Emerging Biotechnology Foods Learning Passport

This is a critical issue for you to know about

Emerging Biotechnology Foods Learning Passport

In the face of the rapid growth of the global population, climate change and the increasing frequency of natural disasters, stabilizing agricultural production and food supply systems has become a critical issue that raise concern worldwide. Many countries are currently investing in the research, development, and the application of genetic modification and gene editing technology, while stipulating appropriate regulations at the same time. This manual will guide you through genetic modification (GM) and gene editing technology, as well as the current status of GM foods and relevant management practices. We hope that emerging biotechnology, which helps improve our food system, will get understanding and acceptance of the public.

Let's learn about the correct knowledge of emerging biotechnology foods !

Table of contents

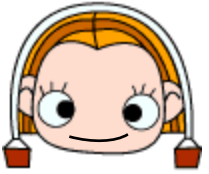
Character introduction and synopsis

Doudou

Specializes in biotechnology. Her dad is a breeding expert who is adept at biotechnology. She wants to become an expert in emerging biotechnology breeding.

Brother Mi

Doudou's elder brother, who specializes in farming techniques, is interested in new agricultural technologies. His wish is to become a professional young farmer.



Kiki

Doudou's elementary school classmates, a high-achieving liberal arts student, good at inspirational prose and science fiction. She loves to ask questions to gather ideas for writing, but knows nothing about biotechnology.

Nonsense

The full-time research assistant in the breeding laboratory of Doudou's dad, and is always busy with running errands. His pet phrase: "I just want to get off work early!"

One day, in the search of inspiration for writing science fiction, Kiki went to the elementary school with her classmate Doudou. They came to the breeding laboratory where Doudou's dad worked. Kiki was curious about why there were so many different shapes of plants, so Doudou flaunted her knowledge in biotechnology. However, since Kiki had absolutely no idea what that is, Doudou had to patiently started from the concept of "heredity"...

What is heredity?

Heredity? what is it?

As the old saying goes, "A dragon gives birth to a dragon, and a phoenix gives birth to a phoenix. The son of a mouse will make holes." and "You get what you sow."! We can clearly see certain traits of our body, such as height, skin color, appearance, and habits, share strong similarities with that of our parents or grandparents. That is heredity!

widow's tip

index finger length

double/single eyelid

hitchhiker's thumb

earlobe position

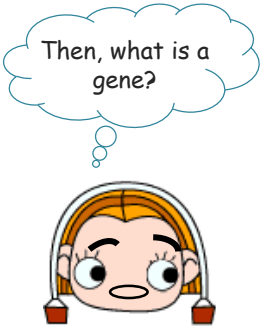
Everyone says that I have my dad's nose and my mom's eyes!

tongue rolling

hand clasping

dimple

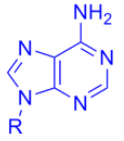
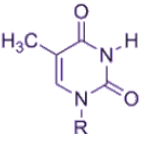
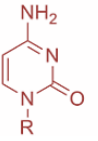
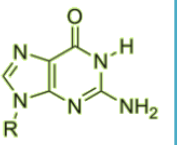
What is a gene?



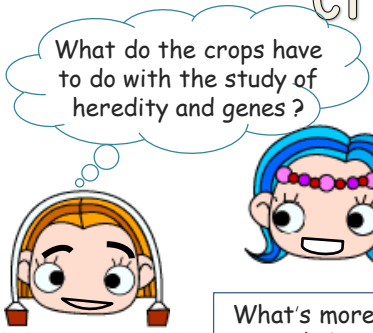
The "genetic material" that carries the heredity information and traits to the next generation is called "genes"! There are four genetic codes, which can have many different arrangement and encode different traits!

DNA double-stranded helix

Genetic code

A	T	C	G
 Adenine	 Thymine	 Cytosine	 Guanine

Crops and food



What we eat come directly or indirectly from the food crops! Nevertheless, because of extreme climate, as well as pests and diseases caused by ecological changes, it is necessary to study the genetic traits and functions of crops and breed the ones that can withstand extreme environment!

What's more important is to develop and upgrade breeding technologies in order to quickly grow crops that can adapt to the climate change and have excellent yield and quality!

