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Review Article

Review on: Public Perception of Biotechnology on Genetically Modified Crops, Bio Policy and Intellectual Property Rights

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Abstract

Public discussion about genetically modified crops is strongly heavily influenced by debates over their risks and benefits. Supporters of biotechnology point to its potential to reduce hunger, prevent malnutrition, treat diseases, and improve overall health and quality of life. However, there is considerable opposition to biotechnology. Some critics argue that it poses risks to human health and the environment, while others oppose it on moral and ethical grounds. The transfer of genes between different species is often criticized as "playing God" or breaking the "Law of Nature." Biosafety on (GM) crops is a rapidly growing field that includes scientific research, ethical issues, and policy and regulatory frameworks to assess and manage risks to human and animal health, including food and feed safety, as well as environmental risks related to modern biotechnology products. Bio-policy refers to the rules, norms, and ethical considerations that govern the development, production, and use of biotechnology products. These policies differ by country and can be influenced by international agreements and organizations. A key international agreement (TRIPS) Agreement, which sets global standards for intellectual property protection. The Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement requires governments to issue patents in technological sectors, including modern biotechnology, to protect innovations in this field. This ensures that biotechnological advancements, including GM crops, are protected under intellectual property laws, aiding their development and commercialization while addressing ethical and safety concerns.

Keywords

Biotechnology, Biosafety, Bio Policies GMO, Genetic Engineering

1. Introduction

Biotechnology involves using biological processes and living organisms or their derivatives to address challenges and produce various products [3]. Countries worldwide are integrating modern biotechnology into their agricultural research and development to enhance food security and stimulate economic growth. However, the debate and controversy surrounding genetically modified organisms (GMOs) persist, particularly in Europe and other regions [17]. Due to scientific

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and industrial advancements, genetically modified (GM) products that offer various benefits to consumers and meet essential food needs are approaching market availability. Over the past 15 years, the media has highlighted various biotechnology and research topics, addressing issues at both global and local levels [24]. However, there are conflicting perspectives among the general public in the United States and other nations about the use of biotechnology in food production [15].

Supporters of biotechnology argue that it can reduce poverty, prevent malnutrition, cure diseases, and enhance health and quality of life. In contrast, opponents see it as an unwarranted modification of nature with potentially disastrous impacts on ecosystems and human genetics. Currently, Europe enforces strict laws on GM crops throughout the food chain, and countries like India and Brazil have also declined to authorize GM crops [25]. Similarly, consumer concerns have made food firms unwilling to adopt genetically modified food products [5]. While some oppose biotechnology due to perceived threats to humans and the environment, others object on moral and ethical grounds, arguing that genetic engineering, especially cross-species gene transfer, is akin to playing God or violating natural laws [7]. Many people worry that patenting genetically modified organisms will make farmers permanently dependent on multinational seed and chemical companies. Others fear that this technology will favor industrialized countries over developing ones, although opinions on this issue differ [26]. Although technical challenges, public support for biotechnology in food production remains a critical factor influencing the growth of agricultural biotechnology. Despite its importance, few studies have thoroughly examined this topic. A recent study found that consumers' acceptance of biotechnology is greatly influenced by their moral and ethical views, perceptions of the risks and benefits of GM products, opinions on corporations, scientific knowledge, and trust in the government [15]. Biosafety of GMOs is a rapidly evolving multidisciplinary field that encompasses science, ethics, policies, and regulations to assess and manage risks to human and animal health, food and feed safety, and environmental hazards related to modern biotechnology products [19]. Biosafety is a holistic concept with direct relation to agricultural sustainability, food safety, and environmental protection, including biodiversity [1]. Intellectual property laws in biotechnology cover a wide range of concerns, such as patenting various products and genetic materials like genes, gene sequences, and fragments thereof sourced from humans, animals, plants, and microorganisms [11]. The aim of this review is to investigate the impact of various factors such as socioeconomic status, social, political, and religious beliefs, education, scientific knowledge, bio policies, and intellectual property rights on public perceptions of biotechnology and its acceptance on genetically modified crops.

