Interrelationships of Wheat Protein Content, Flour Sedimentation Value, Farinograph Peak Time, and Dough Mixing and Baking Characteristics in the F₂ and Generations of Winter Wheat, *Triticum aestivum*

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MILLING quality and baking quality have been for a period of years major criteria for determining the values of new varieties of wheat *T. aestivum*, L. em. Thell. Since milling and baking require substantial amounts of both time and grain, expeditious quality tests requiring less grain have been devised. Most of these tests, however, when used individually, indicate the quality of only one of the characters essential for good baking and more than one test is necessary for significant evaluations.

Wheat breeders and cereal chemists recognize the urgent need of a single quality test, significantly correlated with known characteristics essential to bread baking.

Crude protein content of grain has been used for many years as a measure of baking quality. In grain with protein of the same quality, an increase in protein content results in flour with better baking characteristics. The Udy protein analyzer, with procedures modified for increased efficiency (19), has reduced the time required to determine grain protein content.

More recently, the sedimentation test has been used to indicate protein quality (21, 22, 23). Modifications have reduced the flour required for this test from 3.2 grams to 0.8 or 0.32 gram (20), depending upon the available grain and the desired precision. Either of the smaller amounts of flour can be milled from 5 grams of wheat, an amount less than that normally produced by a plant spaced within rows.

Although both the protein and sedimentation tests can be made on grain from a single plant, little information is available on the improvement in protein content and sedimentation value that can be made by selection in the early generations. There is also inadequate information on the association between protein content and sedimentation value and between these two variables and the other quality characteristics of grain from plants and lines in the early segregating generations. The results reported are from research initiated to determine these associations.

**REVIEW OF LITERATURE**

Clark (4) and Clark and Hooker (5) were first to report their efforts to improve wheat protein content. Since then, various investigators (1, 2, 6, 10, 12) have studied the inheritance of wheat protein content and have postulated that from one to eight genes are responsible for its control.

Middleton et al. (15), in comparisons of varieties of red winter wheat over a 3-year period, found 'Atlas 66' to be 3.2% higher in protein content .and higher in yield than the check variety. Since then, Atlas 66 has been found to have a greater protein content than some of the hard red winter wheats. Breeders have used it in an attempt to develop a winter wheat with the high protein content of Atlas 66 and the strong gluten of hard red winter wheat.

Johnson et al. (11) selected some families from the 'Conley' × 'Comanche' cross which produced more grain and protein content than Comanche.

Recently published reports indicate heritability percentages for grain protein ranged from 25 to 82% for F₂ and F₃ families, depending upon the progeny studied and used in calculating the estimate (6, 10, 13, 18).

Sunderman et al. (2) in quality tests of 24 hard red and soft red varieties grown under dryland and irrigated conditions found those grown on dryland had a much higher protein content, sedimentation value, and baking strength. Varieties grown under both conditions had a range of over 20 points in volume and protein content of approximately 150 cc and 2.5%, respectively. The range of differences in sedimentation values was, however, changed from 44 points for varieties grown on dryland to 7 points for those grown on dryland. Still, the range of segregations for the two groups did not show significant correlations of sedimentation values with protein content and loaf volume when varieties were irrigated, but it was higher when varieties were grown on dryland.

Zeleny et al. (23) made mixogram curves and used them to determine values on 159 flours of F₂ generation from a cross of a high protein, strong gluten strain and a low protein, weak gluten strain. Highly significant correlations were obtained between protein content and flour protein stability, and a high correlation was obtained between peak, stability, and valorimeter values for those flour samples. Significant correlations were obtained between protein content and flour protein stability, and a high correlation was obtained between peak, stability, and valorimeter values for those flour samples.

McNeal et al. (14), in a report of the effectiveness of selection for flour absorption and dough-mixing properties, indicated that the flour absorptions showed a highly significant correlation with absorption; but relationships with peak, stability, and valorimeter were in the opposite direction. Stability and valorimeter were highly correlated with each other, and that selection in F₂ was more effective than selection in F₃ in obtaining lines with improved peak, stability, and valorimeter values.

In a study of F₂, F₃, and F₄ lines from a cross with 'Conley,' Lebsock et al. (13) found selection in the F₂ was positively correlated at the highly significant level with mixing tolerance and protein content. Heritability values for the regression of F₂ and F₃ means on F₁ line values were high for mixing tolerance, somewhat lower for protein content, and relatively low for protein content.

Additional research reports concerned with the quality characteristics considered in this paper are available in the literature (3, 8, 16, 17, 22). The degree of heritability reported varied with the pair of characteristics and the varieties used to produce grain for the test or other report under which they were grown.

**MATERIALS AND METHODS**

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