Extreme Climate

- flood
- chills
- drought
- wind disaster
- high temperature

Crop Breeding

- Conventional crops
- GM crops

Target Traits

- waterlogging-tolerant
- shelf-stable
- drought-tolerant
- prolific
- insect-resistant
- nutrition-fortified
- disease-resistant
- easy to process

Ecological Change

- pests
- disease
- weeds

Land Change

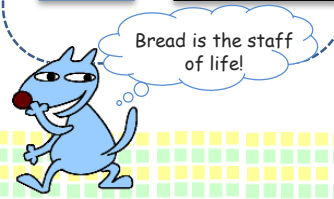
- land salinization
- soil desertification
- less arable land

Consumer Demand

- versatile
- affordable
- nutritious
- safe
- more supply
- less waste

Agricultural Technology

- conventional farming
- chemical fertilizer
- organic farming
- biological fertilizer
- natural farming
- chemical pesticides
- non-toxic farming
- Biopesticide

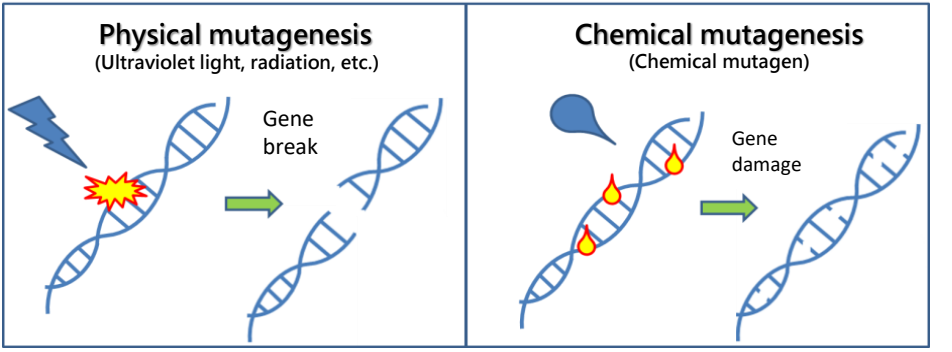


Conventional breeding

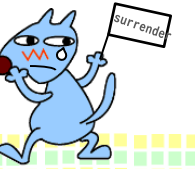
Isn't there breeding technology already?

That's right. Generally speaking, conventional mutagenesis is performed in breeding laboratories. Crops will mutate after their genes are altered. Common target crops include rice, barley, wheat, fruits and vegetables, etc.

However, the disadvantage of conventional breeding is that all mutations occur randomly and cannot be precisely controlled! Breeders need to spend more time on screening the favorable traits instead.



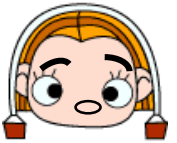
Failure is the mother of success... but I already failed too many times! I don't want to work hard anymore!



Introduction to emerging biotechnology

Is there any better technology for breeding?

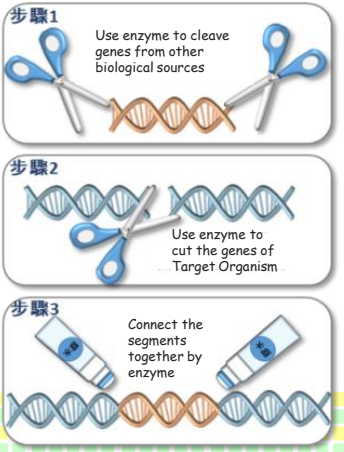
Yes! Here we have "emerging biotechnology"! It can change the specific genes of crops, produce favorable agronomic traits, and speed up the breeding process. It is very efficient!



Emerging biotechnology is most commonly used in "genetic modification (GM)" and "gene editing" of food crops!

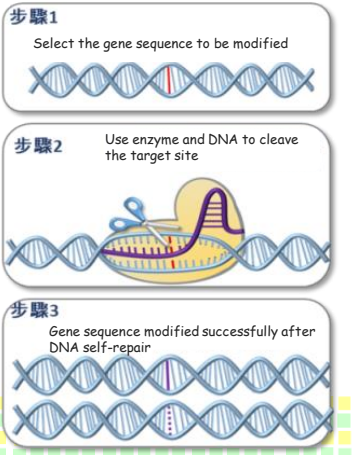
Genetic modification (GM)

GM technology introduces foreign genes to provide new traits for crops



Gene editing

Gene editing modifies the existent genes and express new traits.



