Wheat Biorefinery: Separation into Gluten and Starch for Food and Bioproducts

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Wheat is produced in surplus to domestic needs with as much as half or the domestic production currently exported. Domestic uses include bread, pasta, cakes, cookies, tortillas, and in a lesser amount refined wheat gluten and starch. The refined concentrates are used to fortify weak flours (gluten), as a binder (gluten), as texturized protein (gluten), in shampoo formulations (gluten), as a feedstock for ethanol (starch), as an abrasive for removal of paint from aircraft (starch), in cosmetics (starch), as a cardboard stiffener and adhesive (starch), as a component of lightweight concrete (starch), and as a component in clamshell packaging (starch).

Diminishing export markets for wheat could be replaced by domestic markets created by further development and expansion of the use of wheat as a source of raw materials for bio-based products including ethanol. The amount of wheat potentially available is on the order of the amount of corn grain currently used domestically for bio-based products including ethanol. Thus a wheat-based bio-refinery might rival in size and impact the corn bio-refinery (corn wet milling industry). Further development of wheat for these markets will depend on improved technology for the disassembly and separation of the grain and the conversion of the refined fractions into useful products.

New markets for wheat may arise from WRRC technologies including ideas for the first step in a new wheat bio-refinery: the separation of wheat starch and gluten. The WRRC methods may replace existing technologies that may be characterized as "recent" and highly capital intensive; or "older", non-standardized, capital intensive and water wasteful. All commercial technologies yield gluten products that are physically difficult to dry. WRRC has developed an alternate technology based on cold ethanol displacement of starch and water from a well-developed batter. The cold-ethanol process promises to improve the technology efficiency and improve the quality of the refined fractions. The text below and the panels to the right summarize the research conducted to date and highlight important aspects of the problem and the technology under development and evaluation.

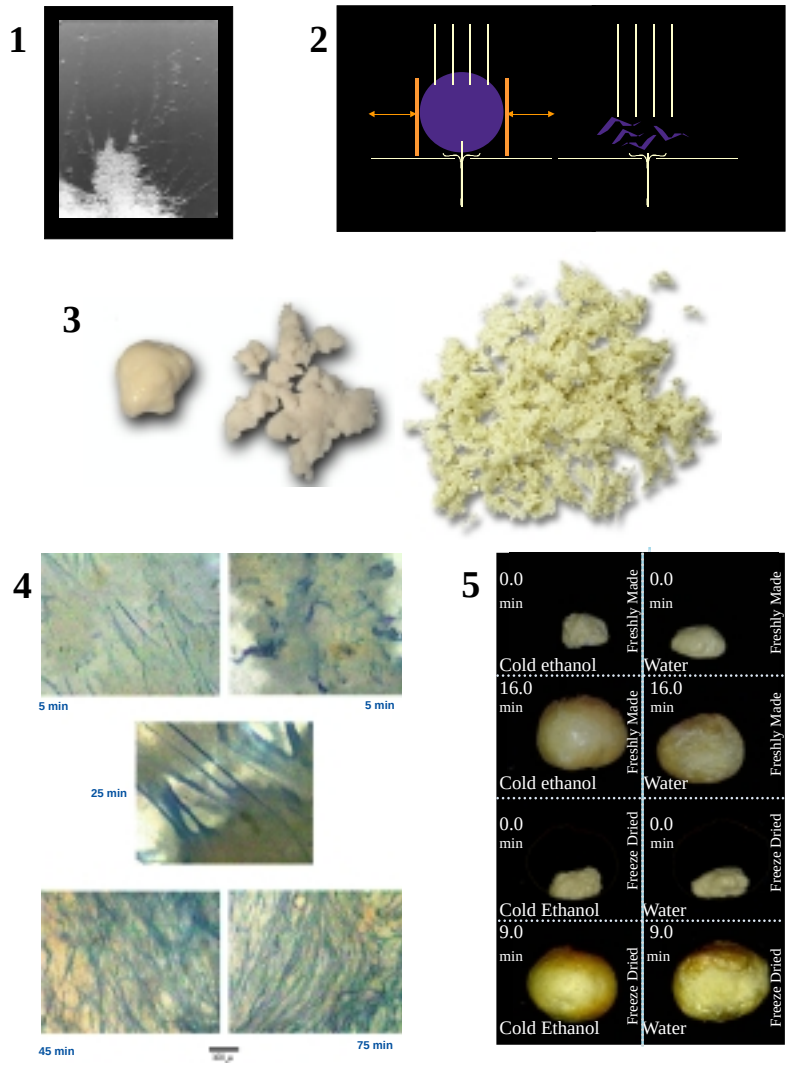
1 When dry, the protein in a wheat flour particles is inseparable from the starch. However in the presence of water wheat protein acquires a high degree of flexibility and elasticity. Even small disturbances such as flow induced by surface tension can draw this protein out into tiny fibrils. These are shown in the micrograph figure at the interface between a particle of wheat flour and a water droplet. With mechanical disturbance (development) these fibrils interact and bind to form cohesive matrices with dimensions much larger than that of the largest starch particle. This property forms the basis of all wheat protein from starch separations.

2 We have discovered that cold ethanol can displace starch from a developed protein network in much the same way that water does. Two separate technologies have been utilized. One, an adaptation of the Martin or dough ball method (left side of figure), flushes a large dough ball with cold ethanol while the dough is being manipulated mechanically. Another, an adaptation of the batter method (right side of the figure) disperses or shreds a developed batter in excess cold ethanol and then washes the cold ethanol from the relatively small protein fragments. In both systems the fluidized starch is carried away from the gluten and passess through a porous supporting base.

3 The physical form of the separated gluten depends on the method of separation. As shown in the figure, the water-based Martin method yields a cohesive, gummy dough ball (left), the Martin-like cold ethanol method yields gluten that is best described as curd-like (middle), and the batter-like cold ethanol method,which also includes more extensive chemical displacement of water, yields a shredded or fibrous product (right). Differences in these gluten forms are attributed to the effectivness of the removal of water from the gluten structure. Both of the forms produced by cold-ethanol processing are exceptionally suited to rapid, low-temperature drying.

4 Development or "mixing" creates segregated starch and protein structures from which the starch can be washed by flooding with a fluid (water or cold ethanol). Our research has found that there is an optimum amount of mixing for subsequent release of the starch and retention of protein. This observation was based on separation experiments, but has been confirmed by microscopy. Microscopic images at different mixing times reveal a unique segregated structure after 25 min (center). This segregated structure corresponds to the condition of best separation. The top subpanel indicates less segregation and the lower indicates development of complex networks that, respectively, allow more protein to be included in the starch fraction or more starch to be trapped in the protein fraction.

5 Conventional gluten quality attributes are important to many applications, Therefore the evaluation of the effectiveness of the cold ethanol method included testing of the relative equivalence of the gluten produced to that produced by an analogous water-based method. We have discovered that there is substantial equivalence when the basis of comparison eliminates high temperature drying. That is to say, samples were tested immediately following separation (and after displacement of ethanol by manipulation under water) or after freeze drying and rehydration. When comparing the ability to extend the stable mixing time in fortified dough in a farinograph, we have found that the freeze dried cold-ethanol gluten produces greater extension than water-based gluten per unit of added gluten. When comparing the ability to produce high volume expansion during baking (baked gluten test), we found that both the cold-ethanol gluten and water processed gluten (freshly prepared (upper four) or freeze dried (lower four)) produced similar volumetric expansions.



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