Effect of Gluten Fractions in Reducing Microwave-Induced Toughness of Bread and Buns

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ABSTRACT

It has been well documented that bread products reheated in a microwave oven can develop an undesirable tough texture. It has been suggested that reducing the size of the gluten network in bread products may reduce microwave-induced toughness. The purpose of this study was to determine whether modified wheat proteins would effectively alter the gluten network in bread products and thereby reduce microwave-induced toughness. Addition of low levels of gliadin, mildly hydrolyzed wheat gluten, or wheat protein isolate to the bread formula effectively reduced the microwave-induced toughness of pup loaf bread but was not effective in reducing the microwave-induced toughness of laboratory-scale hoagie buns.

Since the introduction of the microwave oven in 1947, food developers have been striving to formulate foods that have a desirable texture when cooked or reheated in a microwave oven. Success has been achieved for some products; however, the quality of bread products reheated in a microwave oven is generally poor. Bread products reheated in a microwave oven are soft immediately after heating but develop a rubbery or leather-like texture upon cooling. Microwave-reheated bread products are generally tough, difficult to tear, and difficult to masticate.

Many formula modifications have been shown to reduce microwave-induced toughness of reheated bread products. These include the addition of emulsifiers (7,10), combinations of pregelatinized starches and emulsifiers (12), combinations of high levels of shortening and fiber (6), increased water absorption (10), combinations of fat, methylcellulose, soy protein, and egg protein (11), oxidants (7), hydrogen-bond breakers (7), modified starches (3), and combinations of shortening, milk, egg, and soy proteins (5). Many of these additives, especially at high levels, adversely affect the handling characteristics of the dough and the flavor and texture of the final product.

It has been suggested that improved microwaveability of bread products could be accomplished by reducing the size of the gluten network (13). This is shown by the effectiveness of added protease and deamidase enzymes (7) and reducing agents (4, 7), all of which reduce microwave-induced toughness.

Efforts to develop value-added products from wheat gluten have progressed through the years (8,9). Gliadin and glutenin fractions of gluten are commercially available. Gluten fractions that have been modified to alter their functionality are also available. These modified gluten fractions have been shown to affect dough mixing time and dough elasticity (unpublished data). The purpose of this study is to determine whether modified gluten fractions can effectively alter the gluten network in bread and thereby reduce the toughness that results when bread is reheated in a microwave oven.

MATERIALS AND METHODS

Pup Loaf Bread Preparation

Bread was baked as pup loaves using AACC Approved Method 10-10B, a straight dough procedure with 90-min fermentation (1). The bread formula (flour weight basis [fwb]) consisted of a commercial bread flour (100%), nonfat dry milk (4%), shortening (3%), instant active dry yeast (2%), sugar (6%), and salt (1.5%). Wheat gluten, wheat protein isolate, protease-hydrolyzed wheat gluten, or gliadin (MGP Ingredients, Inc., Atchison, KS) was added at 1, 2, or 3% fwb. Water absorption was 62% for the control bread (no added gluten fraction). The water level was increased 1% for each 1% of added gluten fraction, based on preliminary baking trials. All doughs were mixed to optimum development. After cooling, the loaves were packaged in polyethylene bags and held at room temperature (25°C) overnight.

Hoagie Bun Preparation

The formula for laboratory-scale hoagie style buns was the same as that used for pup loaf buns. Gluten, wheat protein isolate, protease-hydrolyzed wheat gluten, or gliadin was added at 1, 2, or 3% fwb. Water absorption was 64% for the control buns. The water level was increased 1% for each 1% of added gluten fraction, based on preliminary baking trials. All doughs were mixed to optimum development. After mixing, the doughs were rested for 15 min and then molded, stretched to a length of approximately 6 in., and placed on baguette baking screens. The screens were placed in a fermentation cabinet set at 30°C dry/29°C wet to proof for 45 min, after which the buns were baked at 205°C for 20 min. After cooling, the buns were packaged in polyethylene bags and held at room temperature (25°C) overnight.

