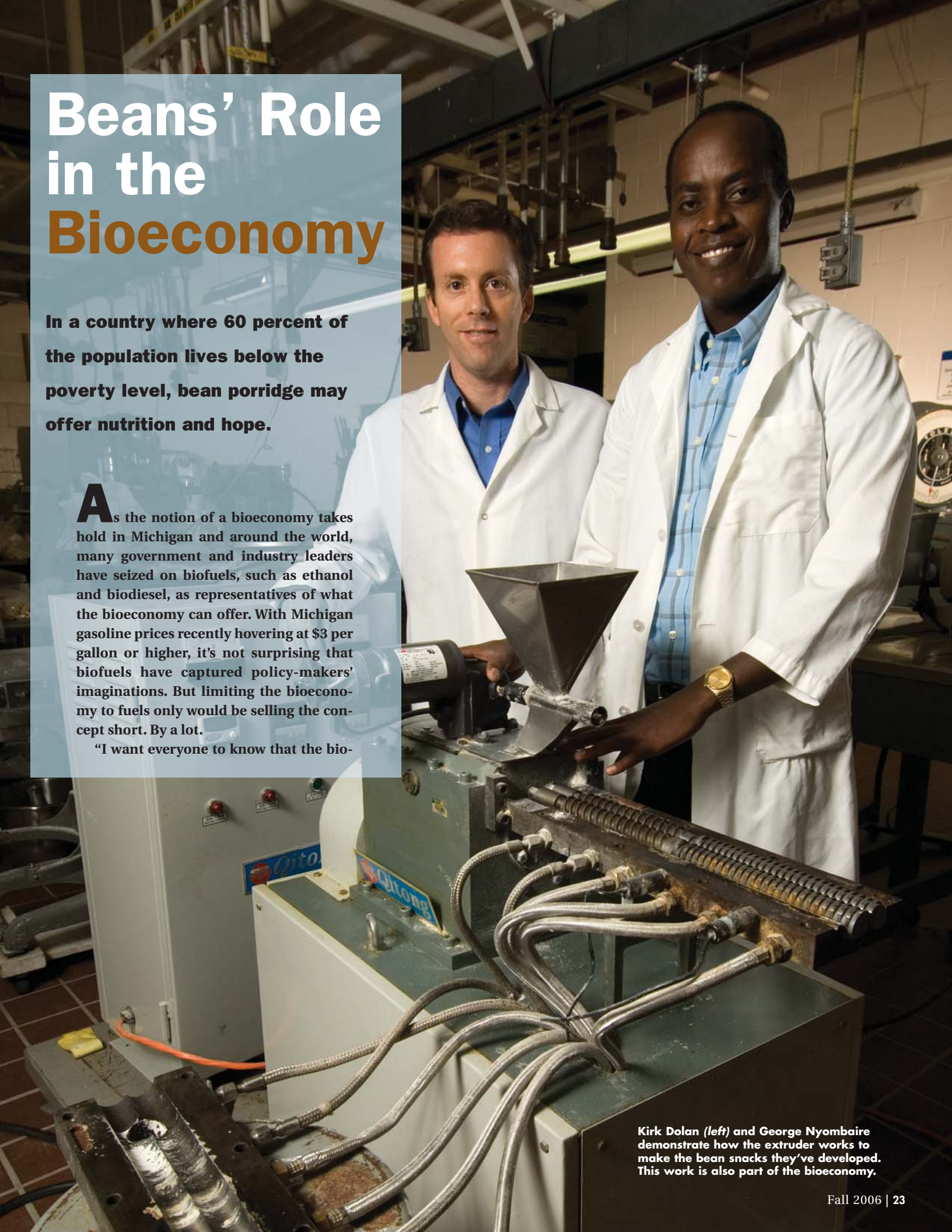
Beans' Role in the Bioeconomy

In a country where 60 percent of the population lives below the poverty level, bean porridge may offer nutrition and hope.