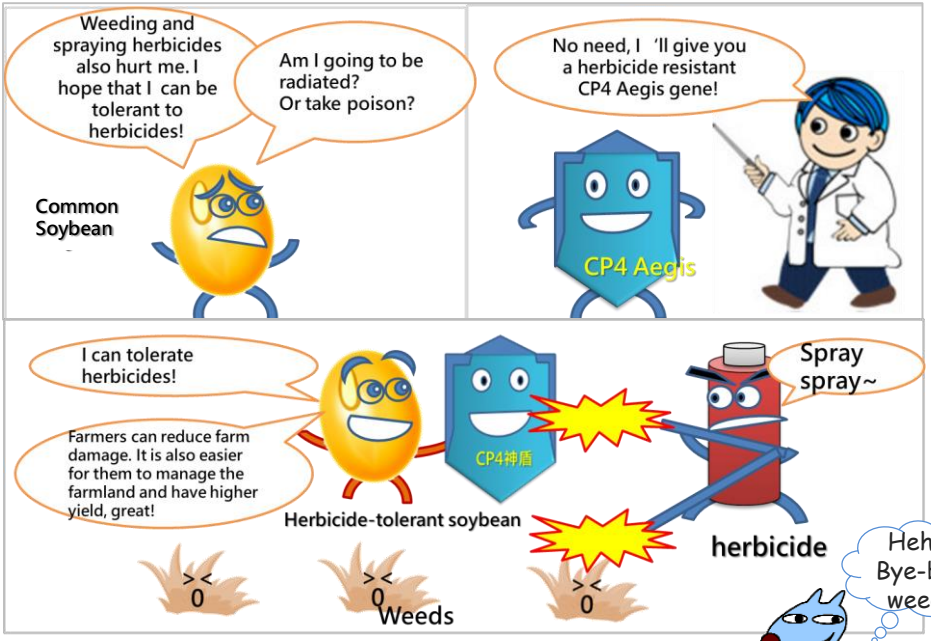
Hehe~
I can get off work early today!

Note: This is a gene editing technology that does not introduce foreign genes

GM crop characteristics

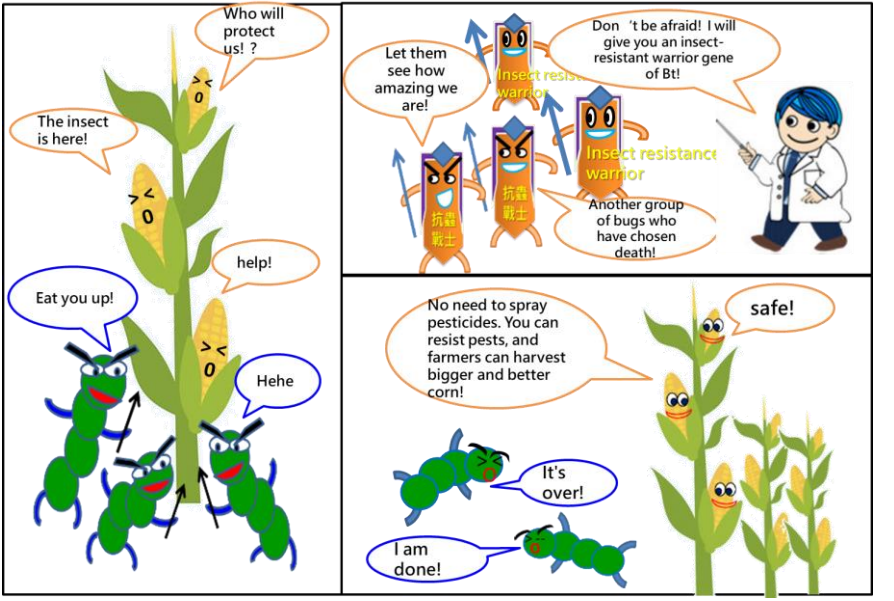
What characteristics do these GM crops possess?

Some crops are resistant to herbicides, which can help farmers manage weeds, reduce pesticide use, and increase yields!



GM crop characteristics

In addition, these crops are insect-resistant. The insect-resistant properties of *Bacillus thuringiensis* (Bt) is commonly adopted in organic agriculture to protect crops from pests, which can also reduce the use of pesticides and increase the yield!



