A Molecular Gastronomer's Dream Come True

A little-known polysaccharide named *konjac flour* may be a molecular gastronomer's dream come true. It's really surprising it hasn't gained more attention because of its unique properties as a *food hydrocolloid*. A hydrocolloid is a substance that controls the movement of water in food, thus increasing the *viscosity* of water, or even turning water into a *gel*, like gelatin.

Dispersions of konjac flour in water at concentrations of 1% are exceedingly viscous. After heating and cooling to room temperature a 1% dispersion of konjac flour, called a *sol*, is more than twice as viscous as the same concentration of a commonly used thickening agent called guar gum. But even more surprising, when the pH of a viscous 1% dispersion of konjac flour is raised to pH 9-10.5 by the addition of a mild alkali, then heated to about 85° C (185° F) for 20 minutes, and cooled, the sol transforms into a very firm, but elastic heat-stable gel. So stable that it will not melt even when placed in a 177° C (350° F) pan or oven!

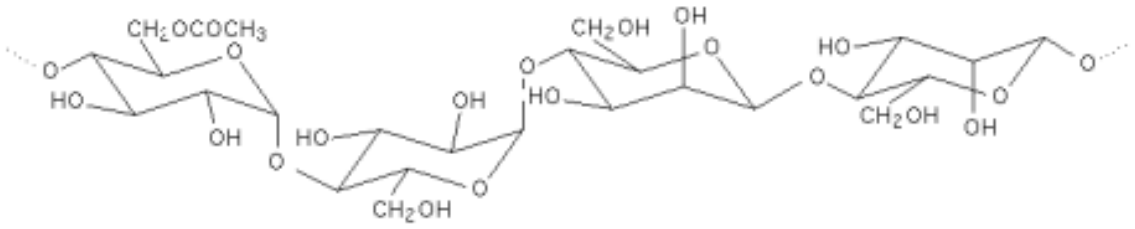
Even more surprising, this firm, heat-stable gel returns to a viscous liquid when cooled to 0°-5° C (32°-40° F)!! This *cold-melt behavior* is just the reverse of most gels that are firm when cold but melt on heating (like gelatin or carrageenan gels). And the process can be repeated. WOW! Reverse ice cream, anyone?

Konjac flour also forms firm, but elastic gels with starch and carrageenan, and extremely elastic gels with xanthan gum (think super-stretchy like the French potatoes aligot). The starch and carrageenan gels are heat-reversible (melt) when formed without alkali, but heat-stable when treated with small amounts of mild alkalis such as calcium oxide, calcium hydroxide, sodium carbonate, and even ground oyster shells. The possibilities for use are almost endless.

Konjac flour has been used in Asia for hundreds of years to form heat-stable noodles and gels. In the U. S. it is classified by the FDA as *Generally Recognized As Safe* (GRAS), and approved for use in meat by the USDA. It has found commercial use in forming heat-stable dessert gels, veggie burgers, and surimi (fish puree), when used at a fraction of 1% by weight. Normally, surimi turns soft and mushy when used in hot foods like seafood chowder. But surimi made with a very small amount of konjac flour, and a much smaller amount of calcium hydroxide (or even ground oyster shells) remains firm and chewy like lobster in hot bisque.

Konjac flour is obtained from the dried tubers of the *Amorphophallus konjac plant* native to many parts of Asia. In its purified form it is a polysaccharide made of mannose and glucose sugars linked together in a ratio of 1:1.6 (called a glucomannan polysaccharide) and a molecular weight that can range from 300,000 to 2,000,000 Daltons (equivalent to 1600-10,000 sugar molecules linked together). The long chains of glucomannan polysaccharides contain short branches of sugar molecules and a small number of acetyl groups ($-COCH_3$)

randomly distributed along the chain, which help provide water solubility. Heating the konjac flour with a mild alkali removes the acetyl groups producing a derivative capable of forming a very heat-stable gel network (see small portion of glucomannan chemical structure below; note acetyl group on left-hand glucose ring; sugar branches not shown).



Like other gelling polysaccharides such as cornstarch, carrageenan, alginates, and agarose, konjac flour was first used in the home, then as a commercial ingredient in processed foods. But unlike other hydrocolloids konjac flour has not been widely adapted by molecular gastronomers despite its amazing properties. Perhaps its time has come.

And finally, one more unusual property of konjac flour not directly related to cooking. When 2% by weight of konjac flour is mixed with 0.02 Molar phosphate solution at room temperature for 30 minutes a viscous dispersion is obtained, as expected. But, when a concentrated solution of various sizes of maltodextrin (hydrolyzed starch) is added, the entire mixture becomes as thin and pourable as milk! Viewed under the microscope it is clear that a *phase-separated polymer system* has been created, with the low-viscosity maltodextrin solution forming the continuous phase, and the konjac flour phase dispersed as droplets[1]. Gelatin and maltodextrin are also well known to form similar phase-separated systems.

But the really unique application occurs when a starch-hydrolyzing enzyme, such as amylase, is added to the watery mixture at 37° C (98.6° F), the mixture becomes extremely viscous again within 1-2 hours! The maltodextrin has been hydrolyzed to glucose forming a single phase thickened by konjac flour. This technology has been applied to the formation of beverages that increase viscosity in the small intestine thus providing satiety, while significantly reducing the absorption of glucose and cholesterol into the blood[2]. Is there a similar application of this technology waiting to be exploited by a clever chef?

Footnotes.

1) Guy Crosby, *Managing Healthy Levels of Blood Glucose and Cholesterol with Konjac Flour,* in Gums and Stabilizers for the Food Industry 11, P. A. Williams and G. O. Phillips, eds. The Royal Society of Chemistry, Cambridge, UK 2002.
2) Valerie Ryan, Chienko Yuan, and Guy Crosby, U. S. Patent 6,733,769, May 11, 2004, *Methods for Lowering Viscosity of Glucomannan compositions, Uses and Compositions.*