Chemistry

Janet Raloff reports from Denver at the American Chemical Society's spring national meeting

No-calorie substitute for flour

It started as a project to make the crop residues fed to cattle and other ruminants more digestible. But the end result may be a no-calorie, high-fiber substitute for flour that can reduce by 10 to 20 percent the caloric value of baked goods.

While ruminants can digest cellulose, up to 40 or 50 percent of that found in straw and certain other feeds is locked into an indigestible matrix by lignin, a natural cement-like polymer, explains chemical engineer Brian K. Jasberg. Realizing, however, that some fungi remove lignin through a peroxide treatment, Jasberg and his co-workers at the U.S. Department of Agriculture's Northern Research Center in Peoria, Ill., worked out a similar process. Bathing cellulosic materials in dilute hydrogen peroxide removes more than half of the lignin. What's left is a more porous cellulose — something they call "fluffy cellulose" — that provides ruminants about the same nutritional value as corn.

Since humans can't digest cellulose, however, it provides them no calories. And that got the researchers thinking about its potential as a source of dietary fiber. They tested it by baking various forms — derived from wheat straw, sugar-beet pulp and citrus pulp, for example — into cakes. Not only did the cakes bake up larger, but because the fluffy cellulose holds more moisture than baking flour, they were moister as well.

Jasberg reports that a panel of 15 trained taste testers couldn't distinguish between chocolate cakes made with baking flour only and those in which 40 percent of the flour was replaced with fluffy cellulose. Jasberg estimates that, depending on the desired moisture content of the baked good, 30 to 50 percent of a recipe's flour can be replaced with one of these cellulose-based fibers. Four companies have been granted exclusive licenses to commercialize baking-flour substitutes based on the USDA procedure.

Making drugs stick to your stomach

Drug capsules and tablets can pass from the stomach and small intestine into the colon within three to four hours of swallowing, notes biophysicist David Harris. And though many drugs have been formulated to slowly release their ingredients over a longer period, not all are well absorbed through the colon. Harris and his colleagues at the University of Manchester in England are pursuing ways to prolong a drug's residence in the stomach by embedding a biodegradable "glue" into capsules of time-released drugs.

In trials with eight volunteers, the researchers tested mock-drug formulations containing a commercially available polymer — either Carbopol-934 or Polycarbophil — that had been shown in animal studies to adhere to the mucous lining of the stomach.

Though the Polycarbophil-based capsules broke down and began exiting the stomach in just 20 to 40 minutes, the Carbopol version in some cases remained for up to nine hours, Harris reports. However, he notes, even the Carbopol-based formulation "was not consistently effective." There are cycles of high and low stomach-emptying activity. And during some of the high-activity periods, Harris says, even the Carbopol-based capsules had a hard time withstanding the stomach's emptying motions. The group is now working on what they believe is an improved formulation: Instead of just blending the bulk resin beads and adhesive powder in a gelatin capsule — hoping they will coalesce into a clumpy drug-glue matrix in the stomach — they are now coating each resin bead with Carbopol. It's expected the beads will survive longer by adhering to the stomach lining individually.

Harris says these formulations could ultimately find use in extending the controlled release of drugs like thiazide diuretics and certain heart medicines.

New sugar may help fat, thin alike

Ongoing research at the Monell Chemical Senses Center in Philadelphia, a nonprofit basic-research laboratory affiliated with the University of Pennsylvania, has been pointing to the liver as a key organ involved in regulating satiety. Organic chemists Michael DiNovi and Robert Rafka were asked to test the underlying hypothesis: that the metabolism of carbohydrates and fats sends out a feedback signal that works to suppress appetite. Results of their new study, involving rats, shore up the hypothesis and point toward a possible noncaloric dietary aid — a sweetener that could help the fat lose weight and the thin gain it.

In the normal metabolism of carbohydrates (including sugars), glucose is converted to fructose, which is then broken down further. The Monell chemists theorized that feeding a synthetic analog of fructose — one that could not be broken down — would block any feedback mechanism involving the liver. So they fed rats such an analog — 200 milligrams of 2,5-anhydro-D-mannitol per kilogram of body weight — just before their normal, nighttime feeding period. And the rats indeed adjusted their diet, cutting food intake 20 to 25 percent. Larger doses curbed appetite even more. However, when the sugar was fed prior to their daytime rest periods, it increased their snacking by 150 to 300 percent.

If this works similarly in humans, DiNovi says, it might — through proper timing — help those who eat too much, or those who eat too little, including the elderly and patients prescribed drugs that affect appetite. However, he notes, human results are not likely to be so dramatic since people, unlike rats, eat for additional reasons besides hunger.

Eyes prefer plasma-coated contacts

More comfortable contact lenses and more biocompatible surgical implants are just two of the envisioned applications for a new plasma-polymerization treatment developed at the University of Missouri's Materials Research Center in Rolla. According to Hirotsugu Yasuda, a developer of the process, not only does an ultrathin (30-nanometer-thick) coating of methane-plasma polymer make "hard" contact lenses more durable, scratch resistant and comfortable, but such coatings could also rescue prospects for silicone rubber as a preferred material for extended-wear lenses. And his preliminary animal studies indicate that this coating, when applied to the polymeric materials used as replacement veins and arteries, reduces their tendency to spawn blood clots.

Yasuda's process involves ionizing methane gas in a 70° to 100°C vacuum chamber. This generates a methane plasma and its polymer — a three-dimensional "network" of amorphous (noncrystalline) carbon containing hydrogen atoms — that coats out to form an ultrathin surface.

In one test, five people were asked to temporarily surrender their "hard" contacts while Yasuda coated one lens in each pair. It wasn't long before these people began complaining to their eye doctor that one of their contacts was bothering them; invariably it turned out to be the untreated lens, the one they had previously worn without complaint. These limited data suggest, Yasuda says, that the coating will make any lens considerably more comfortable.

But their big application may be for the extended-wear market. Here silicone rubber has shown promise, Yasuda notes, because it has better oxygen permeability than any other polymer, good mechanical strength, excellent optical clarity and a physical softness the eyes appreciate. Unfortunately, he adds, it sticks to anything it touches and contributes to the eyes drying out. Yasuda found that by coating the surfaces of these lenses with the new methane plasma, he was able to eliminate both problems.