THE EFFECTS OF GLIADIN FRACTIONS OF VARYING MOLECULAR WEIGHT ON THE MIXING PROPERTIES OF A SYNTHETIC-DOUGH SYSTEM

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ABSTRACT

A synthetic-dough system consisting of gliadin, glutenin, and starch gave a strong mixing curve. When gliadin was replaced by high-molecular-weight gliadin (mol wt = 100,000) isolated by gel filtration, a slightly stronger mixing curve was obtained. In contrast, replacement with gliadin fractions of lower molecular weights (mol wt = 44,000 and 27,000) gave slightly weaker curves. Replacement of gliadin with acetic acid-soluble glutenin or albumin resulted in very weak mixing curves. From these results, it is suggested that the quantitative-molecular-weight distribution of gliadin components in wheat-flour dough systems may be important in determining their properties.

Previous studies in our laboratory have shown that the alcohol-soluble proteins (gliadins) of hard red spring wheat flours can be separated into four distinct fractions (average mol wt 10,000, 27,000, 44,000, and 100,000) by gel-permeation chromatography (1). Significant variations in the quantitative distribution of these fractions were noted in wheats of diverse mixing and baking characteristics. These results suggested that the quantitative-molecular-weight distribution of these proteins in bread wheats may be at least partially responsible for these differences. An attempt was, therefore, made to determine if these fractions differed in their effects on mixing characteristics. Since natural-flour systems are extremely complex, a synthetic-dough system similar to that outlined previously by Murthy and Dahle (2) was chosen. By this method the concentration of natural components could be more easily manipulated and their effects more easily interpreted.

MATERIALS AND METHODS

Alcohol-soluble (gliadin) proteins were extracted by the procedure of Chen and Bushuk (3) from a hard red spring wheat flour (cv. Manitou) with good

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mixing and baking characteristics and then fractionated on Sephadex G-100 with AUC (4) as previously described (1). Each of the four fractions obtained was exhaustively dialyzed against water and freeze-dried. Nitrogen recoveries of approximately 85% from the column were obtained. The protein distribution of each of the four fractions was 37, 17, 41, and 5%, respectively, for fraction 1 (mol wt = 100,000), fraction 2 (mol wt = 44,000), fraction 3 (mol wt = 27,000), and fraction 4 (mol wt = 10,000). All fractions and "whole" gliadin were defatted with chloroform/benzene (50/20:v/v). Protein contents (N × 5.7) were 84.0, 92.2, 84.8, 81.8, and 51.0%, respectively, for whole gliadin and fractions 1–4.

Vital gluten (hard red spring) and commercial wheat starch were obtained from Industrial Grain Products Ltd., Thunder Bay, Ontario. The gluten was tested for denaturation by AACC method 28–20 and found to be vital. Glutenin was extracted from the gluten as previously described by Murthy and Dahle (2).

A synthetic-dough system similar to that of Murthy and Dahle (2) consisting of 0.77 g glutenin, 0.27 g gliadin, 2.00 g wheat starch and water (protein content on dry basis: N × 5.7 = 24.5%) was mixed in an electronic recording dough mixer (5.0-g bowl, 92 rpm) as described by Voisey and Miller (5). The effects of the alcohol-soluble gliadin fractions isolated by gel filtration on the mixing properties of the synthetic-dough system were studied by substituting each fraction on an equal protein basis for "whole" gliadin. Water-soluble (albumins) and 0.1*N* acetic acid-soluble (soluble glutenins) proteins isolated by the procedure of Chen and Bushuk (3) were also included in the study. The amount of water added to each dough system was optimized to give the highest consistency, while retaining the properties of a normal dough. This value was found to be approximately 2.1 ml of water in all cases. Less water gave the doughs a lumpy appearance and more water gave a slack dough.

RESULTS

In order to determine if any physical or chemical changes took place during the fractionation of the alcohol-soluble proteins, the gliadin fractions from a single-column run were isolated as described above and then remixed. Substitution of the reconstituted gliadin for unfractionated gliadin in the synthetic-dough system gave an identical mixing curve. Thus, no noticeable physical or chemical changes detrimental to mixing properties took place during the isolation procedure.

