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The Development Status and Influencing Factors of Genetically Modified Food

Pengju Liu[1], Ying Chen[2], Jing Guan[2], Weizhe Sun[1], Shuang Jiang[1,*]

[1]*Department of Health Management, Changchun University of Chinese Medicine, Changchun, Jilin, China*

[2]*Department of Department of Clinical Medicine, Changchun University of Chinese Medicine, Changchun, Jilin, China*

[*]*Corresponding author*

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Abstract: With the progress of science and technology, genetic modification technology has seen rapid development, and genetically modified foods have been invented in this context. Genetically modified (GM) food has been controversial since it came out. Some people think that genetically modified food is the product of the development trend of science and technology, and we should accept and vigorously develop it. However, some people believe that GM food is not naturally produced and may be harmful to human health. In this paper, the development status, influencing factors, advantages and potential hazards of transgenic food at home and abroad are analyzed and discussed, and the development direction of transgenic food in China in the future is proposed.

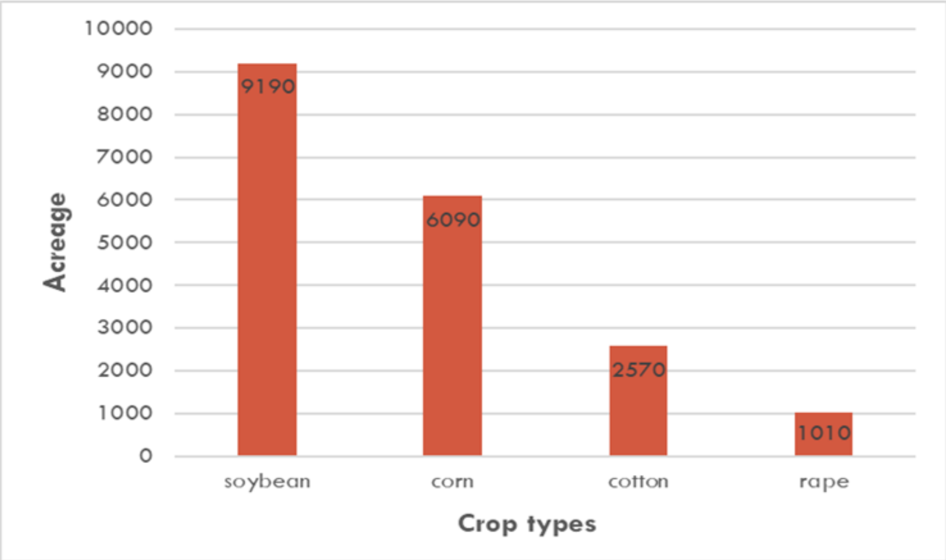
1. Introduction

Genetically modified (GM) food refers to food and food additives produced by animals, plants and microorganisms that use genetic engineering technology to change genomic composition/ the composition of genomes [1]. According to their properties, GM food can be divided into transgenic plants, animals, microorganisms and food processed from them. At present, more than 95% of the approved GM foods on the market are GM plant products, so the GM foods sold on the market are mainly processed foods made from GM plants.

2. Development Status of Genetically Modified Food

2.1. Types of GM Crops

By 2021, the most widely used transgenic crops in the world are mainly divided into four types: soybean, corn, cotton and rape [2]. As shown in Figure 1.



Data is from Agbioinvestor GM monitor, as of December 2021

Figure 1: Categories of GM crops to be planted globally in 2021 (unit: 10000 hectares)

It can be seen from the figure that GM soybeans are the most important GM crops, with 91.9 million hectares (48% of the planting area), followed by corn (60.9 million hectares), cotton (25.7 million hectares) and rape (10.1 million hectares). In addition to the four major crops (corn, soybean, cotton and rape), other GM crops include 27 kinds of crops and fruit trees such as alfalfa, beet, tomato, tobacco, rice, potato, pumpkin, papaya, sugarcane, safflower, eggplant, apple, pineapple, banana, wheat, chickpea, pigeonpea and mustard. Compared with conventional crops, these crops not only have higher economic value and ecological benefits, but also have better properties, which provide more choices for food producers and consumers.

