Foods Derived From Plants Produced Using Genome Editing

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Growing two-dimensional boron pp. 1468 & 1513

Managing biological risk p. 1473

Algal toxin alters spatial memory p. 1545

Science

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AAAS

2015 BREAKTHROUGH of the YEAR

CRISPR

SPECIAL ISSUE

Just under a year ago, a molecular-biology technique was thrust onto the world stage. Researchers in China announced that they had used the nascent gene-editing tool CRISPR–Cas9 to modify the genomes of human embryos, triggering a major ethics debate.

Yet while this controversy has been playing out, researchers the world over have rushed to use the tool to tinker with the genomes of other human cells, viruses, bacteria, animals and plants, and it's in these contexts that the technique promises to have more immediate impact. This issue of *Nature* examines what's going on at the CRISPR frontiers.

Biologists are using CRISPR–Cas9 to better understand genomes — not just by editing DNA, but by devising variations on the technique to precisely manipulate the activity of genes (see page 156). And, armed for the first time with a method that can easily introduce genetic changes to many animals, researchers have edited a veritable menagerie of beasts — from ferrets to elephants to koi carp (see page 160) — in an attempt to combat disease, improve agriculture and even make designer pets.

Such advances in gene editing are creating upheaval for the regulatory bodies that are responsible for approving genetically engineered products — it's a "powder keg waiting to explode", writes Jennifer Kuzma, a science-policy researcher at North Carolina State University in Raleigh, on page 165. She calls for more openness and honesty than has characterized past discussions of biotechnology, and for a regulatory system that better factors in societal views as well as science.

CRISPR–Cas9 may be democratizing gene editing in the laboratory, but Todd Kuiken, who studies science policy at the Wilson Center, a think tank in Washington DC, argues on page 167 that the revolution has not yet swept into home workshops or citizen-science community spaces. Contrary to reports in the popular media, he says, few CRISPR creations are likely to come from the labs of do-it-yourself biologists any time soon. However, this group is arguably ahead of the scientific establishment when it comes to thinking about how to use the technology safely.

For better or for worse, CRISPR–Cas9 is transforming biology. We are now at the dawn of the gene-editing age. ■

CRISPR EVERYWHERE

A special issue explores what it means to be living in an age of gene editing.

CRISPR EVERYWHERE
A *Nature* special issue
nature.com/crispr

ILLUSTRATION BY CHRIS LADZINSKY

Does FDA regulate genome edited plants?

nature biotechnology

NATURE BIOTECHNOLOGY | NEWS

CRISPR-edited crops free to enter market, skip regulation

Emily Waltz

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IN FOCUS NEWS

BIOTECHNOLOGY

Gene-edited CRISPR mushroom escapes US regulation

A fungus engineered using CRISPR–Cas9 can be cultivated and sold without oversight.

BY EMILY WALTZ

The US Department of Agriculture (USDA) will not regulate a mushroom that has been genetically modified with the gene-editing tool CRISPR–Cas9, the agency has confirmed. The long-awaited decision means that the mushroom can be cultivated and sold without passing through the agency's regulatory process — making it the first CRISPR-edited organism to receive a green light from the US government.

"The research community will be very happy with the news," says Caixia Gao, a plant biologist at the Chinese Academy of Sciences Institute of Genetics and Developmental Biology in Beijing, who was not involved in developing the mushroom. "I am confident we'll see more gene-edited crops falling outside of regulatory authority."

Yinong Yang, a plant pathologist at Pennsylvania State University (Penn State) in University Park, engineered the fungus — the common white button mushroom (*Agaricus bisporus*) — to resist browning. The effect is achieved by targeting the family of genes that encodes polyphenol oxidase (PPO), an enzyme that causes browning. By deleting just a hand-

STUART MCCALL/GETTY

The common white button mushroom (*Agaricus bisporus*) has been modified to resist browning.

Does FDA regulate genome edited plants?

- **All food is regulated for safety, regardless of how plant varieties are bred**
- No unique requirements exist for food developed with biotechnology
- Plant Biotechnology Consultation Program (voluntary) addresses relevant safety and regulatory questions
- FDA intends to continue offering consultations for developers of new plant varieties, including those produced using genome editing

White House Memorandum on Modernizing the Regulatory System for Biotechnology Products

July 2, 2015

MEMORANDUM FOR HEADS OF FOOD AND DRUG ADMINISTRATION,
ENVIRONMENTAL PROTECTION AGENCY, AND DEPARTMENT OF AGRICULTURE

FROM: John P. Holdren
Assistant to the President for Science and Technology
Director, Office of Science and Technology Policy