Reproductions of the mixing curves obtained are shown in Fig. 1. Since the proportions of glutenin and starch were constant and the volume of water added was optimized, any changes in the mixing properties of the synthetic-dough system could be directly attributed to the variable component. As shown in Fig. 1, the high-molecular-weight gliadin fraction (mol wt = 100,000) gave the strongest mixing curve as evidenced by its shape and higher consistency. The gliadin fractions of mol wt 44,000 and 27,000 gave weaker curves. Triplicate runs with each of these fractions indicated that the synthetic-dough system containing the fraction of mol wt 44,000 gave a slightly stronger mixing curve than the mol wt 27,000 fraction. Unfractionated gliadin gave a mixing curve intermediate to the high and the two lower-molecular-weight fractions. Substitution of albumin for the gliadin component of the dough system resulted in very weak mixing

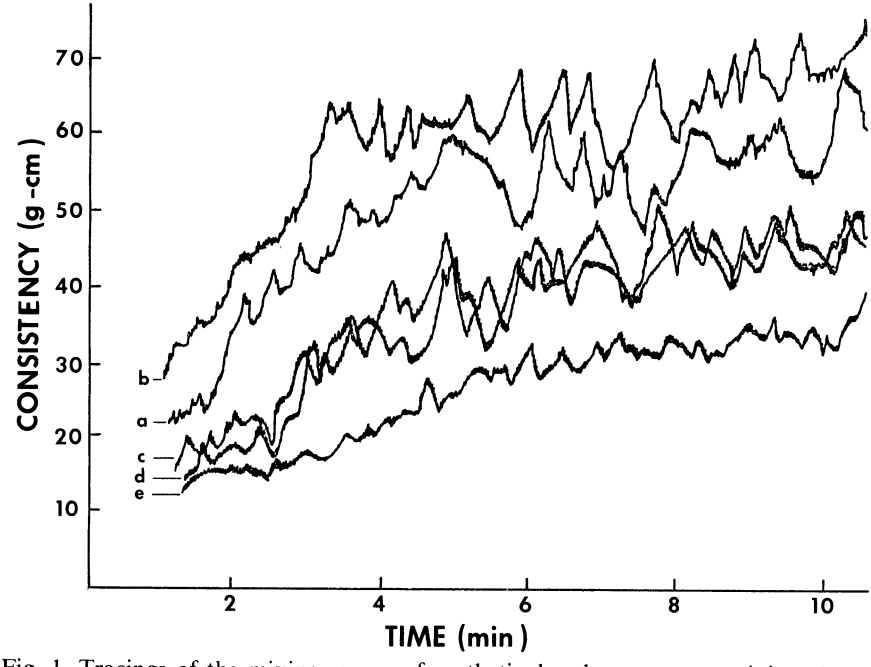

Fig. 1. Tracings of the mixing curves of synthetic-dough systems containing glutenin, starch, water, and **a**) whole gliadin, **b**) mol wt 100,000 gliadin, **c**) mol wt 44,000 gliadin, **d**) mol wt 27,000 gliadin, and **e**) Osborne albumin.

curves (Fig. 1). Equally ineffective was substituting the acetic acid-soluble proteins (soluble glutenin) for gliadin. This resulted in a weak mixing curve almost identical to the albumin (not shown in Fig. 1). These latter results are not surprising since it has long been known that gliadins are required to maintain the unique viscoelastic properties in wheat-flour doughs.

DISCUSSION

The present study shows that in a synthetic-dough system, consisting of glutenin, gliadin, starch, and water, substitution of gliadin fractions varying in molecular weight for "whole" gliadin had significant effects on the mixing properties. Evidence presented indicates that there is a dough-strengthening effect (increase in dough consistency) associated with an increase in the average molecular weight of the substituted gliadin component. Thus it appears that high-molecular-weight gliadins are more effective than lower-molecular-weight gliadins in associating with the other constituents of the dough system, presumably glutenin, giving rise to stronger mixing curves. Although one can only speculate about the actual mechanism giving rise to these differences, one plausible explanation may reside with the larger surface area undoubtedly associated with the higher-molecular-weight gliadins. A larger number of sites would, therefore, be available to interact with glutenin or other components

present in the dough giving rise to stronger interactions and presumably a strengthening effect on the mixing properties of the dough.

Previous studies involving gel filtration, sodium dodecyl sulfate electrophoresis, starch-gel electrophoresis, and amino acid analysis suggested that ethanol-soluble subunits of reduced glutenin may be equivalent to subunits of high-molecular-weight gliadin (6–9). However, in the present study the ability of high-molecular-weight gliadin to effectively replace "whole" gliadin in the synthetic-dough system, in contrast to the deleterious effect of replacement of gliadin with acetic acid-soluble glutenin, indicates that from a functional standpoint, high-molecular-weight gliadin resembles lower-molecular-weight gliadins more closely than acetic acid-soluble glutenin. Thus, even though high-molecular-weight gliadin and glutenin appear to contain similar subunits, their native structures would be expected to be quite different.

Although the present study involved a simple flour-dough system without the inherent complexity of natural-flour doughs, the results suggest that the molecular-weight distribution of gliadins in natural-wheat flours could have a significant effect on their mixing properties. Although no in-depth studies have been published previously which would substantiate these results, evidence presented by Smith and Mullen (10) indicates that at least one factor in the different rheological properties of a long- and short-mixing flour may have been differences in the molecular-weight distribution of their gliadin components. However, further studies are needed to verify these conclusions.

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