A PHYSICOCHEMICAL STUDY ON GLUTEN OF WHEAT VARIETIES OF DIFFERENT BREADMAKING PROPERTIES

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Reuben Cherukut Butaki

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ABSTRACT

Butaki, Reuben Cherukut. M.Sc., The University of Manitoba, May, 1977. A Physicochemical Study on Gluten of Wheat Varieties of Different Breadmaking Properties. Major Professor: Dr. B. L. Dronzek.

Several physicochemical techniques have been applied to study the properties of the glutens of four wheat varieties known to differ in mixing strength and breadmaking potential. Solubility in dilute acetic acid, viscosity, electrophoresis, amino acid analysis, reconstitution studies and the stretching properties of these glutens, were used to determine the basis for the intrinsic differences in the glutens. The effect of flour protein on gluten properties within the three Manitou and three Glenlea samples was investigated.

The 0.05N acetic acid soluble fraction for the weak variety Talbot contained 90.8% of the total gluten protein. The corresponding values for the other varieties arranged in the known order of increasing mixing strength were: Manitou 79.8% - 84.1%, Norquay 80.1% and Glenlea 68.7% - 70.2%.

The relative viscosity number of the gluten proteins dissolved in AUC (0.1M acetic acid, 3M urea, 0.01M cetyltrimethyl ammonium bromide) for the samples of the strong variety Glenlea ranged from 19.9 - 22.5. The relative viscosity numbers for the other varieties arranged in the known order of decreasing mixing strength were: Norquay 18.3, Manitou 11.6 - 12.8 and Talbot 6.3 Treatment with 2-mercaptoethanol lowered the

relative viscosity values to the following: Glenlea 5.2, Norquay 4.5, Manitou 4.3 and Talbot 3.2

The relative viscosity values of the acetic acid soluble fraction for Talbot and Glenlea were nearly the same.

Adding small amounts of freeze-dried gluten to a weak flour greatly improved the mixograph curve of the flour. Mixing tolerance index of the flour was improved most by the varieties in the following order of decreasing ability: Glenlea, Norquay, Manitou and Talbot.

Disc-electrophoresis of the alcohol soluble protein and Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis of the reduced gluten and reduced acetic acid soluble fraction, revealed differences in the subunit number and pattern between varieties. However, electrophoretic results could not be linked directly with breadmaking potential or mixing properties of the flour.

The four varieties showed similar amino acid composition at each level of sample: grain, flour and gluten. The minor differences in amino acid distribution were insufficient to explain the gross differences in the rheological properties of the flours.

Stretching of the glutens under a constant load revealed the following order of increasing resistance to stretch: Talbot, Manitou, Norquay and Glenlea.

This investigation revealed that for the two varieties Manitou and Glenlea, the acetic acid soluble gluten increased slightly with increase in flour protein. However, viscosity, electrophoresis, reconstitution and stretching studies showed little change in any measured gluten parameter with flour protein. This lead to the conclusion that the

gluten properties were characteristic of the variety and were not affected qualitatively by flour protein.

I. INTRODUCTION

The importance of wheat as a human food cannot be overemphasized. Wheat was one of the main crops of China five thousand years ago. Bread containing a raising agent (leavened) was known in Egypt in 2000 B.C. Today wheat is one of the principal food crops in the world and is consumed in Europe, North and South America, Australasia and Africa.

Wheat is consumed in many different forms in different parts of the world. However, many studies on wheat utilization for breadmaking have been based on the production of the well-risen loaf of bread. This product has been adapted to high technological production. Wheat protein has been found to be mainly responsible for the technological success of wheat in bread production. Consequently, studies on wheat utilization have centred on protein content and protein characterization. The higher the protein content of a flour, the larger the loaf of bread produced from it. This relationship can also apply in comparisons of flours from a single variety but having different protein contents.

Two varieties may have the same protein content, yet one will yield a larger loaf of bread than the other for the same weight of flour. Differences in protein type (gluten quality) between varieties have been cited as the basis for these differences in loaf volume potential. Mixing and other rheological properties between wheat varieties displaying different loaf-volume potential are usually different.

Using the prevalent North American baking processes in comparing pure wheat varieties, it is observed that flours with weak farinograph

mixing curves yield small loaves of bread. Wheat varieties whose flours have strong mixing curves give large loaves of bread. However, flours of some varieties which give very strong farinograph mixing curves also yield bread with low volume and poor crumb texture. The flour of such cultivars is characterized by long mixing requirements and extremely elastic glutens. Inadequate dough development results in the poor loaf volume potential of these flours. In Canada wheat varieties of overly strong and weak type are marketed under the utility class.

