

Cassava and Gene Editing:

Eliminating Toxins in Cassava to Unlock its Potential



Cassava's starchy roots produce food and other useful products, even in tough growing conditions. But it is notoriously difficult to breed and requires time-consuming preparation to remove naturally-occurring toxins that can cause cyanide poisoning.

Genome editing promises to make this hardy crop safer and more valuable.

The Pros and Cons of Cassava

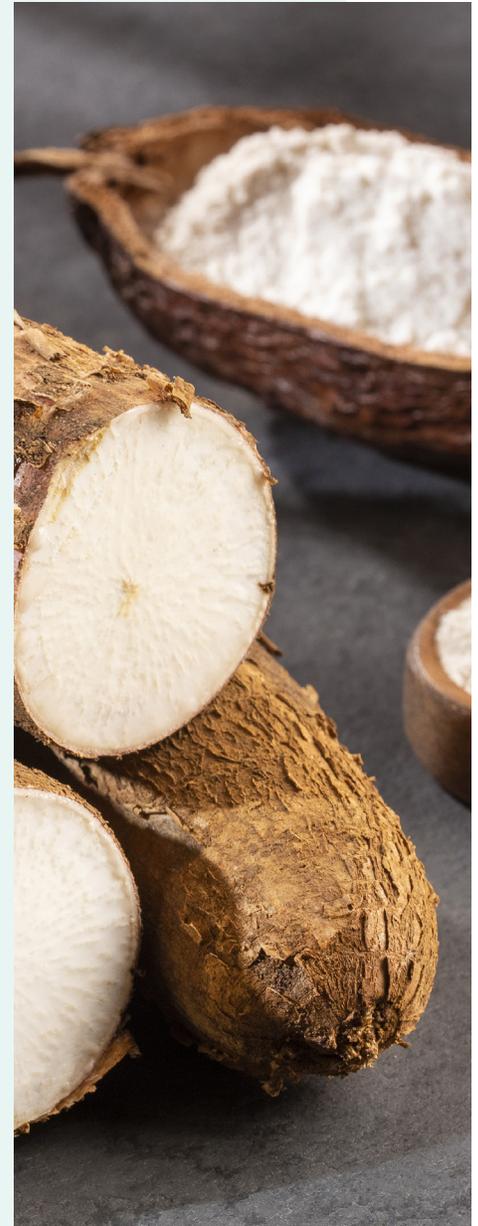
More than 800 million people worldwide eat or use the cassava plant every day. It is a staple food crop for over half a billion people in the developing world, and it also supplies starch (tapioca) and flour for food processing and other industrial uses including animal feed and biofuel.

Cassava is popular with farmers in tropical areas because it grows well in marginal and poor soils and is one of the most naturally drought-tolerant crops. Varieties are easy and inexpensive to plant, and roots can be left in the ground for several months before harvesting in the case of unforeseen circumstances.

While cassava sounds like a farmer’s dream crop, its roots contain toxic levels of cyanide. If not properly prepared before being consumed, cassava could cause cyanide poisoning, which can result in irreversible paralysis in the legs and even death. According to the study *Konzo: a distinct neurological disease associated with food (cassava) cyanogenic poisoning*, there are hundreds of thousands of people who are affected by cyanide poisoning from cassava, including mostly women and children who don’t have access to proper nutrition.

Although cassava grows well in difficult growing conditions, it is susceptible to plant viruses. This is because cassava propagates from stem cuttings — so all the plants in a single field are clones of each other. This means that diseases can spread quickly through a cassava field because they are all equally susceptible to the same disease. Also, some cassava diseases can only be detected by digging and cutting up its roots — meaning an unhealthy cassava stem could be mistakenly replanted.

While cassava possesses many good traits that are farmer-friendly, plant breeders and scientists have long struggled with finding solutions for some of the other cultivation challenges that cassava poses — such as irregular flowering periods, limited quantities of seed with diverse genes, and long growing cycles. The limited genetic diversity can make it difficult to breed new varieties of cassava with desired traits — and the lengthy growing cycles make it difficult to determine whether traits have been inherited through traditional breeding. New gene editing techniques could make cassava safer and harder.