China is not backward in GM food research and development, second only to the United States and Canada. At present48 and 49 transgenic crops have entered the stage of intermediate trial and environmental release respectively; In terms of food crops, the research on transgenic food crops in China has made rapid progress, mainly in cereals and grains, including rice, wheat, corn, soybeans, peanuts, potatoes and so on. China has approved the safety certificate of transgenic production and application, and the crops within the validity period are cotton, rice, corn and papaya [3]. At present, there are only two kinds of transgenic crops approved by the Ministry of Agriculture to be planted in China: cotton and papaya. As cotton is not used as food, there is only one kind of papaya. The approval has been completed, but it has not been commercialized. There are two kinds of rice and corn in the experimental state.

2.2. Planting Area of Transgenic Crops

Since GM crops were allowed to grow commercially on a large scale for the first time in 1996, the planting area of GM crops has increased year by year (see figure 2). By 2021, 29 countries had planted commercially approved GM crops, including 24 developing countries and 5 developed countries, with a total area of 195.5 million hectares, an increase of 3.7% over 2020.

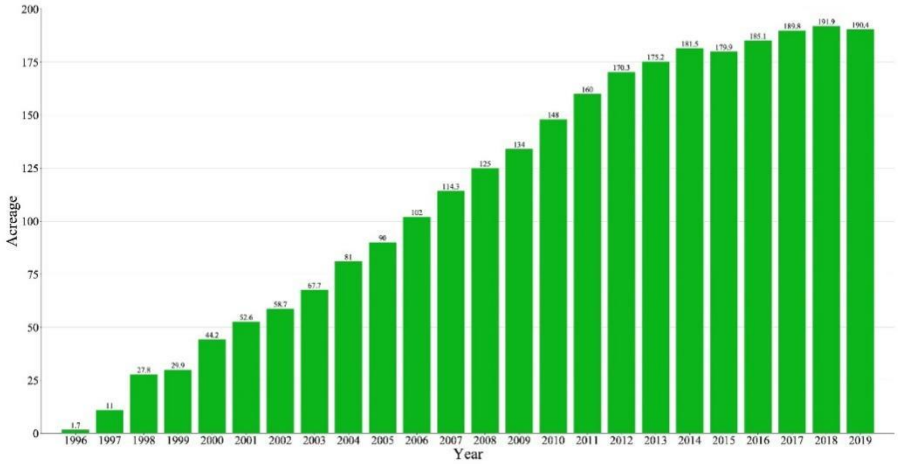


Figure 2: Area of GM crops in the world from 1996 to 2019 (unit: million hectares)

International Organization for Agricultural Biotechnology Application Services (ISAAA), the same below.

According to ISAAA data, by 2019, the United States, Canada, Brazil, Argentina and India are far ahead of other countries in planting GM crops in all countries around the world. These five countries have planted more than 90% of the world's GM crops (see figure 3). In particular, Brazil, Argentina and India are ahead of other developing countries in terms of GM crop acreage.

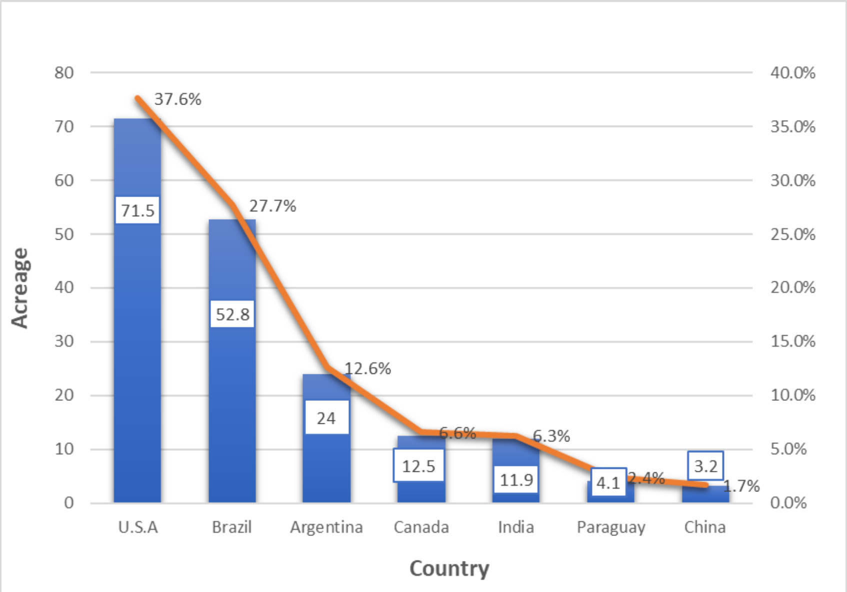


Figure 3: Area and Proportion of Genetically Modified Plants in Countries in 2019 (Unit: million hectares, %)

