Pumping Iron Into Western Africa's Corn

Iron deficiency anemia is endemic throughout western Africa. It afflicts more than half the children and 61 percent of childbearing-age women in Nigeria. In Burkina Faso, 70 percent of children under age 5 and 40 percent of pregnant women are anemic.

Iron is essential to the formation of hemoglobin, an important oxygen-carrying component of red blood cells. Iron deficiency can retard mental development and impair physical growth in children and adolescents and often leads to anemia, which is a deficiency of red blood cells. Anemia can lower disease resistance, complicate pregnancies, and reduce capacity for physical labor.

Preventing iron deficiency and anemia in resource-poor areas is extremely difficult, as people have little choice but to eat foods low in bioavailable iron, and fortification programs are not available.

Undaunted, scientists at ARS' U.S. Plant, Soil, and Nutrition Research Laboratory in Ithaca, New York, and a Nigeria-based international agricultural organization have teamed to meet this challenge. They have made maize, one of the region's staple crops, the centerpiece of their work.

Improving a Good Thing

Through a process called biofortification, the researchers seek to boost the nutrition that western Africa's residents get from maize by simply making available—and popular—the iron-rich varieties already bred, grown, and consumed there.

"People in many areas of western Africa are eating maize that is not as nutritious as other varieties because it has low levels of available iron that the body can absorb during digestion," says the project's leader, Ithaca-based ARS human physiologist Raymond P. Glahn. "We need to get maize to them that has more bioavailable iron. We estimate they need to absorb about 20 to 30 percent more iron from maize than what they are currently getting."

This can be accomplished through conventional plant breeding, he says. "But the starting point is identifying the iron-rich strains already growing in the region and finding which of those strains are most adaptable to all the region's land and climate zones."

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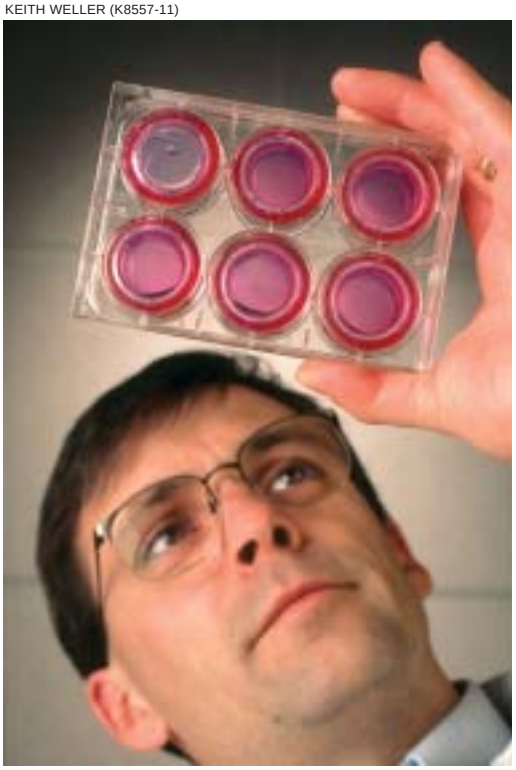

In the late 1990s, physiologist Raymond Glahn developed the so-called artificial gut (several shown here), which allows researchers to simulate human digestion and nutrient absorption in the laboratory. He used the invention to screen 69 corn varieties for iron bioavailability to find those that might help battle iron deficiency in western Africa.

Finding the Best of the Best

The project combined the regional agricultural knowledge of the International Institute of Tropical Technology (IITA), which is headquartered in Idadan, Nigeria, with some of ARS' latest technology, namely an in-vitro artificial gut Glahn invented during the late 1990s. (See "A Gut Issue—Measuring Iron Bioavailability," *Agricultural Research,* August 1999, p. 4.) The model mimics human digestion to the point where nutrients are actually absorbed by a line of human intestinal cells.

The scientists used the artificial gut to evaluate and rank iron bioavailability in kernels of elite maize varieties grown in diverse environments. They examined 69 corn varieties that have historically shown acceptable results in grain yield and disease resistance.

"The model is what made this research possible," says Glahn. "You could not do what we did—screen a whole library of maize samples—using human or animal subjects, as the costs would be enormous."

Glahn began the project after being inspired by recent studies showing that significant differences exist in iron concentration in maize kernels. According to Sylvester O. Oikeh, an IITA soil fertility and plant nutrition specialist assisting Glahn in Ithaca, those differences were due to genetic differences and to the environments in which the germplasm was grown.

Oikeh adds that maize was chosen for the project because per capita consumption of the crop in western Africa is 66 to 216 pounds a year. Maize kernels there are processed into pastes, gruels, and porridge. Green maize serves as an important vegetable crop to bridge a "hunger gap" that occurs each year after the long dry season. It is eaten boiled or roasted on the cob.

Most of the region's rural population relies on cereal- and legume-based diets as their major sources of essential micronutrients.

IITA is an independent organization that conducts research, germplasm conservation, training, and information-exchange activities in partnerships with regional bodies in sub-Saharan Africa. It employs about 80 scientists from more than 30 countries. Oikeh says the Nigerian government collaborated with IITA on this maize-enhancement project.

A Gathering From Near and Far

IITA grew the maize in three climate- and elevation-distinct regions: Ikenne, a forest environment along Nigeria's southern part that is about 180 feet above sea level with a yearly rainfall of about 55 inches; Mokwa, in the southern Guinean savanna, which is 650 feet above sea level and gets an annual rain total of about 47 inches; and Saminaka in the northern Guinean savanna, which is at an altitude of 2,000 feet and receives 35 to 47 inches of rain yearly.