GM crops approved in Taiwan

Are these emerging biotech crops already on the Taiwanese market?

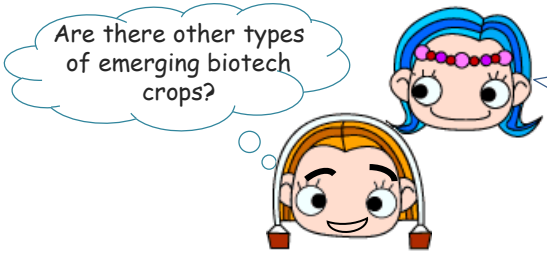
Yes! Currently, there are five approved GM crops in Taiwan, including soybeans, corns, rapeseeds, cotton and beets!

The herbicide-tolerant soybean is the major variety, which is mainly used for oil extraction. The leftover soybean meal can also be used as feed. GM corn is resistant to pests and herbicides, and is mostly used as feed.

You've been talking about food, making me so hungry..

There are insect-resistant and herbicide-tolerant varieties of rapeseed and cotton, which are used as raw materials for oil extraction. In addition, herbicide-resistant varieties of beet can be used as sweeteners of food additives!

GM crops available on the international market



Yes! The GM crops on the international market include tomatoes, non-browning apples and virus-resistant papaya. But none of these have been approved by our government!

Storage-stable tomatoes: They can be harvested and transported during the mature green stage and thus they are less perishable. The increased pectin content can help reduce processing waste and lower the production ncosts. In fact, it is the first GM crop in the world!

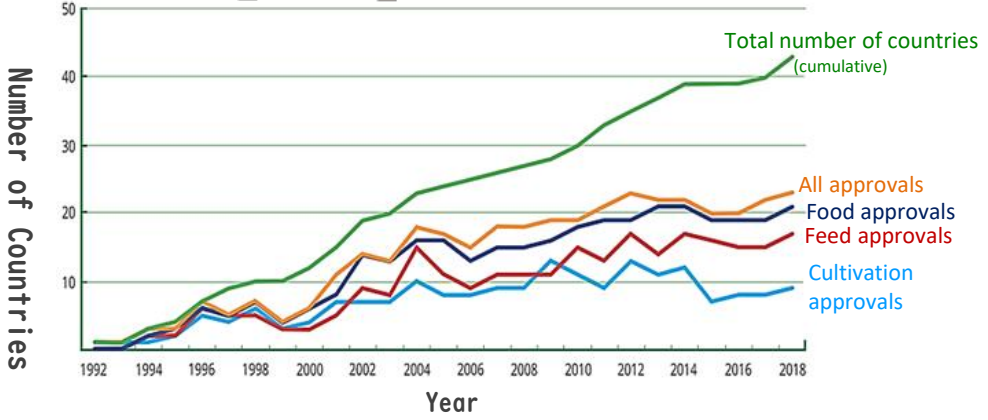
When an apple is cut for a while and turns brown, people lose their appetite for it! Non-browning apple will retain its color rather than being oxidized after cutting, which can reduce food waste, especially for fresh-cut industry.

Virus-resistant papaya: With the anti-viral properties, the use of pesticides can be greatly reduced. Improved orchard environment, increased yield, reduced cost for cultivation, and better appearance of the fruit all contribute to the farmers' income!

Global status of food, feed and cultivation approvals

I didn't know that there are different types of approval..

The approval status of GM crops includes approval of all uses at the same time, or approval of some uses!



According to statistics, we can see that "all approvals" issued for food, feed and cultivation is the most common type! Regardless of the type, the number of countries that have issued GM crop approvals is increasing year by year!