The United States was the first country in the world to conduct research and development of genetically modified crops, and its genetically modified crop planting area is far ahead of other countries. According to the latest data released by the U.S. Department of Agriculture: By 2021, the U.S. has planted a total of 8550 hectares of GM crops, including 37.54 million hectares of corn, 35.46 million hectares of soybeans, 4.69 million hectares of cotton, 810,000 hectares of oilseed rape, 470,000 hectares of sugar beets, and 6.53 million hectares of alfalfa, an increase of 5.4%, 2.1%, -

2.6%, 9.8%, respectively over the previous year. 0.1%, -0.7%; the total area is close to 40% of the global GM crop cultivation area

2.3. Planting Scope of Transgenic Crops

When GM crops were first grown commercially in 1996 [4], there were only five countries, including the United States, Canada, Australia, Argentina, and Mexico; today, there are more than 70 countries involved in GM crop cultivation or citation. The United States, Brazil, Argentina, Canada, and India are the first tier, with more than 10 million hectares of GM crops planted annually; Paraguay, China, South Africa, Pakistan, Bolivia, and Uruguay are the second tier, with between 1-5 million hectares; the Philippines, Australia, Myanmar, Sudan, Mexico, Spain, Colombia, and Vietnam are the third tier, with planted areas between The other countries have very small areas.

China had been the first country in the world to plant GM crops, and in 2000, China was the global leader in GM crop acreage [5]. From Figure 4, it can be found that the area planted with GM crops in China increased year by year from 1999 to 2004, but tended to plateau from 2004 to the present, due to the restrictions of relevant national policies and the fact that the safety of GM foods has been controversial, resulting in the application of GM foods being very hindered.

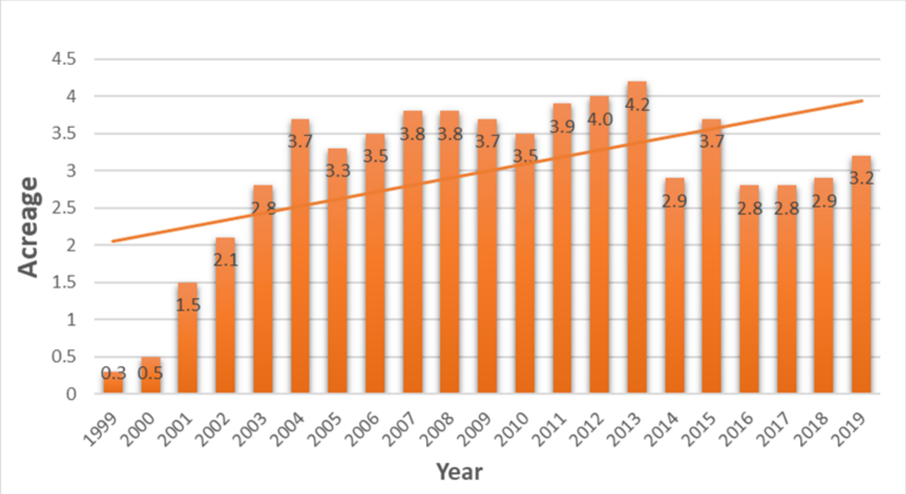


Figure 4: China's transgenic planting area from 1999 to 2019 (unit: million hectares).