As the notion of a bioeconomy takes hold in Michigan and around the world, many government and industry leaders have seized on biofuels, such as ethanol and biodiesel, as representatives of what the bioeconomy can offer. With Michigan gasoline prices recently hovering at $3 per gallon or higher, it's not surprising that biofuels have captured policy-makers' imaginations. But limiting the bioeconomy to fuels only would be selling the concept short. By a lot.

"I want everyone to know that the bio-



Kirk Dolan *(left)* and George Nyombaire demonstrate how the extruder works to make the bean snacks they've developed. This work is also part of the bioeconomy.

After the beans come out of the extruder, they're a crunchy snack that can be eaten as is or ground into a powder, which can be stored safely for long periods of time in plastic packets. The powder is mixed with hot water to make a nutritious porridge.

economy is more than just ethanol — it's more than just fuels," said Steven Pueppke, MAES director, who is also director of the MSU Office of Bio-based Technologies. "It's about making plants more valuable."

Kirk Dolan, MAES food science and human nutrition and biosystems and agricultural engineering researcher, studies processing techniques for new food products. He and graduate student George Nyombaire have developed an extruded bean product that may help ease some of the hunger and nutritional deficiency issues in Rwanda, Nyombaire's native land. This work is also part of the bioeconomy.

"George wanted to focus on a bean product because developing more products that use beans is one of Rwanda's priorities," Dolan explained. "But this is also a new healthy and nutritious product for Michigan consumers and represents a new market for Michigan bean growers. One of the ideas behind the bioeconomy is to offer farmers higher value uses for their crops."

Nourishing Rwanda's Recovery

Land-locked in the east African hill country, Rwanda is both one of the most densely populated and one of the poorest countries in the world. More than 60 percent of Rwanda's population lives below the poverty level.

In 1991, civil war erupted in the northern province of Byumba. In April 1994, the war exploded into one of the most tragic events in modern human history — more than 800,000 Rwandans were slaughtered by their countrymen from April to July.

Today, as the country struggles to emerge from the physical and emotional wreckage of genocide, feeding its people nutritious, healthy food is a top concern for Rwanda's leaders. At the same time, they also need solutions for environmental issues such as deforestation, soil erosion and soil nutrient depletion.

The extruded bean product offers an elegant solution to both nutritional and environmental issues, all wrapped up in one tidy plastic packet.

"Rwandans eat more beans than anyone else," Nyombaire said. Before he came to MSU, Nyombaire was an agriculture faculty member at the National University of Rwanda in Butare in southern Rwanda. His research is also funded by project PEARL (Partnership for Enhancing Agriculture in Rwanda through Linkages). PEARL was conceived and launched by Dan Clay, director of the Institute of International Agriculture at MSU. Backed by U.S. Agency for International Development funding, PEARL is working with Rwandan agricultural institutions to rebuild the country's educational and research capacities. "Each person eats about 60 kilograms [a little more than 130 pounds] of beans per year. In the United States, people eat about 3 kilograms [about 3.5 pounds] per year."

"Beans are to Rwanda are what breads are to the United States," Dolan added.

But beans also are contributing to the country's environmental woes. Because Rwandans don't soak the beans before cooking, the beans have to be boiled for about 5 hours. To cook beans, people are stripping the countryside bare, chopping down trees for firewood. Even though cutting wood has been outlawed, people continue to do it. They need to eat.

Storing the beans is also a problem.

"There's a huge weevil problem in Rwanda," Dolan explained. "About 40 percent of beans are lost each year to insects, animals or spoilage."

About 90 percent of Rwanda's people are subsistence farmers. Families have, on average, a half-acre of land on which to eke out a livelihood. Any crop loss means less food for people.

Nyombaire's innovative solution grinds the beans and then runs them through an extruder, a machine akin to a giant Play-Doh Fun Factory for food. Most processed foods — such as breakfast cereals, snacks and crackers — are made with an extruder. The extruder cooks the bean dough and then presses it out through a small hole known as a die. The bean product is fully cooked and looks somewhat like a small rope of dried cereal. It can be eaten as is or ground into a powder, which can then be stored safely for long periods of time in plastic packets.

Before Nyombaire's research, no one in Rwanda was using or had considered using an extruder to make food products. Typical American or European extruders can cost $100,000 or more, which is too expensive for Rwanda.