Microwave Reheating

Pup loaves were cut into 1-in.-thick slices weighing approximately 30 g. The center three slices from each loaf were tested. Three loaves (three slices per loaf) were measured per treatment. Laboratory-scale hoagie style buns were sliced into 1-in.-thick slices weighing approximately 35 g. The center three slices from each bun were tested. Three buns (three slices per bun) per treatment were tested.

Each slice was placed on an inverted 1-in.-high polyfoam cup in the center of a carousel tray and heated on high power in a 900-W microwave oven (Emerson MW8126W). The true power of the microwave oven was 709 W, as determined by the method de-

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scribed by Buffer (2). The polyfoam cup prevented condensation under the slice and provided more uniform microwave heating. Heating times were 15 sec for pup loaf bread slices and 20 sec for hoagie bun slices. These were the longest times the slices could be heated before they dried out. The slices were removed from the microwave immediately and allowed to cool on wire racks to room temperature before testing. A 1-in.-wide segment cut from the center of the bread or bun slice was tested for toughness.

Toughness Measurement

Toughness was measured using a TA.XT2 texture analyzer (Stable Micro Systems, Godalming, Surrey, UK; Texture Technologies Corp., Scarsdale, NY) and the Miller-Hoseney Toughness Rig (10). The peak force required for the wire probe to cut through the bread was taken as the measure of bread toughness. Higher force values indicate tougher bread.

Statistical Analysis

Statistical analysis was performed using JMP software (SAS Institute, Cary, NC). Mean values and standard deviations were calculated. Least significant difference was determined using the Tukey test at the 95% confidence level. Each treatment was prepared in triplicate.

RESULTS

Effect of Gluten Fractions on Pup Loaf Bread

The effect of gluten fractions on the microwave-induced toughness of pup loaf bread reheated in a microwave oven is shown in Table I. The addition of gluten at 1, 2, or 3% fwb did not significantly affect microwave-induced toughness compared with the control (no added gluten). However, the addition of gliadin or protease-hydrolyzed wheat gluten at all levels tested (1, 2, or 3% fwb) did significantly decrease toughness induced by heating in a microwave oven. The addition of 2 or 3% wheat protein isolate was also effective in reducing microwave-induced toughness, while the addition of 1% wheat protein isolate did not significantly affect toughness after microwaving.

Effect of Gluten Fractions in Hoagie Buns

The effect of the gluten fractions tested on microwave-induced toughness of hoagie buns reheated in a microwave oven is shown in Table I. None of the treatments had a significant effect on microwave-induced toughness.

Table I. Effect of gluten fractions on microwave-induced toughness in bread products[a]

Gluten Fraction	Level (fwb)	Force (g) Pup Loaf[b]	Force (g) Hoagie Bun[c]
Control	0	809.5 ab	228.8 ab
Gluten	1	689.9 a–d	187.9 b
	2	645.3 b–d	219.3 ab
	3	782.2 a–c	232.4 ab
Gliadin	1	569.5 cd	268.3 a
	2	503.1 d	268.1 a
	3	553.9 cd	243.0 ab
Wheat protein isolate	1	893.0 a	249.9 ab
	2	565.5 cd	232.0 ab
	3	531.9 d	239.4 ab
Protease-hydrolyzed gluten	1	559.4 cd	258.9 a
	2	572.9 cd	254.7 a
	3	518.8 d	257.0 a

[a] Values in a column followed by different letters are significantly different at $P = 0.05$.
[b] Slices (30 g) were reheated in the microwave for 15 sec.
[c] Slices (35 g) were reheated in the microwave for 20 sec.

DISCUSSION

The toughness of the control samples (no added gluten fractions) varied depending on the bread product. Microwave-reheated control pup loaf slices had a toughness of approximately 810 g versus 230 g for laboratory-scale hoagie buns. The pup loaves and hoagie buns were made using the same flour and formula but were cut differently by the wire during testing.