3. Advantages of GM Food

3.1. Reduce or Eliminate the Use of Pesticides

Currently, the conventional way to deal with crop pests and diseases is to use agrochemicals. Although the use of pesticides can increase the yield of crops, large amounts of spraying can cause pesticide residues to exceed the standard, and the resulting processed food is digested and absorbed by the human body, which can cause serious harm to people's health in the long run. On the other hand, the long-term use of herbicides and pesticides will make weeds and pests resistant, leading to a decline in the effectiveness of control. Farmers will inevitably spray more pesticides for better profit, which leads to ecological environment contaminated by pesticides, and the serious exceedance of pesticide residues will endanger human health [6]. In contrast, many transgenic crops are inherently resistant to pests and diseases, so they do not need to apply pesticides, which not only solves the problem of pesticide residues, but also eliminates the pollution caused by pesticides to the environment.

At present, the only conventional way to deal with crop diseases and pests is to apply pesticides. Although the use of pesticides can increase crop production, a large amount of pesticide spraying will cause pesticide residues to exceed the standard, and the processed food will be digested and absorbed by the human body, which will cause serious harm to people's health for a long time. On the other hand, long-term use of herbicides and insecticides will lead to drug resistance of weeds and pests, leading to a decline in control effect. Farmers will inevitably spray more pesticides in order to better benefit, thus causing the ecological environment to be polluted by pesticides, and serious excessive pesticide residues will harm human health [6]. Many transgenic crops have the characteristics of disease resistance and insect pests, so they do not need to apply pesticides, which not only solves the problem of pesticide residues, but also eliminates the problem of pesticide pollution to the environment. It has been estimated that the GMO technology has reduced the use of plant protection chemicals by 37% [7]. Studies have shown that growing GM crops with insect and herbicide resistance has reduced global pesticide use by 553 million kg (kilograms), which is equivalent to 8.2% less pesticide spraying [8]. If we look at the Environmental Impact Quotient (EIQ), this corresponds to a 19.1% reduction in the environmental harm caused by pesticides [9, 10].

3.2. More economical and Efficient use of Land

Although China is a vast country, the arable land per capita is only 0.007 square kilometers due to the large population, so the arable land is very valuable. With the same yield, transgenic crops occupy less arable land, which can play a positive role in "returning farmland to forest" and reducing soil erosion. At present, saline- and drought-tolerant transgenic maize has been successfully cultivated [11-13], marking the possibility of cultivation in saline and arid areas, which can increase food production on the one hand and expand the range of maize cultivation on the other.

3.3. Higher Economic Benefits

Growing GM crops has higher economic benefits than conventional crops, and ISAAA reports that the annual market for GM crop seeds has exceeded $3 billion worldwide. In the U.S., planting GM soybeans has increased earnings by about $50 per hectare, planting GM cotton has increased earnings by about $40 per hectare, and planting GM corn has increased earnings by more than $20 per hectare. Insect-resistant maize has been shown to increase yields by an average of 7% to 9% compared to non-GM controls of the same variety in the United States and Canada [7], while reduced pesticide use can reduce input costs [14] and increase income and improve quality of life for farmers in developing and poor countries.

3.4. Reducing CO2 Emissions

According to ISAAA, researchers have re-evaluated the climate benefits of increased production from growing GM crops by including the opportunity cost of carbon (COC) as a consideration, showing that if GM crops were widely grown in the EU, greenhouse gas (GHG) emissions could be reduced by 33 million tons of carbon dioxide equivalent per year, equivalent to 7.5% of total GHG emissions in 2017. This is equivalent to 7.5% of the total GHG emissions from EU agriculture in 2017. The above indicates that the cultivation of GM crops is more environmentally friendly than conventional crops and more in line with the concept of sustainable development [15, 16].

3.5. Better Quality

In 1994, the world's first commercialized genetically modified (GM) food, the extended ripening and storable tomato, was approved for marketing by the United States. Dr. Ingo Potrykus invented "golden rice" [17], which uses transgenic technology to produce β-carotene in the endosperm of rice, which is also called golden rice because of its golden color. Converted to vitamin A, which can reduce the occurrence of blindness and immune deficiency symptoms caused by vitamin A deficiency. Research also reports that the GM plants are expected to produce therapeutic recombinant protein and vaccines in the future [18].

4. Potential Hazards of Transgenic Plants

The emergence of any new thing has its two sides, and transgenic technology is no exception. Genetically modified crops not only bring huge economic benefits to human beings, but also bring some hidden dangers.

