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Extension Properties of Frozen Hard Wheat Flour Doughs Mixed with Ascorbic Acid and Gluten Hydrolysate

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Abstract The textural properties of doughs mixed with L-ascorbic acid (AA), trypsin hydrolyzed gluten peptide (THGP), and a mixture of AA-THGP were investigated using texture analyzer under the fermentation of the full formula and the freezing process. The full formula dough (FFD) required a shorter mixing time than the flour and water formula dough (FWD). The maximum resistance (Rmax) values of both the unfrozen and frozen doughs were lower for the FFD. The effects of AA and THGP additions were not significant ($p<0.01$) in FFD, however, they were significant in FWD. The freezing effect was significant ($p<0.0001$) for FFD, indicating that yeast fermented dough was much more sensitive to damage from freezing, which subsequently affected dough strength. Additions of AA ($p=0.0026$) and THGP ($p=0.0097$) had a significant effect on the extensibility (E-value) of unfrozen FWD, where THGP increased and AA decreased the E-value. However, freezing did not significantly effect the extensibilities of FWD ($p=0.64$) or FFD ($p=0.21$). The area of FFD was lower than the area of FWD for both the unfrozen and frozen doughs. However, the frozen dough mixed with THGP alone had the largest area overall. The addition of additives did not result in significantly different ($p<0.01$) areas under the curve, except in the frozen FFD. Freezing caused a statistically significant difference in the area of FWD ($p=0.0045$).

Keywords: wheat flour dough, dough extension, frozen dough, gluten peptide, ascorbic acid

Introduction

The extension properties of dough are of special interest to bakers because they influence dough characteristics during development, fermentation, and oven spring (1). Dough rheology is affected by processing conditions, as well as additives. It has been reported that fermentation affects both the dough strength and extensibility (2, 3). Salt and fermentation time can have different effects on the inherent flour strength (4). Ice crystallization and recrystallization cause physical damage to the gluten network, leading to changes in the rheological properties of frozen dough (5). The incorporations of gum (6) and peptides (7, 8) were reported to reduce frozen damage and increase loaf volume. Controlling protein cross-linking by the sulfhydryl oxidation of gluten protein is very effective for increasing the gluten strength of frozen dough. The addition of oxidants, therefore, increases the retention of fermented gas at the gluten network, and improves the final bread volume of the frozen dough (5, 9, 10).

The particular interest has been the introduction of a TA.XT2 texture analyzer (TA, Texture Technologies Corp., Scarsdale, NY, USA) equipped with a SMS/Kieffer dough and gluten extensibility rig (Stable Micro Systems, Surrey, UK) to perform a simple extension test on small dough strips (11-13). The extensigraph parameters commonly used to characterize dough extension properties include the following: the maximum resistance (maximum height of the curve) in extensigraph units (Rmax), the extensibility from start until the dough ruptures (E), the area under the curve in square centimeters (A), and the viscoelastic ratio determined by the ratio of maximum resistance to the extension (Rmax/E) (14).

The purpose of this study was to investigate the dough textural properties resulting from the additions of dough improving additives and changes in processing, using a TA.XT2 texture analyzer. The processing variables that we compared were fermentation and freezing, and the selected additives used were L-ascorbic acid and trypsin hydrolyzed gluten peptide (THGP), which are used to improve loaf volume of frozen dough.

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Materials and Methods

Materials Commercial bread flour containing 12.17% protein (N × 5.74) and 13.80% moisture was obtained from Samyang Co. (Seoul, Korea). Instant yeast, white sugar, salt, and shortening were obtained from Saf levure (Marcq, France), Samyang Co. (Seoul, Korea), Hae-pyo (Seoul, Korea), and Alfs Shortening (Heinz Sam-lip Oil, Seoul, Korea), respectively. L-Ascorbic acid (AA) was obtained from Sigma (Sigma-Aldrich, St. Louis, MO, USA). The trypsin hydrolyzed gluten peptide (THGP) was obtained by following the procedure of Song and Koh (8).