"That's really more than this project needed, both cost-wise and technology-wise," Dolan explained. "We wanted something simple and inexpensive that was easy to operate. I was having a

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conversation with Maurice Bennink [MAES food science and human nutrition researcher], and we started talking about inexpensive extruders made in China. We thought they would be very suitable for what we were doing in Rwanda, so we ordered one.

"This really isn't competition for U.S. extruders," he added. "It's like comparing a go-kart to a real car — there's no comparison."

After some modifications in the biosystems and agricultural engineering lab to make the extruder suitable for food use, Nyombaire was ready to begin production.

"The beauty of George's solution is that the bean product is a safe product," Dolan said. "It's dry and fully cooked and is resistant to microbial spoilage, and animals and insects can't get into it. Many times harvested beans are stored under tarps or piled in corners, so it's easy for them to become contaminated. The extruded bean product solves all those problems."

The powder can be mixed with some warm water and a little bit of sugar to make a rather tasty porridge, similar in texture to grits or Cream of Wheat. The bean product is also nutritious, containing 22 grams of protein, 1 gram of unsaturated fat and 24 grams of fiber per 100 grams of product.

"The protein in beans is rich, high quality protein," Nyombaire said. "We think this is a really nutritious product that people will enjoy eating. We are also investigating adding sweet potatoes to the mix. This would add beta carotene, a form of vitamin A, to the product, which would help reduce that nutritional deficiency."

Approximately 250 million children are at risk for vitamin A deficiency worldwide, and about 4.4 million preschool-age children have visible eye damage due to this deficiency. African countries have particularly high levels of vitamin A deficiency.

And though the extruder cooks the beans, it takes much less money, energy and firewood to make the extruded bean product and mix up the porridge than it does to cook the beans for 5 hours as people do now.

"Using electricity is far cheaper and safer than using firewood," Nyombaire said. "Using the extruder also reduces air pollution from the smoke from the cooking fires."

According to Dolan and Nyombaire, a company could be set up to make the bean product in Rwanda.

"You'd need a consistent electrical supply, three pieces of equipment — a grinder, an extruder and a packaging machine — and a room to put the equipment in," Dolan said. "It would probably cost about $20,000. It wouldn't be easy, but this gives entrepreneurs, or the government or even a cooperative of farmers a plan to follow. Creating information like this is a good role for the university — this can improve people's health, give them a better quality of life, and help the economy and the environment."

The Final Test: Do People Like It?

In May 2006, Nyombaire spent time in Rwanda conducting taste tests on the bean porridge and the dry extruded bean product as a snack. Though many Rwandans are accustomed to eating porridge, he wasn't sure how people would react to eating porridge made from beans or to the dry snack food.

"We got very good results," he said. "I made up the porridge and didn't tell people what it was made from. They liked it and guessed that it was made from corn, millet, sorghum or wheat — they didn't believe me when I told them it was made from beans."

The scientists had some concern that the porridge might have a bean flavor that wouldn't be pleasing to potential consumers.

"The anecdotal evidence points to a loss of bean flavor during extrusion," Dolan said. "We thought the cooking reduced the 'beaniness' of the porridge, but we weren't sure what the Rwandan consumers would think. All the testing went really well."

Nyombaire took the bean porridge and snack to the National University of Rwanda Hospital and asked women who had just given birth to try them. He also went to elementary and middle schools. The results were unanimous: everyone enjoyed them. Nyombaire didn't have the opportunity to test the product among adult men, but the results bode well because women make most of the meal selections in Rwanda.

"If the product is going to be marketed, you'd want to do a lot of demonstrations, especially for the snacks," Dolan said. "There might be a little education needed there because that's not really similar to anything Rwandans eat right now."

As Nyombaire finishes his degree, he is excited about the possibilities for helping Rwanda.

"People, especially women, can form associations and buy extrusion equipment," he said. "They can process and sell extruded bean products and make money to pay medical bills and school fees for their children. In doing so, they improve the nutrition of Rwandans and at the same time boost the economy of the country."

::: Jamie DePolo