4.1. May Cause Allergic Reaction

Because transgenic technology inserts a new gene into the original gene sequence, the products expressed by these new genes may cause allergies [19], such as inserting a peanut gene into the potato gene. People who are allergic to peanuts will not be allergic to conventional potatoes, but eating genetically modified potatoes containing peanut genes may cause allergies. Anaphylaxis is a serious problem that can cause intense reactions in the immune system and may lead to tumors in the long term.

4.2. Increase Drug Resistance

The commonly used transformation method in plant transgenic technology is Agrobacterium tumefaciens transformation. After transformation, certain concentration of antibiotics should be used. It is suspected that after the transgenic food containing antibiotics is digested and absorbed by the human body, antibiotics will remain in the human body, which may increase drug resistance for a long time in the past [20], or the food containing antibiotic genes may contact with the flora in the digestive tract, These bacterial groups may change into drug resistant strains when exposed to antibiotics.

4.3. Possible Impact on Ecological Environment

Some experts believe that because GM crops are not naturally occurring, the sudden release of a large number of products from this new technology into the environment will cause damage to the original ecological environment. Other experts believe that GM crops will hybridize with inbred weeds through pollen dispersal, and that hybrid weeds may acquire the insect and herbicide resistance of GM crops through genetic inheritance and form "super weeds" that are difficult to remove, and affect the normal growth of crops and ecological balance [21].

5. Factors Affecting the Development of Genetically Modified Food Conclusions

5.1. Consumer Attitude

The key to measuring the success of a product is whether consumers pay for it, and GM foods are no exception. Only if consumers are willing to buy GM foods can they directly contribute to the development of GM foods. If there is no demand or little demand for GM foods to consumers, the produced GM foods lose their value and become "worthless". From the study of Huo L [22], Xu R et al [23], it was found that Chinese consumers generally have low awareness of GM foods, although most of them have heard of GM foods, they do not understand the principles of GM foods, and in addition, they are concerned about the safety of GM foods, therefore, it is crucial to improve the awareness level of consumers to change their attitude.

5.2. Public Opinion Guidance of Network Media

In the information age, people rely on the Internet media for a large part of news and information. The results of a survey by Li L et al [24] on college students' knowledge of genetically modified foods in Kunming, China, showed that the Internet was the main source of information about genetically modified foods for college students, and it is evident that the Internet has become the main way for college students to obtain knowledge. Nowadays, the publicity, reporting and evaluation of something by online media can cause a great effect, and the reports of online media can even influence people's judgment and behavior for those who lack knowledge. Therefore, the attitude of the online media toward the propaganda of GM foods will, to a certain extent, influence the future development of GM foods.

5.3. Scientific and Technological Level

The development of transgenic technology cannot be separated from the progress of science and technology level, which plays a decisive role in the development of transgenic technology. The main direction of the current international research and development on transgenic technology focuses on precision and safety. At present, a variety of safe GM technologies have been reported, which can be divided into the following four categories according to their principles and purposes: safe marker gene method, marker gene rejection and gene superposition, chloroplast transformation method to prevent gene drift and gene splitting method, and gene targeted modification technology [25], and the development of the above mentioned science and technology will affect the future direction of GM food to a certain extent.

5.4. National Attitude and Policy towards Genetically Modified Food

As the birthplace of transgenic technology, the United States has obtained a lot of benefits from transgenic food. Therefore, the attitude towards transgenic technology is very open, and the approval of the United States Department of Agriculture on genetically modified crop seeds is very loose. The principle of substantial equivalence holds that if the generally modified product contains substantially equivalent ingredients present in the conventional product, then no further safety rules are required [26]. On the food label, food producers can choose whether to add the label of genetically modified food according to the principle of voluntariness. However, according to US Public Law 114-216, from January 1, 2022, food producers in the United States will be required to label foods containing genetically modified organisms (GMO), which indicates that the United States has begun to be strict in its attitude towards the label of genetically modified food [1]. Compared with the United States, Europe has a strict attitude towards genetically modified food. Since the experience of the "food crisis" [27], Europeans have paid special attention to food safety issues. Therefore, the EU has a strict attitude towards genetically modified food [28, 29], which mainly stipulates that all foods with genetically modified components accounting for more than 0.9% of the food ingredients must be labeled. In addition, the EU also requires and stipulates that restaurants If the food sold in coffee shops and other places contains genetically modified ingredients, it must be marked on the menu. Japan adopts a combination of mandatory labeling and voluntary labeling to supervise the labeling of genetically modified food [30], which is more consistent with the purpose and requirements of the labeling system of genetically modified food.