Howard Shelanski
Administrator, Office of Information and Regulatory Affairs
Office of Management and Budget

Darci Vetter
Chief Agricultural Negotiator
United States Trade Representative

Christy Goldfuss
Managing Director, Council on Environmental Quality

SUBJECT: Modernizing the Regulatory System for Biotechnology Products[1]

White House Memorandum on Modernizing the Regulatory System for Biotechnology Products

- National Academies of Sciences horizon scanning study
- Update the Coordinated Framework for the Regulation of Biotechnology to clarify current roles and responsibilities
- National Strategy for Modernizing the Regulatory System for Biotechnology Products

National Strategy for Modernizing the Regulatory System for Biotechnology Products

Product of the Emerging Technologies Interagency Policy Coordination Committee's Biotechnology Working Group

September 2016

"FDA intends to clarify its policy for the regulation of products derived from genome editing techniques, including, as appropriate, identifying and/or updating relevant existing guidance documents."

NATIONAL ARCHIVES
FEDERAL REGISTER
The Daily Journal of the United States Government
FDA
Notice

Genome Editing in New Plant Varieties Used for Foods; Request for Comments

A Notice by the Food and Drug Administration on 01/19/2017

PUBLISHED DOCUMENT

AGENCY:

Food and Drug Administration, HHS.

ACTION:

Notification; establishment of docket; request for comments.

SUMMARY:

The Food and Drug Administration (FDA or we) is announcing the establishment of a docket to receive comments on the use of genome editing techniques to produce new plant varieties that are used for human or animal food. We invite comment on specific questions contained in this document related to foods derived from such genome edited plant varieties. FDA is taking this action to help inform our thinking about foods derived from new plant varieties produced using genome editing techniques.

582

DOCUMENT DETAILS

Printed version:
PDF

Publication Date:
01/19/2017

Agencies:
Food and Drug Administration

Dates:
Submit either electronic or written comments by April 19, 2017.

Comments Close:
04/19/2017

Document Type:
Notice

Document Citation:
82 FR 6564

Page:

FDA & Genome Editing of Food Plants

1. **Request for Information: Summarized Questions**
   - Is past experience relevant to genome-edited crops?
   - Are there types of genome-edited crops that would be
     - *less* likely to raise different or greater risks?
     - *more* likely to raise different or greater risks?
     - If so, which ones?
   - Are there ways we help small companies work with us?

3. **We identified substantive responses out of the 582 received**

4. **We are considering substantive responses and are developing a course of action**

Food from Genetically Engineered Plants

Consumer Info About Food from Genetically Engineered Plants

Foods Derived From Plants Produced Using Genome Editing

How FDA Regulates Food from Genetically Engineered Plants

Submissions on Bioengineered New Plant Varieties

Foods Derived From Plants Produced Using Genome Editing

Q: What is genome editing?

A: "Genome editing" is a term used to describe a relatively new set of technologies that enable one to make precise changes in the DNA of a plant, animal or other living organism. For example, such technologies can be used to introduce, remove, or substitute one or more specific nucleotides at a specific site in the organism's genome. Genome editing is being performed using, for example, clustered regularly interspersed short palindromic repeat associated nucleases (CRISPR), zinc-finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and oligonucleotide-directed mutagenesis (ODM).

Q: What is FDA doing in this area?

On January 18, 2017, FDA announced a Request for Comments (RFC) seeking public input to help inform its regulatory approach to human and animal foods derived from plants produced using genome editing. The RFC asks for data and information in response to questions about the safety of foods from genome edited plants, such as whether categories of genome edited plants present food safety risks different from other plants produced through traditional plant breeding.

Additionally, the agency is asking for information on how best to engage small businesses, including those that may be considering using genome editing to produce new plant varieties for use in human or animal food.

On April 13, 2017, the FDA extended the comment period for the Request for Comment. Comments should be submitted to the FDA by June 19, 2017 to ensure they are taken into consideration. Comments received will help inform FDA's thinking on human and animal foods derived from new plant varieties produced using genome editing.

To comment on the RFC, go to Regulations.gov and insert docket number FDA-2016-N-4389. To submit comments to the docket by mail, use the following address. Be sure to include docket number FDA-2016-N-4389 on each page of your written comments.

Division of Dockets Management
HFA-305
Food and Drug Administration
5630 Fishers Lane, Room 1061
Rockville, MD 20852

Q: Why is the FDA requesting information from the public regarding crops used for human and animal food that have been produced through the use of genome editing?

A: In September 2016, OSTP issued a National Strategy for Modernizing the Regulatory System for Biotechnology

Thank You

FDA U.S. FOOD & DRUG ADMINISTRATION