While people in many parts of the world depend on beans for protein and iron, cooking these nutrient-packed staples takes so long that it can come at considerable costs. In East Africa, for example, people typically cook with charcoal, an expensive fuel, or with wood, which is time consuming to collect. Cooking 1 kg of beans takes upwards of 7 kg of firewood, and gathering enough wood for a household takes about 11 hours per week.

So CSSA member Karen Cichy decided to help ease those personal and economic costs by breeding beans that cook faster.

“I saw a need,” says Cichy, a USDA-ARS plant geneticist based at Michigan State University. “I’ve done international work and have always thought about the importance of beans, especially in East Africa.”

As part of a Feed the Future team funded by the U.S. Agency for International Development (USAID), Cichy is working to boost bean production in sub-Saharan Africa, which is...
the bulk of the continent. The project aims to develop beans that pack more nutrients that farmers will choose to grow and that consumers will choose to eat. Higher yields and stronger disease resistance are obvious characteristics of a better bean, but African farmers also care about cooking time because their customers prize beans that cook fast. Beans that cook faster sell better and fetch higher prices in the market.

“People everywhere in the world want faster meals,” Cichy says. Beans can take an hour or two to cook, and if this makes East African people eat other foods instead, their diets could suffer. East Africans get a lot of their protein from beans, ranging from 15% in Ethiopia to 38% in Rwanda and 55% in Burundi. And all of Africa will soon have more mouths to feed. The continent is the fastest-growing part of the world, according to the United Nations, and by 2050, the population there is projected to double to 2.5 billion—or one quarter of the global population.

Moreover, while beans are good for you, cooking them the East African way with charcoal or wood is not. “Exposure to smoke is bad for the lungs, especially in an enclosed space,” Cichy says. “People often cook in the same place where they live and sleep.” According to the World Health Organization, cooking with wood contributes to more than 4 million premature deaths worldwide, particularly among women and children under five years old. Cooking with wood also contributes to deforestation and, by adding carbon to the air, climate change.

15-Minute Beans

When Cichy began her quest for quick-cooking beans in 2012, she was a pioneer. “No one was breeding for this trait,” she says. One of her first tasks was figuring out how to measure cooking time, and she settled on a device that dates back to the 1950s: “We had to have it custom-made by our machine shop.” The device has a circular plate with 25 wells for beans, which are held in place with long, weighted pins (see photo above). “The whole thing goes into water and is cooked,” she explains. How can she tell when the beans are done? “The pins drop and pierce the beans when they’re soft,” she continues. While the process is slow, at least people don’t have to watch for the pins to drop the way they used to. Instead, the device is hooked up to a computer, which records cooking time based on sensors that are activated when the pins drop.

Focusing initially on kidney, cranberry, and other beans favored in Africa, Cichy screened strains for cooking time. Her effort paid off big time: she found beans that—after presoaking for 12 hours—cook in just 15 minutes. As anyone who’s ever gone to the trouble of cooking beans will know, that’s astonishingly fast. “It’s really exciting,” she says. Now she’s incorporating these strains in her breeding program to develop quick-cooking beans that also grow well and have good yields. And, of course, she also wants to know why some beans cook so much faster than others.
To find out, Cichy and her collaborators are investigating the genetics and biochemistry of quick-cooking beans. “We don’t know how many genes control the trait, but it’s highly heritable,” she says. This suggests that perhaps just a few genes are involved.

Bodo Raatz, a plant breeder at the International Center for Tropical Agriculture (CIAT) in Colombia, is also working to sort out the genetics of quick-cooking beans. His focus is types popular in southern Mexico and Central America where people get 10 to 15% of their protein from beans such as small reds and blacks. “Cooking time is important for us primarily because of its relevance to consumer acceptance,” Raatz says. “To achieve impact, our materials have to be adopted by end users, mostly smallholder farmers who require good performance on traits like cooking time.” At just a year into the study, he has yet to identify any of the genes that make beans cook faster. But when he does, his goal, like Cichy’s, is to breed them into new varieties of beans.

Cichy also wonders why there are genetic differences in cooking time in the first place. “It’s not relevant to the bean,” she points out. “Does the trait confer an advantage?” And she thinks she may know the answer: to beans, the 12-hour soak is like getting ready for germination, and the trait that makes beans germinate faster may also make them cook faster. “It was like a revelation to me, an ‘aha’ moment,” she says.

