

## GENE EDITED BANANAS: SCIENCE & TECHNOLOGY

**NEWS:** How new gene-edited bananas could help reduce food waste

### WHAT'S IN THE NEWS?

A UK-based biotech company has developed genetically-modified bananas with a longer shelf life and reduced browning by silencing the gene responsible for polyphenol oxidase (PPO). This innovation aims to reduce food waste, lower greenhouse gas emissions, and extend the freshness of bananas.

### Ripening of Bananas

- **Ethylene Hormone:** Bananas naturally produce ethylene, a plant hormone that plays a key role in the ripening process. Ethylene is released as the banana matures, triggering the onset of ripening. It is a gas that signals the fruit to undergo various changes, such as softening, color changes, and sugar development. Ethylene is the reason why bananas, even after being harvested, continue to ripen and change over time.
- **Polyphenol Oxidase (PPO) and Browning:** Ethylene activates the production of polyphenol oxidase (PPO), an enzyme responsible for the browning of bananas. PPO reacts with oxygen in the air, causing the breakdown of the yellow pigment (chlorophyll) and leading to the formation of brown pigments. This process is why bananas turn brown once they ripen or are bruised.
- **Bruising and Accelerated Ripening:** When bananas are bruised, the damaged cells release more ethylene, which further accelerates the ripening and browning process. The bruised area becomes softer and browner much faster than the rest of the fruit, contributing to the fruit's overall spoilage.

### Latest Developments in Genetically-Modified Bananas

- **Genetic Modification to Prevent Browning:** Scientists have modified bananas genetically by silencing the gene that produces polyphenol oxidase (PPO). This means that the bananas are still able to ripen normally, but the enzymatic reaction that causes browning is inhibited. As a result, the bananas maintain a fresh and yellow appearance for longer, preventing the aesthetic spoilage usually caused by browning.
- **Maintaining Freshness without Affecting Ripening:** The modification doesn't stop the banana from ripening but helps keep it fresh for a longer period. This is essential as bananas still need to ripen for flavor development and consumer preference, but

the browning is reduced, which adds to the fruit's shelf life. This approach helps in extending the time window during which bananas can be consumed after being peeled or harvested.

- **Application in Arctic Apples and Other Crops:** A similar genetic modification method was applied to Arctic apples, which have been commercially available since 2017. The Arctic apple does not brown as quickly as traditional apples, making it more appealing for consumers. This genetic modification has been used in various other crops as well, including tomatoes, melons, kiwifruits, and mushrooms, demonstrating its broader potential to reduce waste in different types of produce.

### What is Gene Editing?

- **DNA Modification:** Gene editing is a technique that allows scientists to modify the DNA of organisms—plants, animals, and microorganisms. Through gene editing, scientists can directly alter specific genes in an organism's genome, resulting in changes to physical characteristics (e.g., skin color, growth rate) and potential disease risks (e.g., reducing susceptibility to diseases like cancer or genetic disorders).
- **Timeline of Gene Editing Development:** Early gene editing technologies were developed in the late 1900s with methods like ZFN (zinc-finger nucleases) and TALENs (transcription activator-like effector nucleases). However, the major breakthrough came with CRISPR technology in 2009, which revolutionized the field. CRISPR allows scientists to cut DNA at specific points and make precise changes, facilitating quicker and more accurate genetic modifications.
- **CRISPR Revolution:** CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is a technology that has become widely used due to its simplicity, speed, cost-effectiveness, and precision. It enables targeted changes to an organism's DNA by using a guide RNA that directs the Cas9 protein to the desired location in the genome. This technology has transformed genetic research, allowing for faster experiments and more predictable outcomes.