Once transported to Ithaca, dried maize samples were ground to uniform fine powders and stored at 4˚C (39.2˚F) before being analyzed in the artificial gut. The strategy was to measure both the iron content and the availability of the iron.

"Improving maize or any other crop as a source of iron involves improving the iron content while maintaining iron bioavailability, improving that bioavailability, or better yet, both," says Glahn. Results indicate that the selected varieties show promise, but much more work remains.

"A much greater increase in iron bioavailability needs to be developed in these lines to ensure nutritional impact," says Glahn. "We also need to monitor the stability of the genetic differences over consecutive growing seasons and across regions."

The next step is a series of artificial gut screening trials coupled with animal and human trials to verify the success of the breeding program.

"Biofortification will produce better crops that are acceptable to both farmers and consumers," Glahn says. "In this situation, we want to use traditional breeding techniques, as they are more acceptable to the consumer, thus increasing the likelihood of success. Furthermore, biofortification is a more sustainable approach and can be done and maintained for a fraction of the cost of other fortification programs."

Glahn adds that similar testing has begun with wheat and rice from other parts of the world and that other vegetable and staple crops will be subjected to the research as well.—By **Luis Pons,** ARS.

This research is part of Human Nutrition, an ARS National Program (#107) described on the World Wide Web at www.nps.ars.usda.gov.

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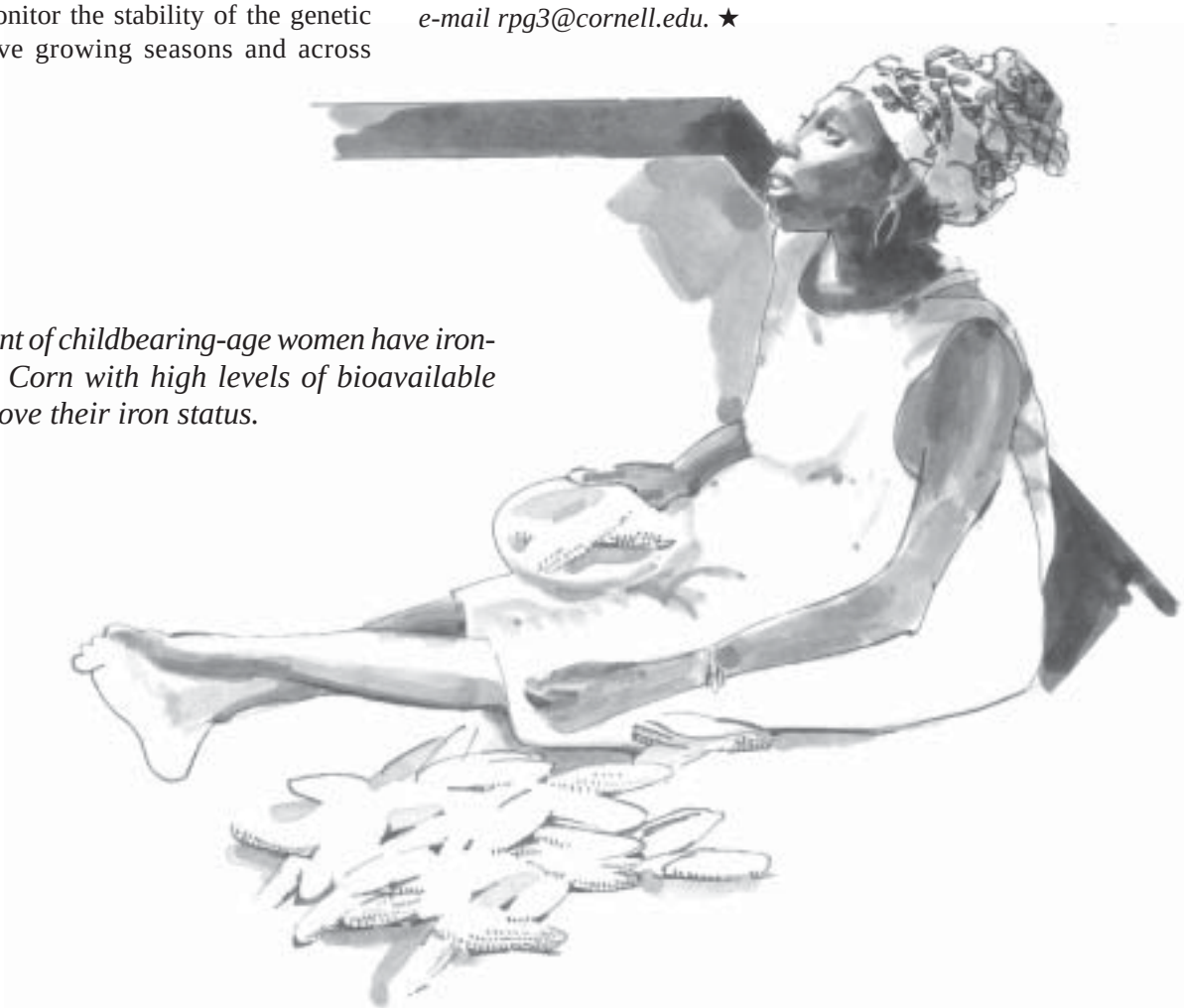

In Nigeria, 61 percent of childbearing-age women have iron-deficiency anemia. Corn with high levels of bioavailable iron may help improve their iron status.