A clue to the biochemistry behind the quick-cooking trait is that when beans are younger, they generally cook faster. This is because their cell walls are relatively tender. As beans age, however, a compound in the cotyledon—which becomes the first leaves when a bean sprouts—breaks down, indirectly strengthening the cell walls. The compound is phytic acid, which stores phosphorus for young plants but also binds ions including calcium and magnesium. When the phytic acid in the cotyledon breaks down, it releases calcium and magnesium, and these divalent cations then crosslink polysaccharides in the cell wall, toughening it. “This is a big contributor to the increase in cooking time with age,” Cichy says. “Is the same mechanism involved in beans selected for faster cooking times?”

Crop Science Society of America President Mike Grusak, who like Cichy is part of the USAID Feed the Future Bean Research Team, is helping her find out. “We’re trying to tease out the mineral component of beans that cook faster,” says Grusak, a USDA-ARS plant physiologist and professor at Baylor College of Medicine in Houston. “Cooking time is based on softening of beans,” he explains, “and because minerals come into play with linkages in cell walls, we think they may affect cooking time.” If he’s right, the next step will be to identify genes that control mineral composition and then breed beans accordingly. “We’d like to increase minerals in the beans to begin with and also keep cooking time to a minimum,” he says.

Nutrition Boost

But are beans that cook faster still as good for you as their slow-cooking cousins? “We’re trying to maintain or enhance their nutrition,” Grusak says. So far, it looks like beans that cook fast are even better for you. For one thing, Cichy says, they tend to have a little more protein. And Grusak has found that they also have more iron and other essential minerals. Minerals can be water soluble and so can leach out in cooking water. But because quick-cooking beans spend less time in water, they lose fewer minerals. “That’s good for everyone, whether they’re in Africa or here in the U.S.,” says Grusak, who enjoys beans so much that he goes through periods of eating them for breakfast.

Iron is one of the most important minerals to track. Iron deficiency is the most widespread nutritional dis-
order worldwide—more than half of pre-school-aged children in Rwanda, for example, are anemic—and beans are a major source of this mineral for at-risk populations in Africa and Latin America.

But just because beans that cook faster contain more iron that doesn’t mean they provide more of this essential mineral to people. So CSSA member Ray Glahn is assessing quick-cooking beans for iron bioavailability with an assay that mimics digestion and iron uptake in people. “When we consume food, it hits our stomachs and is acidified to start the break-down process. Then enzymes in the small intestine attack it,” says Glahn, a USDA-ARS nutritional physiologist based at Cornell who, along with Cichy and Grusak, is part of the USAID Feed the Future Bean Research Team. “In our bioavailability studies, we reproduce digestion in test tubes and then essentially feed these digests to human intestinal cells grown in culture.”

Like our stomachs, the assay breaks down food by coupling an enzyme called pepsin with an acidic environment. “Anything you could cook and feed to a person, you can feed to our bioassay,” he says, adding that testing nutrient bioavailability in cell culture is far cheaper than in people at roughly 1% of the cost of a similar study in people. How do you cook for cultured intestinal cells? “We run beans through an autoclave, which is rapid and clean; then they’re freeze-dried and ground into powder,” Glahn says. Altogether, the assay for digesting bean powder takes four to five hours.

Iron bioavailability is naturally higher in beans with a lighter-colored seed coat or skin. Compared with beans with white and yellow skin, those with red and black skin contain more compounds that bind iron and keep our digestive systems from absorbing this nutrient. That said, “Iron bioavailability tends to be higher in faster-cooking beans of any given color,” Glahn says.

Why would iron be more bioavailable in quick-cooking beans? “Perhaps the cell wall of fast-cooking beans is not quite as strong, and as the bean is cooked and digested, more iron is released and available for absorption,” Glahn says. “Breeding for faster cooking time now appears to be a strategy for enhancing nutritional quality—this represents a double benefit for consumers and for growers...”

Taste Test

So far so good, but are beans that cook faster as tasty as their slow-cooking cousins? “It’s a really important question,” Cichy says. “We’re starting a study on flavor with a major U.S. bean processor.” Grusak explains that U.S. bean processors care about bean cooking time because it affects their bottom line: “They don’t want to be cooking them forever because the cost margin on beans is so low.”

Cichy is also working with CIAT’s Bodo Raatz on the canning quality of beans. “It’s a related trait, based on cooking time, texture, and visual appearance,” Raatz says. Beans with better canning quality are more attractive to processors, giving smallholder farmers another market for their crops. “Market access is a major driving force of poverty reduction,” he says.

Besides helping to raise the standard of living and bolster nutrition in East Africa, beans that cook faster would also benefit those of us in the U.S. who make them from scratch. Much as she likes eating beans herself, even Cichy doesn’t always take the time to cook them. “A bean bag says they take one to two hours to cook,” she says. “A rice bag says 15 to 20 minutes—if we could put a time like that on bean bags, people here might buy and cook them more.”

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