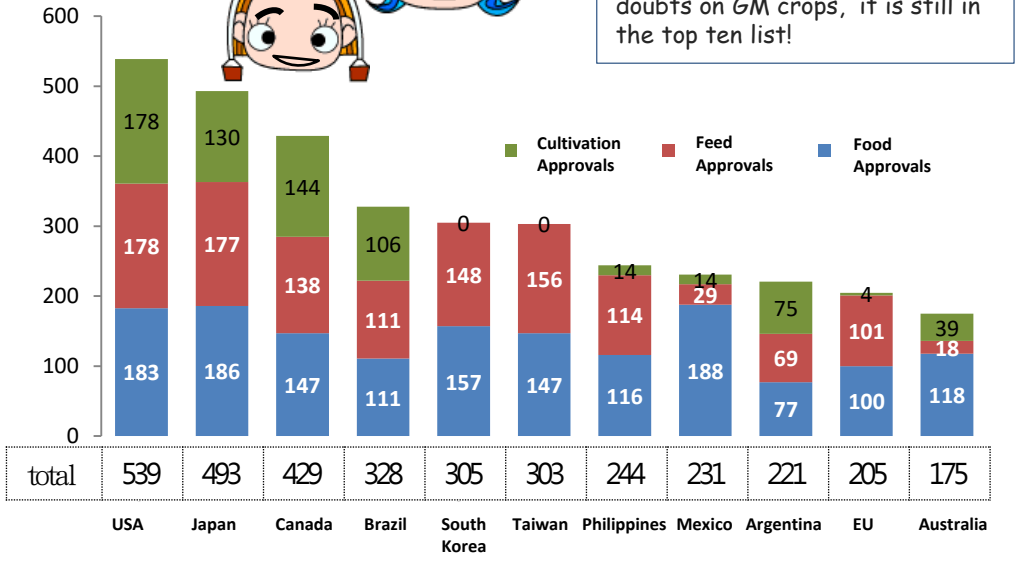
It seems that there are many lifetime research assistants like me all over the world, haha!

source:ISAAA, 2019

Top 10 countries that granted the most GM crop approvals

Which countries have issued the most GM crop approvals?

The top three countries are the United States, Japan and Canada. Even though EU casts some doubts on GM crops, it is still in the top ten list!



total	539	493	429	328	305	303	244	231	221	205	175
	USA	Japan	Canada	Brazil	South Korea	Taiwan	Philippines	Mexico	Argentina	EU	Australia

Strict monitoring will ensure the health of the public!

However, our government has strict review standards and only approve the use of GM crops as food and feed. Cultivation of GM crops is forbidden!

source:ISAAA, 2019 Note: Taiwan statistics as of2019

The safety of GM foods

How do you know the crops derived from emerging biotechnology are safe to eat?

It can be evaluated with the concept of "as safe as conventional crops"! That is, the concept of "substantial equivalence", which is an assessment method approved by the World Economic Cooperation Organization, the World Health Organization, and the Food and Agriculture Organization of the United Nations.

Composition
- ✓Nutrients
- ✓Anti-nutrients*
- ✓Endogenous toxin
- ✓Allergen

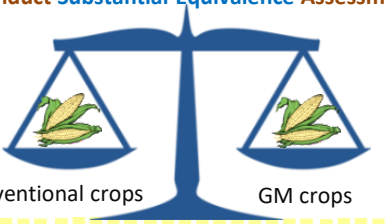
Safety
- ✓Toxicity
- ✓Allergenicity
- ✓Processing safety
- ✓Dietary intake

Genetic traits
- ✓Agronomic traits
- ✓Appearance
- ✓Growth
- ✓Yield

Expert review

Experimental evidence

Conduct Substantial Equivalence Assessment



Conventional crops

GM crops

In other words, GM crops must have characteristics comparable to conventional crops, especially for their composition and safety, so that we can make sure they are safe.

Lots of experiments to do...but I am in for food safety!

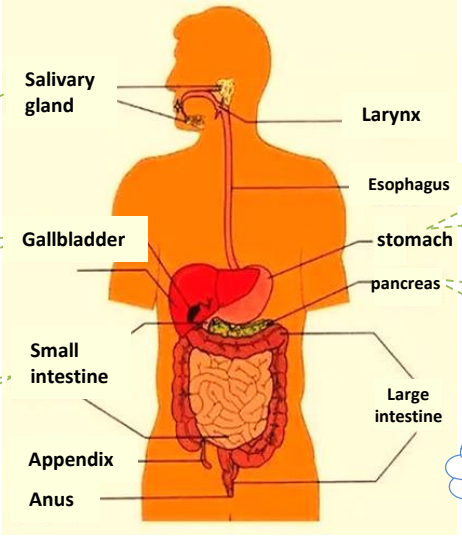
*Anti-nutrients: substances that interfere with or hinder the body's absorption of nutrients.

Digestion and absorption of GM foods

For the safe consumption of GM foods, intestinal protein digestibility tests must be carried out! This is to prove that when GM foods are digested and the nutrients are absorbed, the entire process is the same as when eating non-GM foods, so it is not harmful to health.