The addition of gliadin, protease-hydrolyzed wheat gluten, or higher levels of wheat protein isolate effectively reduced the toughness of microwave-reheated pup loaf bread. However, the effect was not observed in laboratory-scale hoagie buns. A possible explanation for this result is the way in which the products are prepared. During the production of pup loaves, the dough is sheeted twice during fermentation and then is sheeted, molded, and placed in a pan to proof, resulting in an alignment of the gluten strands in the bread. The pup loaves were sliced cross-sectionally along (parallel to) the aligned strands to produce the slices for testing. The wire used in measuring toughness cut across (perpendicular to) the gluten strands. The toughness observed might have been caused by the interaction of adjacent gluten strands when the water was removed during microwave heating. Thus, cutting across (perpendicular to) the gluten strands in the pup loaf bread during testing measured the degree of interaction.

Laboratory-scale hoagie buns are given a short rest after mixing and then are sheeted, molded, stretched slightly and laid on baguette screens to proof. This results in only limited alignment of the gluten strands. Thus, there is less opportunity for the gluten strands to interact as a result of microwave heating, leading to less resistance to the cutting wire during testing.

CONCLUSIONS

Gliadin, protease-hydrolyzed wheat gluten, and wheat protein isolate reduced the microwave-induced toughness of pup loaf bread but did not affect the toughness of microwave-reheated laboratory-scale hoagie buns. It is speculated that the limited gluten alignment in the hoagie buns resulted in less gluten interaction (i.e., less toughening) during microwave heating.

References

1. AACC Method 10-10B, Optimized Straight-Dough Bread-Baking Method. *Approved Methods of the American Association of Cereal Chemists*, 10th ed. The Association, St. Paul, MN, 2000.
2. Buffer, C. R. *Microwave Cooking and Processing*. Van Nostrand Reinhold, New York, 1993.
3. Cochran, S. A., Benjamin, E. J., Crocker, M. E., Seidel, W. C., and Cipriano, V. L. Microwaveable baked goods. U.S. Patent 4,885,180, 1989.
4. Cochran, S. A., Cin, D. A., and Veach, S. K. Microwaveable baked goods. U.S. patent 4,957,750, 1990.
5. Corbin, D., and Corbin, S. Method of making a microwaveable bakery product. U.S. patent 5,266,345, 1992.
6. Engelbrecht, D. A., and Spies, R. D. Microwaveable bread product. U.S. patent 5,162,216, 1992.
7. Huang, V. T., Hoseney, R. C., Graf, E., Ghiasi, K., Miller, L. C., Weber, J. L., Gaertner, K. C., Matson, K. L., Hunstiger, A. M., Rogers, D. K., and Saguy, I. A. Starch-based products for microwave cooking or heating. U.S. patent 5,035,904, 1991.
8. Lens, J.-P., Mulder, W. J., and Kolster, P. Modification of wheat gluten for nonfood applications. Cereal Foods World 44:5, 1999.
9. Maningat, C. C., Bassi, S. D., and Hesser, J. M. Wheat gluten in food and non-food systems. AIB Tech. Bull. 16:1, 1994.
10. Miller, R. A., and Hoseney, R. C. Method to measure microwave-induced toughness of bread. J. Food Sci. 62:1202, 1997.
11. Ohlin, E. A., and Biebaut, D. M. A. Improver for microwave-reheatable bakery products. U.S. patent 6,123,975, 2000.
12. Saari, A. L., Langler, J. E., Dechaine, R. C., Monroe, E. R., Bergstrom, J. P., and Kusske, W. P. Method of preparing microwave bread. U.S. patent 5,049,398, 1991.
13. Shukla, T. P. Bread and bread-like dough formulations for the microwave. Cereal Foods World 38:95, 1993.