China's attitude towards genetically modified food is similar to that of the EU, which also requires mandatory labeling [31]. On May 9, 2001, China issued the Administrative Regulations on the Safety of Agricultural Genetically Modified Organisms and promulgated three corresponding administrative measures, namely, the Administrative Measures for the Safety of the Import of Agricultural Genetically Modified Organisms, the Administrative Measures for the Labeling of Agricultural Genetically Modified Organisms and the Administrative Measures for the Safety Evaluation of Agricultural Genetically Modified Organisms. The method clearly stipulates that all agricultural genetically modified organisms listed in the label management directory and used for marketing shall be labeled; Those not marked or marked as required shall not be imported or sold. Strict policies and systems have protected consumers' right to know and improved the safety of GM food on sale. However, the labeling system also has certain restrictions on the development of GM food.

6. Summary

According to experts, the world population will be close to 10 billion in 2050. On the one hand, the traditional planting of chemical agriculture has caused heavy pressure on the earth's environment, and on the other hand, due to the reduction of arable land and the lack of traditional food production is extremely prone to food crisis, so the planting of higher yielding genetically modified crops is one of the optimal choices. Although China's grain production is increasing year by year, it is mainly wheat and rice. Data show that China's share of global grain imports has increased from 5% to 30% over the past 20 years, and today China relies on imports for 85% of its soybeans and 10% of its corn, of which more than 80% are genetically modified varieties. This indicates that China's soybean and corn production is insufficient and very dependent on imports. On the contrary, in other countries, the planting area of GM crops has been increasing year by year since the commercial planting in 1996, which has brought huge economic benefits to the countries growing GM crops on the one hand; on the other hand, it has made great contributions to solve the problem of food and clothing in many developing and poor countries.

At present, the development of GM food in China faces many problems, especially in commercial cultivation, safety certification and labeling system, which need to be solved by multiple departments. In addition to GM crops, the focus of future GM food development in China should be on improving consumer awareness of GM food and GM food safety.

References

[1] Bawa, A.S. and K.R. Anilakumar, Genetically modified foods: safety, risks and public concerns-a review. J Food Sci Technol, 2013. 50 (6): p. 1035-46.

[2] Hwang, H. and S.J. Nam, The influence of consumers' knowledge on their responses to genetically modified foods. GM Crops Food, 2021. 12 (1): p. 146-157.

[3] Lassen, J., K.H. Madsen and P. Sandøe, Ethics and genetic engineering – lessons to be learned from GM foods. Bioprocess and Biosystems Engineering, 2002. 24 (5): p. 263-271.

[4] Szabala, B.M., P. Osipowski and S. Malepszy, Transgenic crops: the present state and new ways of genetic modification. J Appl Genet, 2014. 55 (3): p. 287-94.

[5] Wang, X. and S. Jia, [Comparison of commercialization of transgenic crops in China and world-wide]. Sheng Wu Gong Cheng Xue Bao, 2008. 24 (4): p. 541-6.

[6] Tsatsakis, A.M., et al., Impact on environment, ecosystem, diversity and health from culturing and using GMOs as feed and food. Food Chem Toxicol, 2017. 107 (Pt A): p. 108-121.

[7] Phillips T. Genetically modified organisms (GMOs): transgenic crops and recombinant DNA technology. Nat Educ.