I see. They are all digested and absorbed!

Whether you eat GM or non-GM foods, the process of digestion and absorption is identical!



Secrete amylase to decompose starch

Secret strong acid and pepsin to break down proteins

Secrete bile to promote lipolysis

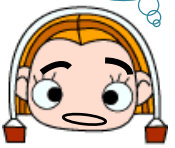
Secrete various digestive juices to break down protein, carbohydrates, fats and nucleotides

Secrete digestive enzyme to digest sugars, amino acids, and nucleotides

Your stomach must be full before going to work

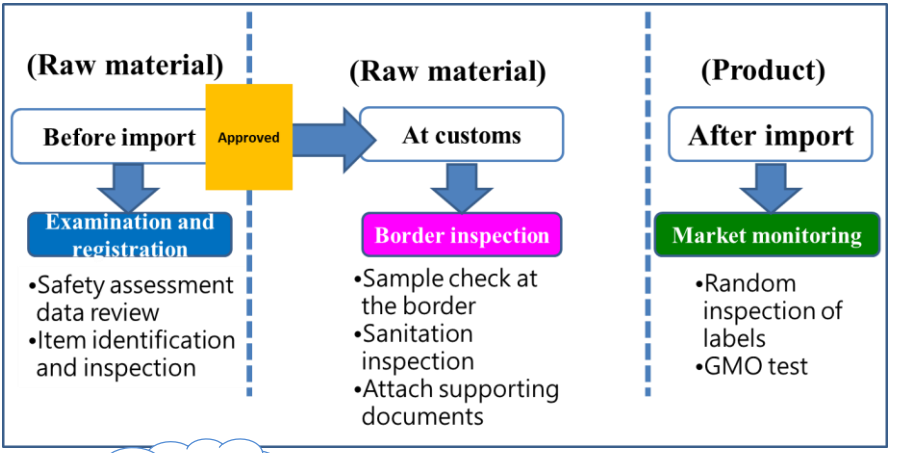
GM foods management system in Taiwan

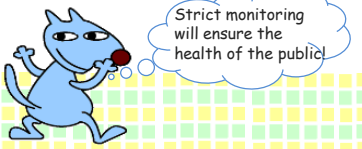
How are GM foods administered in Taiwan?



To safeguard public health, Taiwan Food and Drug Administration (TFDA) of the Ministry of Health and Welfare has invited experts and scholars from various fields to form a GM foods review panel (GMFRP) to conduct strict review of GM foods on a case-by-case basis! GMFRP members also include representatives of consumer protection groups!

Besides the strict review process, border inspections and random inspections of market commodities are conducted. Last but not least, GM foods need to be clearly labeled.





GM foods labeling system in Taiwan

Yes! When GM ingredient is present during processing, it must always be labeled, whatever the level of content. If the product is accidentally contaminated with GM ingredient in the process of transportation and manufacturing, it is exempted from labeling when the presence of GM ingredient is less than 3%. However, if the content exceeds 3%, the product must be labeled.

Raw material

Primary processed food

Highly processed food

Whether they are raw materials, primary processed foods or highly processed foods, they must be labeled to protect consumers' right to know. I'm quite impressed by the government's effort to protect our citizens! I have confidence in their control of GM foods!

Labeling example(1): "genetically-modified","with genetic modification", "used genetic modified (organisms)"
Labeling example(2) :"This product is made of genetic modified (organisms), but does not contain any transgenic DNA fragment or transgenic proteins", "This product does not contain any transgenic DNA fragment or transgenic proteins, but its ingredients contain genetically modified (organisms)"
Labeling example(3):"This product does not contain transgenic DNA fragment or transgenic proteins, but is made of genetically modified (organisms)","This product does not contain transgenic DNA fragment or transgenic proteins, but its ingredients contain genetically modified (organisms)"

The environmental impact of GM crops

Does the use of GM crops have impacts on the environment?

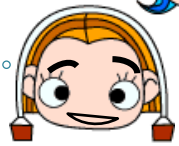
The European Union (EU) has invested more than 30 million euros for biosafety research of GMO since 1982. To date, the results of 500 independent research teams show that there is no scientific evidence that GM crops pose higher risks to the environment, food, and feed safety than conventional crops do.