Preparation of dough Two different formulas of dough were prepared as shown in Table 1. The flour-water dough (FWD) was prepared with flour and water with and without additions of THGP and AA. The full formula dough (FFD) was prepared according to the standard AACC 10-10B formula (15) with and without additions of THGP and AA. THGP was substituted for wheat flour to give an amount of 8% of the flour weight, as was determined by Song and Koh (8) to be the optimum level of THGP for loaf volume. The amounts of added AA (60 ppm) were based on the frozen dough research of Inoue and Bushuk (9). The dough was prepared at 10 g mixograph (15) at a constant water level (65%), for an

Table 1. Control flour and water dough (FWD) and full formula dough (FFD) formulas

	FWD		FFD	
	Baker's%	Batch	Baker's%	Batch
Flour	100	9.885 g	100	9.885 g
Water	65	6.015 g	65	6.015 g
Yeast	-	-	1.77	17.6 mg
Sugar	-	-	6	60 mg
Salt	-	-	1.5	15 mg
Shortening	-	-	3	30 mg

optimum mixing time that varied based on the additions of gluten, THGP, or AA.

For the frozen dough study, we followed a method described by Kim and Koh (16). Here, the mixed dough (final dough temperature of 28±2°C) was immediately wrapped with polyethylene film (Kim's wrap, Chung-Jung Food Co., Seoul, Korea) to prevent water evaporation while in a laboratory air freezer (SR-62EA; Samsung, Seoul, Korea), and was frozen at -20°C for 1 week. The stored frozen dough was defrosted at 4°C and 85±5% relative humidity for 16 hr. Three dough replicates were prepared for each experimental batch.

Measurements of dough textural properties For each sample, 3 dough replicates were prepared according to Suchy *et al.* (13) and allowed to rest for 90 min at 30°C and 85% RH. Four dough strips for each resting period were tested on a texture analyzer (TA-HD; Texture Technologies Corp., Scarsdale, NY, USA) equipped with a SMS/Kieffer dough and gluten extensibility rig (Stable Micro Systems) with a hook extension speed of 3.3 mm/sec, and a trigger force of 1 g by using a 50-kg load cell. The parameters used to characterize dough extension properties were the maximum resistance (maximum height of the curve) in the extensibility graph units (Rmax), the extensibility from start until dough rupture (E), and the area under the curve in square centimeters (A).

Statistical analysis All statistical analyses were performed using SAS version 8.02 (17). Generalized linear model (GLM) analysis was conducted to analyze the significance of the effects on dough textural properties from additions of AA, THGP, and the AA-THGP mixture in each processing formula. Student's *t*-test was conducted to analyze the significance of the effects of freezing on the FWD and FFD textural properties.

Results and Discussion

The optimum dough mixing times are shown in Table 2. The addition of THGP decreased mixing time, whereas AA did not influence the mixing time. The mixing time for the FFD was shorter than that for the FWD without the THGP addition. In the FFD, the reduced mixing time that resulted from the addition of THGP was regained slightly with the addition of AA.

The effects of THGP and AA on dough extension properties are shown in Table 3. The values of major importance are the peak force (resistance to extension, maximum resistance, Rmax), and the distance (extensibility, E-value) at which the peak force occurred at the extension limit, which is the measurement of extensibility. The Rmax of FFD was lower than that of FWD in both the frozen and un-frozen doughs. Shiba *et al.* (18) reported that the difference in dough strength between unfermented and fermented doughs was caused by a decrease in surface hydrophobicity of the soluble glutenin. We observed a decrease in dough strength (Rmax) from freezing in both the FWD and FFD. This result is consistent with previous research on frozen dough (5, 9, 10, 19), where increases in freezing time caused decreases in yeast viability and gluten network strength. The significance of differences in textural properties with the additions of AA and THGP are shown in Table 4. The different additives significantly ($p<0.001$) improved Rmax in both the frozen and unfrozen FWD, and in the unfrozen FFD. The effects of AA and THGP on Rmax were not significantly ($p=0.016$) different in the frozen FFD, and the effect of freezing on Rmax was more significant ($p<0.0001$) for FFD, as shown in Table 4. This indicated that the yeast fermented dough was much more sensitive to freezing damage, which affected its dough strength.

