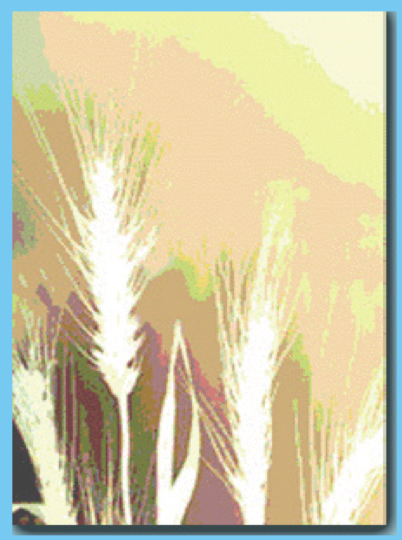

National Associaton of Wheat Growers
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Genetics, Engineering, and Chemistry for Improving the Economies of Wheat:

2. Ethanol-based separation of wheat gluten and starch

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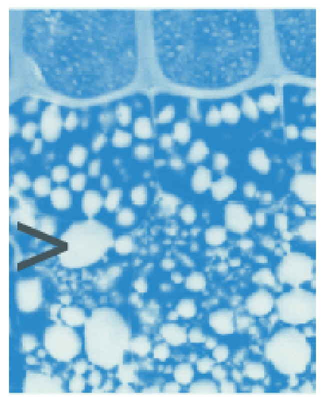
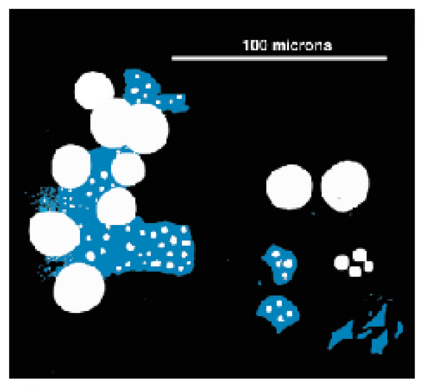
Wheat gluten and starch require separation and purification before being applied to their many uses. The existing gluten-separation industry uses technologies including expensive centrifugal methods, traditional dough-washing methods, and complex pneumatic driers. All technologies are capital and energy intensive and produce a gluten product that is difficult to dry. The US the gluten separation industry produced 170 million lbs (1998) (equivalent to about 2 billion pounds of of wheat). This poster describes a new alternative separation method.

Wheat protein-from-starch separation difficulty arises from the well-mixed native state in the wheat endosperm (A). Milling to a flour (B) is the first step in all methods but this produces heterogeneous populations of largely inseparable particles. All commercial technologies require water to hydrate the protein, raise it above its glass transition, and develop aggregated protein matrix (matrices) to enable size-based differentiation. There is a need to maintain the functionality of the fractions for most uses by preventing process overheating. Large quantities of dilute waste can be produced.



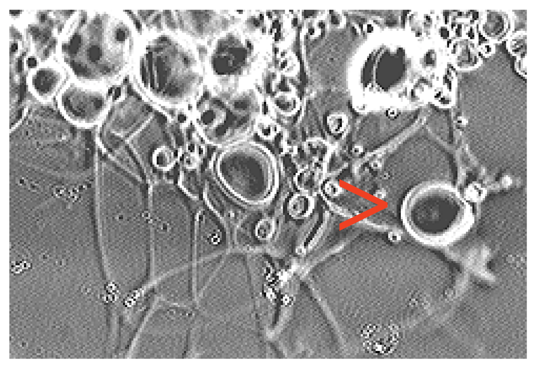
(A) **NATIVE** wheat endosperm is a "well-mixed" distribution of starch and protein as in this micrograph. ("A" starch >)



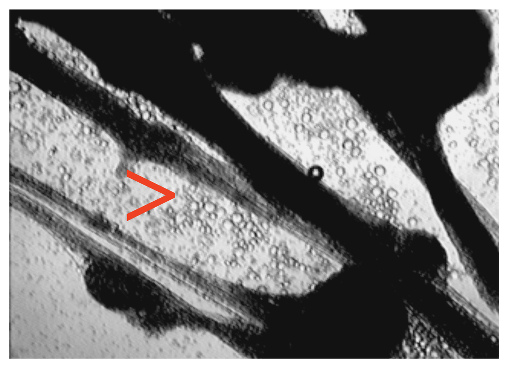
(B) **MILLING** to a flour results in most particles remaining "well-mixed". ("A" starch >)

A WRRC-patented process separates the fractions by using refrigerated, concentrated ethanol to displace starch and water from a hydrated and developed flour batter. In this technology, the displaced starch passes through a screen while the protein is retained. This technology produces a gluten that is relatively easy to dry. The separation is very rapid and suggests energy advantages stemming from the displacement phenomenon. This process has been researched at WRRC using a laboratory Glutomatic™.The effectiveness of the separation has been assessed for a number of factors by computing the overall process separation factor ($\alpha_{p/s}$). The separation factor is ideally a number much greater than 1.