When a stiff dough is gently washed under tap water, an elastic insoluble pellet of protein known as gluten results. Glutens, isolated from flours of different protein contents, contain essentially the same protein content. Therefore, protein content differences between flours are eliminated by washing the gluten. Consequently, any physicochemical differences or similarities between glutens reflect the type of protein without the influence of protein content.

This thesis was initiated to study physicochemical differences between glutens of wheat varieties known to differ in mixing properties and breadmaking potential. The varieties and the classification on the farinograph were: Talbot (weak), Manitou (medium strong), Norquay (strong) and Glenlea (very strong). For each of two varieties (Manitou and Glenlea) grain was selected at three different protein contents. Within each cultivar gluten from the three derived flour samples was compared to determine if flour protein affected gluten properties. Consequently, the objectives of this investigation were: to examine any characteristic properties associated with glutens of weak, medium strong, strong and very strong varieties and to determine if these properties were affected qualitatively by flour protein content.

II. LITERATURE REVIEW

A. Flour Protein and Breadmaking Quality

Wheat flour protein is the single most important component that has maintained the technological superiority of common wheat (*T. aestivum*) over other cereals for making bread. The protein content of flour commonly used for bread production is around 12.0% on 14.0% moisture basis. However, the viscoelastic and gas-retention properties of dough during fermentation, resulting in a light soft-textured bread, are due to the protein (Pomeranz, 1968).

Highly significant positive correlations between loaf volume and flour protein is well established. Examples of early work in this field include those by Larmour (1931) and Harris and Bailey (1937). The higher the protein content, the larger the loaf produced from the flour. Sandstedt and Ofelt (1940) reported wide differences in loaf volume at any protein level within pure varieties. These differences increased with increasing protein content. Protein-loaf volume regression lines within pure hard winter wheat varieties were found (Bayfield *et al.*, 1941) to be characteristic of the variety. They concluded that differences in regression lines inferred differences in gluten quality.

Protein content of the flour for a single variety had a large influence on the mixing characteristics (farinograph curves) and loaf volume (Bushuk *et al.*, 1969). In the same study, the loaf volume by the remix baking procedure, was highest for the medium strong variety

and decreased with decreasing or increasing strength as judged by the farinograph test. Finney and Barmore (1948) found that protein content was the major factor accounting for variation in loaf volume within a pure variety. They found that despite the linear relation between these two factors, certain varieties had distinctly different regression lines. These were interpreted to represent differences in protein quality.

The first comprehensive study of wheat flour proteins was made by Osborne (1907). Using sequential fractionation for the classification of proteins, Osborne identified four main fractions on the basis of solubility characteristics. These were albumin (water-soluble and heat coagulable); globulin (salt-soluble); gliadin (soluble in 70% ethanol); and glutenin (insoluble in alcohol but soluble in dilute acid or dilute alkali). The contribution of the different flour protein fractions to breadmaking has received much attention in recent years.

1. Albumins and Globulins

The albumins and globulins have been prepared by various techniques. This soluble flour protein fraction has been extracted from wheats of widely varying baking quality. Studies have been made in an attempt to identify its role in rheological properties of dough.

Pence and Elder (1953) prepared albumins from flour by extraction with a dilute phosphate buffer and separately extracted globulins using 1M sodium chloride solution. The purified albumin consisted of at least six individual components of similar molecular size but different in electrophoretic properties. Three individual components were found in the purified globulin fraction. Bell and Simmonds (1963) differentially

extracted flour proteins from twenty-six wheat samples, ranging in nitrogen content from 1.49 - 2.92%. The solvents used were 0.01M sodium pyrophosphate pH 7.0 and 0.05M formic acid pH 3.5. A negative correlation was found between total nitrogen and the sodium pyrophosphate soluble fraction. In contrast the formic acid soluble fraction and total nitrogen were both positively correlated with baking score.

Mullen and Smith (1965) obtained similar amounts of albumins and globulins from the short and long mixing flours. Characteristic differences in relative amounts of individual electrophoretic components were reported by Pence *et al.* (1954a) between albumins of durum wheat flours and club and common wheat flours. Among the common wheat and club wheat flours, only minor varietal differences were observed. Pence *et al.* (1954b) reported that the water-soluble protein contents of thirty flours of widely varying type and baking quality ranged from 13 - 22% of the total flour protein. Neither the content nor the ratio of soluble: gluten protein was correlated to baking quality.

Several studies have been made on the effects of the water and salt-soluble flour proteins on the baking performance of glutens or flours. Exclusion of the water-soluble fraction from reconstituted doughs caused no reduction in loaf-volume or bread quality (Finney, 1943). However, the soluble flour components were found to be required for maximum performance of all the glutens except that from the durum wheat (Pence *et al.*, 1951). The water-soluble fractions from wheat varieties of widely different flour quality, had similar effects on reconstituted flours (Hoseney *et al.*, 1969a). They concluded that despite its necessity