The FWD containing THGP had a higher E-value compared to the FWD containing AA and the control FWD as shown in Table 3. Previous research (8) has investigated decreases in mixing tolerance and increases in extensibility after optimum mixing time, for dough substituted with 8% THGP, where the addition of THGP increased the extensibility of 90 min proofed FWD. Here, the effect of AA on FWD was similar to that of other oxidants like $KBrO_3$, as reported in a previous report (20), with less extensibility and more dough resistance than the control FWD. However, the effect of AA on FFD was somewhat different from that of FWD. The extensibilities of the frozen and unfrozen FFD that had added AA became larger than those of the frozen control and the unfrozen FFD. This indicated that AA reduced the gluten network during yeast fermentation, thus increasing extensibility. This result from using AA as the oxidant was different than that of $KBrO_3$ on FWD (20). The addition of different additives to both the unfrozen FWD ($p=0.0026$) and FFD ($p=0.0097$) significantly improved the E-values, as shown in Table 3. However, THGP and AA additions did not significantly improve the extensibilities of the frozen FWD ($p=0.8900$) and frozen FFD ($p=0.2688$). Table 5 shows that the freezing effect on extensibility was

Table 2. Optimum mixing times (min) of flour and water dough (FWD) and full formula dough (FFD)

	FWD	FFD
Flour	5.1	4.3
+ 60 ppm AA[1)]	5.2	4.3
+ 8% THGP[2)]	3.4	3.2
+ 8% THGP + 60 ppm AA	3.4	4.0

[1)]AA, L-ascorbic acid.
[2)]THGP, trypsin hydrolyzed gluten peptide.

Table 3. Extension properties of wheat flour doughs mixed with AA (L-ascorbic acid), THGP (trypsin hydrolyzed gluten peptide), and the AA-THGP mixture

	Maximum resistance to extension (g)	Extensibility (mm)	Area (g mm)
Unfrozen flour and water dough			
Flour	43.04±5.05	38.99±3.38	560.18±84.45
+ 60 ppm AA[1)]	54.86±5.07	36.87±3.83	635.87±135.14
+ 8% THGP[2)]	41.30±3.32	43.33±1.72	597.33±97.94
+ 8% THGP + 60 ppm AA	39.25±6.02	44.47±3.34	615.23±92.71
Unfrozen full formula dough			
Flour	36.13±2.47	39.61±2.82	485.79±98.97
+ 60 ppm AA	32.89±6.62	46.70±4.37	547.26±153.28
+ 8% THGP	39.29±4.56	39.23±4.28	499.87±123.59
+ 8% THGP + 60 ppm AA	27.24±2.39	41.581.95	383.06±58.31
Frozen flour and water dough			
Flour	48.13±7.98	41.59±4.94	715.32±152.83
+ 60 ppm AA	47.57±1.56	40.41±0.67	620.75±70.71
+ 8% THGP	43.18±2.55	41.17±2.03	717.67±85.94
+ 8% THGP + 60 ppm AA	57.56±3.62	40.36±2.63	793.41±96.09
Frozen full formula dough			
Flour	28.58±1.98	44.22±2.24	428.14±72.44
+ 60 ppm AA	23.89±6.87	47.44±4.31	352.83±100.30
+ 8% THGP	32.64±1.37	47.28±4.56	560.36±107.13
+ 8% THGP + 60 ppm AA	24.92±3.34	43.90±3.12	353.08±40.42

1)AA, L-ascorbic acid.
2)THGP, trypsin hydrolyzed gluten peptide.

Table 4. *p*-Values of textural property differences in doughs with additions of AA, THGP, and a mixture of AA-THGP[1)]

Freezing	Formula[2)]	Maximum resistance to extension	Extensibility	Area
Unfrozen	FWD	0.0004	0.0026	0.6111
	FFD	0.0033	0.0097	0.2426
Frozen	FWD	0.0008	0.8900	0.2456
	FFD	0.0166	0.2688	0.0028

1)Differences were analyzed with the control dough and doughs mixed with the additions of AA, THGP, and AA-THGP.
2)Flour and water dough = FWD; Full formula dough = FFD.

Table 5. *p*-Values of textural property differences after doughs were frozen[1)]

Formula[2)]	Maximum resistance to extension	Extensibility	Area
FWD	0.0128	0.64	0.0045
FFD	<0.0001	0.21	0.0232

1)Differences were analyzed between the frozen doughs and unfrozen control, AA (L-ascorbic acid), THGP (trypsin hydrolyzed gluten peptide), and AA-THGP added doughs.
2)Flour and water dough = FWD; full formula dough = FFD.

not statistically significant for FWD (p=0.64) or FFD (p=0.21).

