.64^a	0.53
Moistness	6.10±1.61^a	6.17±1.30^a	6.07±1.74^a	0.97
Taste	5.85±1.77^a	6.07±1.27^a	5.96±1.40^a	0.87
Overall acceptability	5.96±1.31^a	6.28±1.08^a	5.92±1.43^a	0.52

[1)]Mean±standard deviation.
[2)]Values with different superscripts within rows are significantly different by Duncan's multiple range test at $p<0.05$.



Control Sour dough A-added bread Sour dough B-added bread

Fig. 1. Scanning electron microphotographs of bread.

the quality of bread prepared by *Bifidobacterium bifidum*-added flour brew, which increased the sensory quality of bread by using sour liquid ferments (13). Moistness, softness and overall satisfaction were improved in Hong and Kim's (11) *Enterococcus* sp. and *Lactobacillus* sp. added-bread. Sour dough fermentation is known to produce lactic acid, acetic acid and amino acids from yeast during fermentation, influencing the flavor of bread, accelerating acidification of dough and increasing mechanical resistance (18).

REFERENCES

1. Shin EH, Jung SJ. 2003. Optimization of bread fermentation with lactic acid bactria & yeast isolated from Kimchi. *Korean J Culinary Research* 9: 130-140.
2. Kanabe M. 1981. Physiological activitives of extracelluar polysaccharides produced by lactic acid bacteria. *Jap J Dairy Food Sci* 30: 219-225.
3. William HK. 1977. The staling of bread. *Bakers Digest* 51: 52-57.
4. Xu A, Chung OK, Ponte J. 1992. Bread crumb amylograph studies. I. Effect of shortening, flour lipid and surfactants. *Cereal Chem* 69: 495-501.
5. D'Appolonia BL, Plseookbunteing WP. 1983. Bread staling studies. I. Effect of surfactants on moisture migration from crumb and firmness values of bread crumb. *Cereal Chem* 60: 82-91.
6. Chamberlain N, Collins TH, McDermott EE. 1981. α-Amylase and bread properties. *J Food Tech* 16: 127-152.
7. Martinez-anaya MA, Pitarch B, Bayarri P, Benedito de Barber C. 1990. Microflora of the sourdoughs of wheat flour bread. X. Interactions between yeasts and lactic acid bacteria in wheat doughs and their effects on bread quality. *Cereal Chem* 67: 85-91.
8. AACC. 1983. *Official Methods of the AACC*. 8th ed. Ameican Association of Cereal Chemists, St. Paul, MN.
9. Song MS, Lee YJ, Cho GS, Kim BC. 1990. *Data Analysis using SAS*. Free Academy, Seoul, Korea.
10. Park SI, Hong KH. 2003. Effect of Japanese apricot (*Prunus mume Sieb. et Zucc.)* flesh on baking properties of white breads. *Korean J Food Culture* 18: 506-514.
11. Hong JH, Kim KJ. 2001. Effect of barley bread using sourdough prepared by *Enterococcus* sp. and *Lactobacillus* sp. II physicochemical and rheological properties of barley bread. *Korean J Dietary Culture* 16: 361-370.
12. Cho NJ, Lee SK, Kim SK, Joo HK. 1999. Effect of wheat brew with bifidobacterium bifidum on rheological properties of wheat flour dough. *Korean J Food Sci Technol* 28: 1275-1282.
13. Chang JH, Ann JB. 1996. Effect of lactic acid bacteria on the qualities of white pan bread. *Korean J Food Nutr* 9: 509-515.
14. Kook SU. 1996. Development of starter cultures for the extension of the shelf life of bread. *Korean J Food Nutr* 9: 236-241.
15. Pomeranz Y. 1988. Composition and functionality of wheat flour components in wheat. In *Chemistry and Technology*. 3rd ed. Ameican Association of Cereal Chemists, St. Paul, MN, USA.
16. Shim EJ, An JH, Yu JH. 1996. Studies on the effect of *Lactobacillus delbruckii* on the quality of bread. *Korean Dairy Techno* 14: 85-95.
17. Lee MG. 2003. Quality characteristics of frozen dough bread prepared with flour ferments containing wheat flour koji and lactic acid bacteria. *PhD Dissertation.* Konkuk Univ., Korea.
18. Lee JY, Lee SK, Cho NJ, Park WJ. 2003. Development of the formula for natural bread-making starter. *J Korean Soc Food Sci Nutr* 32: 1245-1252.

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