2008; 1:213.
[8] Klumper, W. and M. Qaim, A meta-analysis of the impacts of genetically modified crops. PLoS One, 2014. 9 (11): p. e111629.
[9] Brookes, G. and P. Barfoot, Environmental impacts of genetically modified (GM) crop use 1996-2013: Impacts on pesticide use and carbon emissions. GM Crops Food, 2015. 6 (2): p. 103-33.
[10] Barfoot, P. and G. Brookes, Key global environmental impacts of genetically modified (GM) crop use 1996-2012. GM Crops Food, 2014. 5 (2): p. 149-60.
[11] Wang, C., et al., Enhanced expression of phospholipase C 1 (ZmPLC1) improves drought tolerance in transgenic maize. Planta, 2008. 227 (5): p. 1127-1140.
[12] Wang, X., et al., Genetic variation in ZmVPP1 contributes to drought tolerance in maize seedlings. Nat Genet, 2016. 48 (10): p. 1233-41.
[13] Malenica, N., et al., Genetic Approaches to Enhance Multiple Stress Tolerance in Maize. Genes (Basel), 2021. 12 (11).
[14] Bouis, H.E., B.M. Chassy and J.O. Ochanda, 2. Genetically modified food crops and their contribution to human nutrition and food quality. Trends in Food Science & Technology, 2003. 14 (5-8): p. 191-209.
[15] Olesen, J.E., et al., Modelling greenhouse gas emissions from European conventional and organic dairy farms. Agriculture Ecosystems & Environment, 2006. 112 (2): p. 207-220.
[16]. Brookes, G., Genetically Modified (GM) Crop Use 1996-2020: Impacts on Carbon Emissions. GM Crops Food, 2022. 13 (1): p. 242-261.
[17] Datta, K., et al., Bioengineered 'golden' indica rice cultivars with beta-carotene metabolism in the endosperm with hygromycin and mannose selection systems. Plant Biotechnol J, 2003. 1 (2): p. 81-90.
[18] Waltz, E., Nonbrowning GM apple cleared for market. Nat Biotechnol, 2015. 33 (4): p. 326-7.
[19] Lassoued, R., et al., Expert opinions on the regulation of plant genome editing. Plant Biotechnol J, 2021. 19 (6): p. 1104-1109.
[20] Haslberger, A.G., Policy forum: genetic technologies. Monitoring and labeling for genetically modified products. Science, 2000. 287 (5452): p. 431-2.
[21] Pontiroli, A., et al., Fate of transgenic plant DNA in the environment. Environ Biosafety Res, 2007. 6(1-2): p. 15-35.
[22] Huo, L. and Y. Liu, Genetically Modified Rice: Do Chinese Consumers Support or Go Against It? Based on the Perspectives of Perceived Risk and Trust. Front Psychol, 2022. 13: p. 813862.
[23] Xu, R., Y. Wu and J. Luan, Consumer-perceived risks of genetically modified food in China. Appetite, 2020. 147: p. 104520.
[24] Li, L. and J.R. Bautista, Examining Personal and Media Factors Associated with Attitude towards Genetically Modified Foods among University Students in Kunming, China. Int J Environ Res Public Health, 2019. 16 (23).
[25] Shewry, P.R., H.D. Jones and N.G. Halford, Plant biotechnology: transgenic crops. Adv Biochem Eng Biotechnol, 2008. 111: p. 149-86.
[26] Karalis, D.T., et al., Genetically Modified Products, Perspectives and Challenges. Cureus, 2020. 12 (3): p. e7306.
[27] Lucht, J.M., Public Acceptance of Plant Biotechnology and GM Crops. Viruses, 2015. 7 (8): p. 4254-81.
[28] Turnbull, C., M. Lillemo and T. Hvoslef-Eide, Global Regulation of Genetically Modified Crops Amid the Gene Edited Crop Boom - A Review. Front Plant Sci, 2021. 12: p. 630396.
[29] Entine, J., et al., Regulatory approaches for genome edited agricultural plants in select countries and jurisdictions around the world. Transgenic Res, 2021. 30 (4): p. 551-584.
[30] Farid, M., et al., Exploring Factors Affecting the Acceptance of Genetically Edited Food Among Youth in Japan. Int J Environ Res Public Health, 2020. 17 (8).
[31] Du L. GMO Labelling and the Consumer’s Right to Know: A Comparative Review of the Legal Bases for the Consumer’s Right to Genetically Modified Food Labelling. McGill J. Law Health. 2014; 8:1–42.