The area under the curve of both the unfrozen and frozen FFD had decreases compared to the area of FWD as shown in Table 3. This result was consistent with previous research showing that fermentation decreased the extensigram length and area (3, 4). The frozen FWD mixed with the AA-THGP mixture showed a large increase in area. The frozen FFD mixed with THGP alone had the largest overall area among the additives. Table 4 shows that differences in area from the addition of additives were not statistically significant, except in the frozen FFD. A statistically significant difference resulting from freezing was observed in FWD (p=0.0045), but not FFD (p=0.0232), as shown at Table 5. Freezing did not significantly effect the area under the curve of FFD, although it did significantly effect the Rmax (p<0.0001) of FFD.

References

1. Bloksma AH. Rheology of the bread making process. Cereal Food World 35: 228-236 (1990)
2. Kilborn RH, Preston KR. A modified extensigraph procedure for measuring the stretching properties of fermented dough. Cereal Chem. 59: 381-384 (1982)
3. Preston KR, Kilborn RH. Sponge-and-dough bread: Effects of fermentation, bromate, and sponge salt upon the baking and physical dough properties of a Candian red spring wheat. J. Food Sci. 47: 1143-1148 (1982)
4. Casutt V, Preston KR, Kilborn RH. Effects of fermentation time, inherent flour strength, and salt level on extensigraph properties of full-formula remix-to-peak processed doughs. Cereal Chem. 61: 454-459 (1984)
5. Varriano-Marston E, Hsu KH, Mahdi J. Rheological and structural change in frozen dough. Baker's Dig. 54: 32-34 (1980)
6. Sharadanant R, Khan K. Effect of hydrophilic gums on frozen dough. I. Dough quality. Cereal Chem. 80: 764-772 (2003)
7. Koh BK, Lee GC, Lim ST. Effect of amino acids and peptides on mixing and frozen dough properties of wheat flour. J. Food Sci. 70: S359-364 (2005)
8. Song KA, Koh BK. Effect of enzymatically hydrolyzed vital wheat gluten on dough mixing and the baking properties of wheat flour frozen dough. Food Sci. Biotechnol. 15: 173-176 (2006)
9. Inoue Y, Bushuk W. Studies on frozen dough. I. Effects of frozen storage and freeze-thaw cycles on baking and rheological properties. Cereal Chem. 68: 627-631 (1991)
10. Inoue Y, Bushuk W. Studies on frozen dough. II. Flour quality requirements for bread production from frozen dough. Cereal Chem. 69: 423-428 (1992)
11. Basman A, Kõksel H, Ng PKW. Utilization of transglutaminase to increase the level of barley and soy flour incorporation in wheat flour breads. J. Food Sci. 68: 2453-2460 (2003)
12. Kieffer R, Wieser H, Henderson MH, Graveland A. Correlations of the breadmaking performance of wheat flour with rheological measurements on a micro-scale. J. Cereal Sci. 27: 53-60 (1998)
13. Suchy J, Lukow OM, Ingelin ME. Dough microextensibility method using a 2-g mixograph and a texture analyzer. Cereal Chem. 77: 39-43 (2000)
14. Preston KR, Hoseney RC. Applications of the extensigraph. pp.13-19. In: The Extensigraph Handbook. Rasper F, Preston KR (eds). The American Association of Cereal Chemists, Inc., St. Paul, MN, USA (1991).
15. AACC International. Approved Methods of the AACC. 10th ed. Method 10-10B, Optimized straight-dough bread-making method; Method 54-40A, Mixograph method. The American Association of Cereal Chemists, Inc., St. Paul, MN, USA (2000)
16. Kim DH, Koh BK. Freezing and fermentation curves of the dough frozen at the different freezing condition. Food Sci. Biotechnol. 11: 99-104 (2002)
17. SAS Institute, Inc. SAS User's Guide. Statistical Analysis System Institute, Cary, NC, USA (1990)
18. Shiba K, Negishi Y, Okada K, Nagao S. Chemical changes during sponge-dough fermentation. Cereal Chem. 67: 350-353 (1990)
19. El-Hady EA, El-Samahy SK, Seibel W, Brummer JM. Changes in gas production and retention in non-prefermented frozen wheat dough. Cereal Chem. 73: 472-477 (1996)
20. Kuninori T, Matsumoto H. L-Ascorbic acid oxidizing system in dough and dough improvement. Cereal Chem. 40: 647-657 (1963)