### Recent Trends in Gene Editing

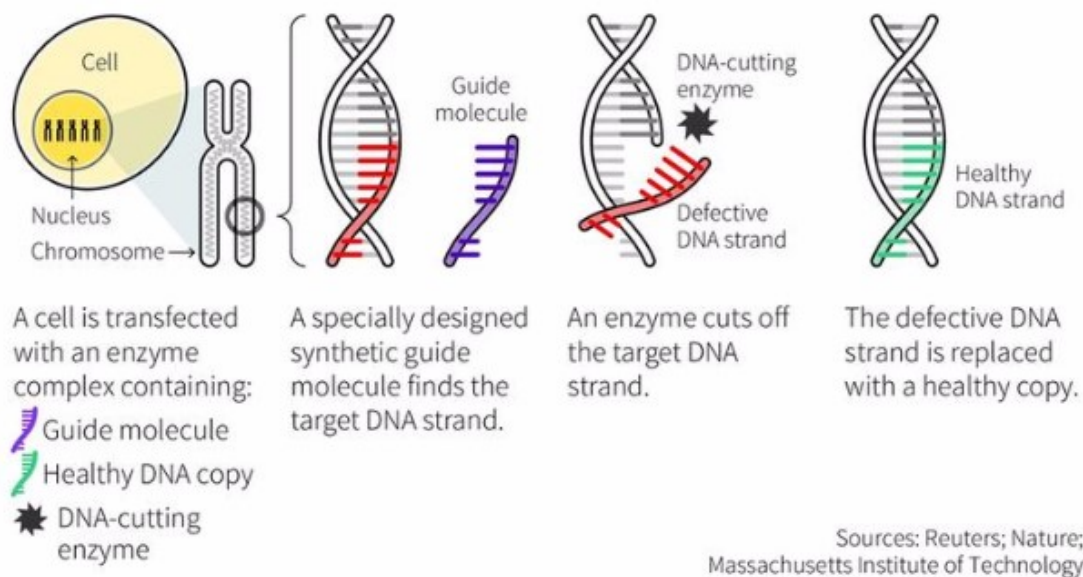
- **CRISPR Technology Advancements:** While CRISPR-Cas9 remains the most widely used gene-editing tool, research is exploring other Cas enzymes such as Cas12 and Cas13, which have different properties and may offer new possibilities for editing. These enzymes, along with alternative CRISPR systems, are being studied to improve efficiency, precision, and adaptability in gene editing.

- **Improved Delivery Methods:** A major challenge in gene editing is getting the edited genes into the right cells in an efficient and precise manner. Researchers are working on better delivery methods, such as using viral vectors, lipid nanoparticles, and other innovative delivery systems. These methods ensure that the genetic material reaches the target cells while minimizing off-target effects and improving the overall efficiency of gene editing processes.
- **Gene Therapy for Genetic Diseases:** Gene editing technologies, especially CRISPR, are showing great promise in treating inherited genetic disorders. Diseases like sickle cell anemia, cystic fibrosis, and Huntington’s disease could potentially be treated by directly modifying the faulty genes that cause these diseases. Gene editing could provide life-changing or even curative therapies for individuals affected by such genetic conditions.
- **Crop Improvement:** Gene editing is increasingly being applied to improve agricultural crops. Through gene editing, crops can be developed to have enhanced traits, such as improved resistance to pests and diseases, higher nutritional content, and greater resilience to climate change. Crops can also be made more productive, which is important for feeding a growing global population.

## DNA editing

A DNA editing technique, called CRISPR/Cas9, works like a biological version of a word-processing programme’s “find and replace” function.

### HOW THE TECHNIQUE WORKS



## Regulations in India

- **Genetic Engineering Appraisal Committee (GEAC):** In India, the GEAC, which functions under the Ministry of Environment, Forest and Climate Change (MoEFCC), is responsible for evaluating and approving genetically modified (GM) crops and organisms. This committee assesses the environmental safety of GM crops before they are allowed for field trials or commercial cultivation.
- **FSSAI and GM Food Products:** The Food Safety and Standards Authority of India (FSSAI) is responsible for regulating genetically modified food products. It ensures that GM foods meet safety standards before being released into the market for consumption. FSSAI conducts assessments to confirm that GM foods do not pose a risk to human health.

### Current Status in India

- **GM Mustard Hybrid Approval:** India has approved the genetically modified mustard hybrid, DMH-11, for seed production and field testing. This is the first GM crop to be approved in India for research and trials. However, India has yet to approve CRISPR-based crops for commercial use.
- **ICAR's Role in Gene Editing Research:** The Indian Council of Agricultural Research (ICAR) is actively involved in exploring gene-editing technologies to enhance crop characteristics, such as improving climate resilience and pest resistance. This research is still in the experimental phase and has not yet reached the stage of commercial approval for gene-edited crops.

### Importance of Non-Browning Bananas

- **Banana Perishability and Waste:** Bananas are one of the most widely consumed fruits in the world, but they are also highly perishable. Nearly 50% of the global banana crop is wasted annually due to their short shelf life and tendency to turn brown quickly. This high level of waste represents a significant issue for food security and sustainability.
- **Food Waste and Environmental Impact:** Food waste contributes significantly to global greenhouse gas emissions. When bananas (or any other food) are discarded, the resources used in their production, transportation, and storage are wasted, and this adds to environmental pollution. Reducing banana waste could help mitigate these effects.
- **Reducing CO<sub>2</sub> Emissions:** According to Tropic, the company that developed the non-browning banana, their bananas could potentially reduce carbon dioxide (CO<sub>2</sub>) emissions equivalent to removing 2 million cars from the road annually. This is due to

the significant reduction in banana waste, which would decrease the environmental impact of producing and discarding bananas. By extending the freshness of bananas, Tropic aims to contribute to the reduction of food waste and help in mitigating climate change.

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