The Sustainable Development Goals (SDGs) adopted by UN include 17 global goals and 169 targets to address the world's social, economic and environmental challenges. All the goals are interconnected to achieve sustainable development. Emerging biotech crops can provide effective solutions to target no.2, no. 12 and no.15. Therefore, more and more types of emerging biotech foods have been developed!

Suddenly I feel so important! I can save the world!

Gene-edited crops available on the international market

Is there any gene-edited crop on the global market?



Yes! Gene-edited crops available abroad include high oleic acid soybeans, high GABA tomatoes, and so on. However, our government did not receive any application for the approval of such crops yet!

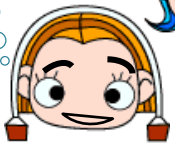
High oleic acid soybeans are derived from gene-editing technology. They are high in oleic and low in linoleic acid. The U.S. Department of Agriculture has determined that this type of soybean contains no foreign genes, so it is not overseen by the GMO regulatory framework.

High GABA tomatoes are even more powerful. GABA (γ-Aminobutyric acid) can help lower blood pressure, relieve stress, anxiety, and insomnia symptoms. Therefore, in response to an aging society, Japanese scientists have used gene editing technology to breed this variety. Currently, it is only grown and sold in Japan for consumption!

I may need to eat some high GABA tomatoes to relieve my stress!

Gene-edited crops under development

There are gene-edited crops currently under development?



Correct! There are non-browning mushrooms and low-acrylamide potatoes currently under development abroad. Whether they will be available in the future depends on market acceptance.

Non-browning mushrooms produced by gene-editing technology can reduce the activity of enzymes that cause browning by 30%, and therefore are less prone to browning and spoilage. It is the first gene-edited crop approved by the U.S. Department of Agriculture, but it is not available on the market yet.

Low-acrylamide potatoes were developed to reduce the production of asparagine, and therefore decrease the formation of acrylamide during frying process. .In addition, reduced occurrence of dark spots and improved capacity for cold storage make these potatoes more conducive to food processing! This product is currently under development in the United States!

I don't need to be worried about eating french-fries and potato chips anymore!

Global status of gene-edited crop management

How are gene-edited crops administered internationally?

Most countries have announced relevant measures and regulations. For example, the U.S. government has a relatively open attitude towards GM and gene-edited agricultural and fishery products. This has encouraged agricultural-related biotechnology industries and academic units to commit to the research and development of gene-edited crops.

However, some EU countries believe that gene-edited crops should be overseen like GM crops. Some other EU countries have gradually loosen their regulations on gene-edited crops. On the other hand, Japan considers crops that do not contain foreign genes as non-GM, which can be sold on the market after notifying the government. At present, Taiwan is also carefully developing management rules for gene-edited crops!

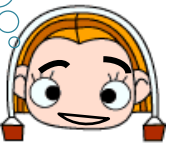
International Regulations	Product-oriented	Process-oriented	Remark
Substantial equivalence	U.S.A. Canada		Early consultation system
Crops containing foreign genes are subject to GM regulations	Japan		
All genetically-engineered crops are subject to GM regulations		EU, Australia, New Zealand	Adjusting regulations based on the definition of gene-editing

No matter how the technology changes, I will still be a conscientious lifetime research assistant!

Source: Huang Qinghui,2019, The future of gene-edited food and the international situation, agricultural policy and agricultural situation,329:116-120
Yu Qiwei, Lin Yanhong,2021, Cross-country comparison of international gene-editing-derived food management mechanisms, Taiwan Economic Research Monthly 44(2),P13-21

Websites related to emerging biotechnology foods

Thank you both for the explanation. I will write about the story of high GABA tomatoes saving the life of the insomniac alien then!



Scan these QR codes in case you need to know more about GM foods. There is a lot of information in it! Wish you luck!

衛福部基改專區

GM Foods Page

Food and Drug Administration, Ministry of Health and Welfare

基改食品Q&A

Q&A about GM Foods

Food and Drug Administration, Ministry of Health and Welfare

新興生物技術食品專區FB

Emerging Biotechnology Foods Fan Page

基改原料查詢

Approval list of GM ingredient

Ministry of Health and Welfare

基改食品標示Q＆A

Q&A about GM foods labeling

We are recruiting fans!

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