Personal Genetics Education Project

Ethical, Legal and Social Issues in Personal Genetics

SNAPSHOT

Could a Deadly Disease be Prevented by Editing the Genome of the Cassava Plant?

Adapted from pgEd's lesson plan:
Engineering the World Around Us: Genome Editing and the Environment

HARVARD MEDICAL SCHOOL | BLAVATNIK INSTITUTE GENETICS

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The Big Picture

- The cassava plant, an important food source for 800 million people worldwide, naturally produces a toxin that can cause Konzo, a disease that leads to paralysis and can potentially be deadly.
- Might Konzo be prevented by editing the genome of the cassava plant to produce less of the toxin that causes the disease?

In the past decade, scientists have developed new tools for editing the DNA of living organisms. This technology offers new approaches to improving human health, crops, and the environment. While these genome editing tools are powerful, not everyone agrees that they should be used or that the benefits would outweigh potential unintended negative consequences. Konzo, a potentially deadly disease caused by toxins in the cassava plant, provides a powerful example.

What is cassava and how does it cause a disease called Konzo?

Cassava is an important food crop, eaten by over 800 million people, and increasing in popularity worldwide – for example to make the tapioca pearls in bubble tea. One of the reasons for its popularity is that it can grow in dry and nutrient-poor soil where many other crops would not survive. While it is a common food crop, the cassava plant naturally produces a toxin. The drier the soil cassava grows in, the more toxin the plant produces. Eating these toxins can lead to Konzo, a disease that causes paralysis, organ damage, and potentially death.

Cassava is safe to eat when it is eaten as part of a protein-rich diet and when it is processed properly, such as by soaking it in water for a couple of days. While these solutions seem relatively simple, neither of these is easy in certain regions of the world where Konzo is prevalent. Why? Because European colonialism left behind extreme

poverty in many regions where cassava is grown and eaten, such as the Democratic Republic of Congo (DRC). Here, access to water and protein-rich foods can be scarce, especially as the problems of drought worsen. Even with access to water, waiting several days to soak cassava is not possible for people who are urgently hungry. Additionally, people suffering paralysis caused by Konzo are often unable to make the trip to the nearest river or well to collect the water needed for soaking the cassava. For these reasons, Konzo is considered a disease of poverty, and Konzo maintains the cycle of poverty as people with the disease lose the ability to work.

How might genome editing help improve health and reduce disease for people who rely on cassava?

Two genes are primarily responsible for the production of toxins in cassava. Scientists have proposed using a genome editing technique called CRISPR to make specific changes to these genes with the goal of reducing the plant's toxicity. One major advantage of using CRISPR to introduce genetic changes is that it is much faster than traditional breeding methods. Furthermore, CRISPR technologies can be narrowly applied to local varieties of the cassava plant, thus hopefully maintaining characteristics of the plant that make it well-suited to the region where it will be grown.

What are the risks and benefits of using genome editing to lower cassava toxicity?

While researchers think they can reduce the toxicity of the cassava plant by editing its genome, many questions remain. The cassava's toxicity appears to be correlated with its ability to tolerate drought, as the drier the environment is, the more toxin the plant produces. One of the risks to consider is the possibility that edits to reduce toxicity could negatively affect the plant's drought-tolerance. Furthermore, cassava's toxicity is thought to provide a defense against insects. Could the edited cassava plants require farmers to use pesticides in order to grow their crop? Lastly, what will the economic implications be? Who will own the plants as well as the seeds of the edited cassava? Will farmers be able to afford this new crop?

Genome editing is one possible solution to the problem of cassava toxicity, but are there other possible approaches? Could scientists use conventional breeding methods to choose cassava varieties with specific beneficial genetic traits, that accomplish some of the same goals as the engineering approach? Since access to water and protein-rich food can prevent Konzo, should disease reduction efforts focus on these issues and on breaking the cycle of poverty at the root? Might a combination of approaches be the best way forward? As with many complex questions, there are no right or wrong answers, but it is important that the people most affected by the problem (and by the potential solutions) have a voice in the decision about the path forward.

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STUDENT WORKSHEET

What have we learned? A few short questions:

1. Cassava is an important food crop eaten safely by millions of people daily. What condition causes the cassava plant to produce more toxin, which can possibly cause Konzo?

2. Why is Konzo considered a "disease of poverty"?

3. What genetic changes are researchers thinking of making to the cassava plant?

4. What concerns do people have about editing the cassava DNA?

5. What are some other possible approaches to preventing Konzo?

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TEACHER'S GUIDE

Related pgEd lesson plans and addition information

- This module was adapted from pgEd's lesson, "Engineering the World Around Us: Genome Editing and the Environment".

- For additional information, we recommend teachers read: "Poverty Plus a Poisonous Plant Blamed for Paralysis in Rural Africa" by Amy Maxmen, *National Public Radio* and "Bitter Harvest: Cassava and Konzo, the Crippling Disease" in *Global Health*.

Answer Key

1. Cassava is an important food crop eaten safely by millions of people daily. What condition causes the cassava plant to produce more toxin, which can possibly cause Konzo?

   The toxins in cassava are in higher concentration when the plant is grown in dry soil.

2. Why is Konzo considered a "disease of poverty"?

   The toxic effects of cassava that result in Konzo can be avoided by soaking it in water for several days and by eating it as part of a protein-rich diet. Many people living in poverty do not have easy access to clean water or sources of protein. They may also be urgently hungry and unable to wait for the cassava to soak.

3. What genetic changes are researchers thinking of making to the cassava plant?

   Researchers are considering altering the two genes primarily responsible for producing the toxins in cassava.

4. What concerns do people have about editing the cassava genome?

   There are concerns that lowering the toxicity of the cassava plant may make it less drought-tolerant and/or more vulnerable to insects. If it is more vulnerable to insects, pesticides may need to be used, thus increasing the cost of growing

the cassava. Additionally, they are concerned about who would own the genetically altered seeds and plants and whether the farmers would be able to afford to grow the crop.

5. What are some other possible approaches to preventing Konzo?

   Traditional breeding methods could be used to try to create less toxic cassava that is still drought-tolerant and insect-resistant. Efforts to reduce poverty and increase access to water and sources of protein could prevent Konzo. Or a combination of approaches may be used.