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Cis-editing for all

CRISPR technologies offer new opportunities to democratize gene-edited crops and promote global sustainability.

The first CRISPR-edited food to enter the market, in 2020, was a tomato, the GABA-enriched Sicilian Rouge from Sanatech Seed[1]. Del Monte has since grown pink pineapples that produce higher concentrations of lycopene and markets them for a mind-blowing $400. Mustard greens are being genetically edited using CRISPR to remove the gene family responsible for their pungent taste[2] while keeping the nutritional profile intact. The Arctic apple is modified from a Golden Delicious apple, but is resistant to browning. These edited fruits and vegetables are eye-catching news, but new products could go beyond edgy consumer benefits or nutritional upgrades: CRISPR-edited foods have the potential to counter the effects of a changing climate and make local crops with increased yield that tolerate heat and disease.

CRISPR editing of plants is becoming increasingly popular, thanks to the development of cis-editing tools. CRISPR cis-editing introduces changes that are indistinguishable from those obtained by conventional breeding – only much faster. And unlike genetically modified organisms (GMOs), which introduce minor (but unpopular) novel configurations of genetic materials, often from a different species, CRISPR-edited GM plants are not considered transgenics, and policies regulating them are generally much less stringent than for GMOs.

The public has viewed GM crops with suspicion, if not outward rejection. Most GM crops were ultimately developed by large agricultural companies, such as Monsanto (now owned by Bayer), and their benefits – resistance to insects, viruses and herbicides – accrued to farmers rather than to consumers. Rarely, early genetic modifications addressed nutritional deficiencies. Even when they did, skepticism prevailed, as in the case of Golden rice. This rice was engineered to prevent blindness caused by vitamin A deficiency by introducing β-carotene, a precursor to vitamin A, into the endosperm through expression of three proteins from other species: two from daffodils and one from bacteria. Golden rice never reached its potential, primarily due to regulatory obstruction and opposition from environmental groups. Despite its public health benefits, it and other biofortified transgenics such as wheat, maize, soybeans and cassava have been tarnished by accusations of cultural imperialism. Nutritional benefits have not been enough to persuade some regulators of the foods' safety.

CRISPR cis-edited crops may not face the same obstacles as transgenics and therefore may yet achieve global impact. CRISPR could give crop diversity a much-needed boost: the tools can be deployed relatively quickly in a lab setting, so the technology need not be dominated by large agrichemical industries, as has been the case with GM crops. The push for better traits can stretch beyond commercial cultivars of staple crops like maize and wheat, and instead focus on local crops and benefit farmers that grow them. Even with reduced regulation, however, it will still be a challenge to get those cis-edited crops to the people who would benefit most from the enhanced nutritional profiles and climate-tolerance traits.

A handful of companies are jumping at these opportunities. In 2021, the non-profit Innovative Genomics Institute (IGI) launched a series of projects that are applying genome-editing technologies to plants important to the developing world, such as rice, cassava, sorghum and broccoli. Their approach to counteracting climate change involves CRISPR-editing genes to develop heat- and drought-resistant crops, as well as reducing emissions by generating permanent changes to the microbiomes of livestock and modifying soil microbiomes to restore carbon sinks. IGI has formed strong partnerships on the ground in India and Africa, and is training farmers and government regulators to use CRISPR technologies and seeds.

IGI is also working on expanding technologies for apomixis – asexual reproduction through seeds, providing seeds identical to the parent by bypassing genetic recombination. This is most useful for hybrid lines, valued in many regions because of their higher quality and expensive because farmers need to purchase seed for them yearly. Expanding apomictic hybrid technologies would mean that farmers in countries such as India could save high-yielding, climate-resilient hybrid seeds year to year, relying less on big seed companies.

Another non-profit, Semilla Nueva, is working with researchers to produce biofortified corn, regarded as a cheap and productive crop in many lower- to middle-income countries, although it is limited in nutrients. Until now, Semilla Nueva has used conventional breeding to select varieties with higher nutrient content, but several genes have been discovered that increase nutrition and can be edited with CRISPR technology, for a fraction of the price of breeding. The edited corn contains higher levels of important nutrients – 39% more zinc, 19% more iron and between 30% and 80% more lysine and tryptophan than traditional corn. Semilla Nueva is subsidizing seed companies in countries such as Guatemala and El Salvador to sell their biofortified seeds at lower prices to farmers. They are then seeking to persuade governments to take over the subsidies.

Still, those deploying CRISPR tools will face limitations. Companies hold patents on their CRISPR platforms, and without a commercial license, non-profits or startups cannot take the technology to a seed company or to a farmer. AI could help circumnavigate barriers, enabling the design of new CRISPR enzymes that share sequence similarity but differ in just enough sequence to fall outside existing intellectual property[3]. An open-access CRISPR enzyme that could be used freely might be an even better tool.

Gene-edited crops seem poised to step in and succeed where GM crops floundered. Free from regulatory obstruction and public disapproval, the power of agricultural biotech could be harnessed to better the planet and our own health. This will require collaboration between large seed companies and non-profits, governments and farmers, but it is important to think about long term, big-picture humanitarian goals, much as everybody loves the taste of a $400 pineapple.

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