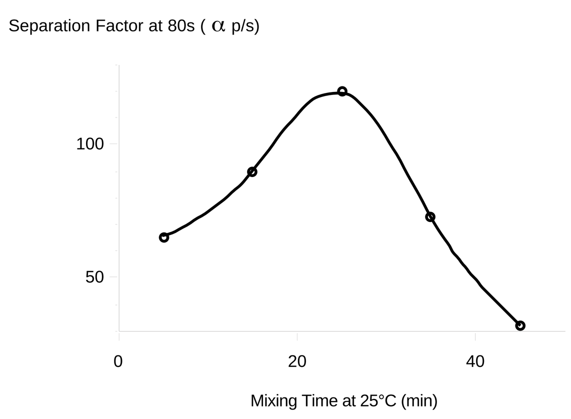
Separate development and displacement steps are used in the WRRC process. Changes occur in each step that lead to separability. During development, water and flour are manipulated in a micro-farinograph. Microscopy reveals hydrated protein microfibrils instantly form in water (C) and slowly aggregate into elastic bands 100 μ dia or larger. At the same time, starch and water collect as a mobile phase (D). Excessive development breaks the protein into smaller segments and reduces $\alpha_{p/s}$. The importance of development is reflected in a maximum separation factor corresponding to the stru



(C) **HYDRATION** instantly forms protein micro-fibrils but does not of itself lead to improved separability without aggregation by mechanical development. ("A" starch >)

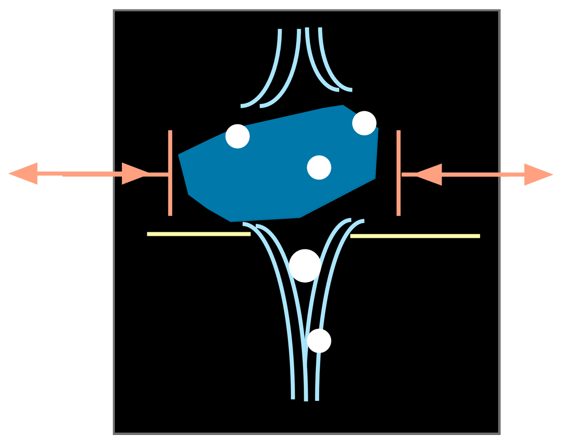


(D) **DEVELOPMENT** induces segregation of protein into macro bands and starch into a mobile water-rich phase. This structure corresponds to the optimum separation at 25 min. These bands break with additional development and inhibit effective separation (see I at right). ("A" starch >)

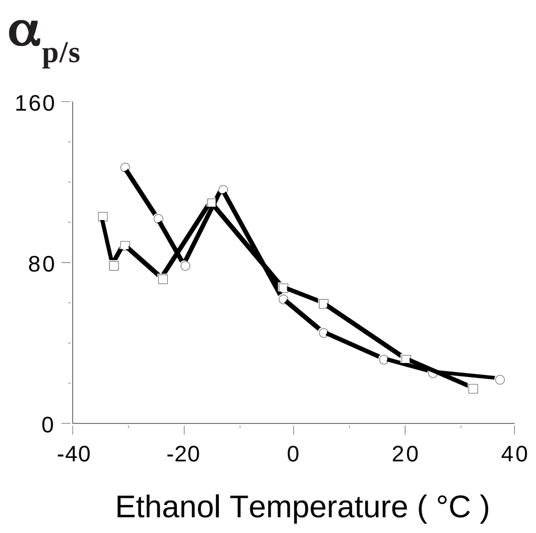


(E) **DEVELOPMENT INDUCED** separation resulting from controlling the development time with optimum separation at 25 min correlatiing with strong protein bands (see D at left).

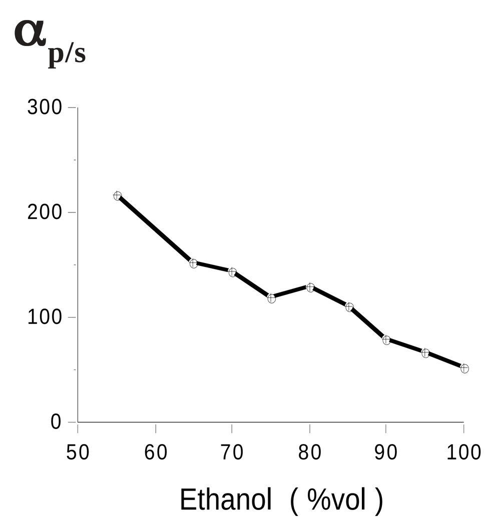
The displacement step capitalizes on the developed segregation by flushing the mobile aqueous starch phase away from the relatively immobile protein and through a perforated support. Additional manipulation by compression and stretching of the matix is required (F). Reduced temperature and increased water content of the ethanol improved the separation. Progressively better separations occured as the temperature was lowered (to -30°C) and correlated with a parallel reduction in gluten disolution (G). Separations were better when some water was present in the ethanol (up to 50% v/v) and correlated with a previously unreported swelling (H) for wheat proteins that is maximum at about 50%v/v. Additional swelling would enhance retention of the protein.



(F) DISPLACEMENT is shown schematically where refrigerated ethanol displaces starch and water during additional mechanical development.



(G) DISPLACEMENT BY COLD ETHANOL improves the separability of the protein and relates to the lowered solubility of the protein.



(H) DISPLACEMENT BY ETHANOL CONTAINING SOME WATER leads to improved separation probably resulting from enhanced swelling.

Gluten produced by the ethanol displacement process is spongy, less elastic, and less cohesive than conventional water-washed gluten . The separation of the ethanol gluten is more rapid and the spongy nature suggests more rapid drying. After drying and rehydration, the ethanol-washed gluten properties are similar to those of water-washed gluten.

(I) Wheat gluten produced by displacement of water and starch by ethanol (left) and by the conventional water process (right).

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References:

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Robertson and Cao US Patent 5,851,301 December 22, 1998. (process description)

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