Using Genome Editing to Make Cassava Safer for Consumers

Plant scientists at the Innovative Genomics Institute (IGI), a non-profit research organization formed from a partnership with University of California-Berkeley and University of California-San Francisco, were intrigued by the challenge of making cassava safer for consumers. Michael Gomez, Postdoctoral Scholar and one of the project researchers at IGI, believes the “development of cyanogen-free cassava varieties could save thousands of people from konzo - a debilitating disease, especially in regions where the disease is prevalent and/or where a future konzo threat is likely.” Konzo is a paralytic disease that is prevalent among hunger-stricken rural populations in Africa where diets are high in insufficiently processed cassava.

The IGI team is using CRISPR/Cas9 editing to silence two genes—*CYP79D1*

and *CYP79D2*—which produce the main cyanogens in cassava. By silencing the genes one at a time — and together — researchers hope to learn more about how the toxins are produced, especially in drought-stressed plants, and how they may influence protein synthesis.

Gomez says the use of CRISPR/Cas9 is a natural next step for breeding improvements into cassava, with significant advantages over traditional breeding methods because the technology can potentially silence the *CYP79D* genes individually, or simultaneously. The new plant varieties would be akin to what could be achieved through traditional breeding, but in a shorter time period. This means plant breeders would be able to more quickly see if the desired traits have been inherited, so they can continue researching other farmer-preferred varieties.

“CRISPR/Cas9 technology provides us with a flexible, precise, and rapid approach to cassava improvement,” Gomez says.

Ultimately, the researchers hope that using gene editing to silence these genes will lead to cassava plants that produce little or no cyanogen. This could reduce or even eliminate the danger of cyanide poisoning as well as the need for time-consuming processing of harvested cassava plant and its roots.

Breeding a Hardier Cassava Plant

Researchers also believe that gene editing could make cassava plants more resistant to cassava brown streak disease (CBSD), a viral plant disease spread by whiteflies. Some have called CBSD the “Ebola of plants” because it is hard to detect, highly infectious from plant to plant, and new strains develop quickly. It has destroyed crops across East Africa and is considered a major threat to food security.

Plant scientists have used CRISPR/Cas9 technology to edit multiple genes involved in the plant’s susceptibility to the virus, resulting in tolerance to the disease (Gomez et al., 2018). These changes could be made to virtually any cassava variety without changing qualities that make it particularly useful or popular to a certain group of farmers or consumers.



Improving Cassava for Processing

The most useful type of starch for food processing and other industrial uses is known as “waxy starch.” It is produced easily from maize, potato and wheat — and this secondary use of these crops increases their economic value.

In contrast, the large quantities of starch produced by cassava roots are not considered waxy because they contain high levels of amylose, a crystallizable component that is more soluble in water. Reducing the amylose levels could allow cassava to produce waxy starch — giving it a secondary use and make it more desirable for manufacturers, and increase its economic value to farmer and rural communities. Researchers at the Swiss Federal Institute of Technology (ETH) have used CRISPR/Cas9 to adjust the genes that produce varying levels of amylose, which can in turn improve the overall suitability of cassava starch for commercial processing (Bull et al., 2018).

Plant Breeding Innovations Can Improve Cassava for Consumers, Farmers, and Rural Communities

Even as advances in agriculture technology produce bigger and better crops than ever with fewer resources, food safety and security remain very real challenges for hundreds of millions of people every day. Many depend on crops like cassava because they grow well in changing climate and soil conditions, even if they come with risks as deadly as cyanide poisoning.

Gene editing and other innovations in plant biotechnology can be used individually or in combination, to provide new solutions to the challenges farmers and consumers face with cassava. For example, plant scientists can use genome editing to develop cassava with waxy starch in tandem with cassava that can flower earlier and make research faster thanks to biotechnology.

These innovations can be applied to a wide variety of crops and are critically important to the future of agriculture for farmers and consumers everywhere.



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