2. Factors Influencing on Global Public Attitude and Acceptance Towards Modern Biotechnology

Public opinion on a specific technology can be evaluated through six main categories (agreement, knowledge, technical, economic, social, and political), with the effectiveness of each category in advancing the overall solution regularly evaluated. However, only four of these categories—agreement, knowledge, technology, and social—closely aligned with attitude factors, while economic and political considerations had minimal impact on the acceptance of modern biotechnology [27]. During the initial commercial rollout of genetically modified (GM) foods, only a small fraction of farmers in the United States of America (USA) were willing to gamble on the commercial viability of GM crops. However, over time, US farmers have increasingly recognized the potential benefits of GM crops in the global agricultural market. This understanding has led to a significant growth in commercial large-scale plantings of GM crops, with annual increases exceeding 10%, expanding from 1.7 hectares to 58.7 million hectares [7].

Asians exhibit less worry about genetically engineered therapeutic items compared to genetically modified food. Conversely, in Europe, public awareness of GM technology and its current implementation level is lacking. Concerns persist regarding the long-term effects of genetically modified food on the environment and human health, and skepticism surrounds its potential benefits for farmers and consumers [27]. Acceptance of modern biotechnology in Ghana is mediocre to low, evident in the public's understanding and the necessity of creating new genetically modified crop varieties to address food insecurity, poverty, and malnutrition, crucial for Africa's burgeoning modern biotechnology sector [16]. Concerned Ghanaians fear that GM products primarily favor large multinational corporations, amplifying their distrust in the government [27].

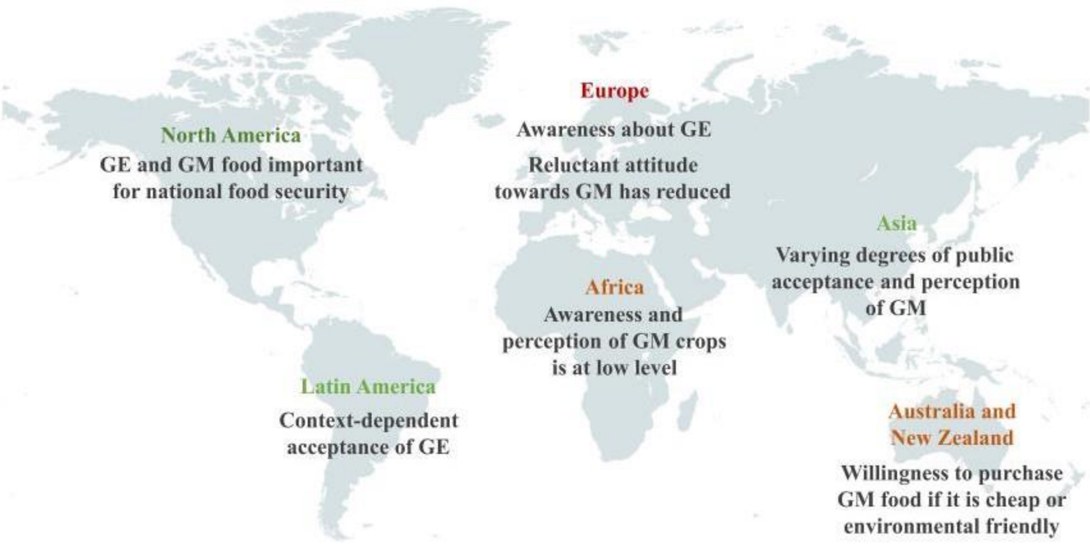

Figure 1. *Public perception on biotechnology in different regions of the world [7].*

2.1. Globally Genetic Engineering Crops and Their Role in Building Global Food Security

Meeting the needs of the planet's expanding population requires a 25 to 70 percent increase in global food production. While expanding farmable land seems a solution, the majority is already utilized for various agricultural purposes. Approximately 36% of the world's total land area, around 4.7 billion hectares, is classified as agricultural, with 10.8% deemed arable. Genetic engineering's role in food security prompts public debate [28].

The advancement of genetically modified crops can boost food production, availability, and nutritional quality. Additional benefits encompass decreased pesticide exposure, reduced cancer incidences, fewer farmer suicides, and improved mental well-being among farmers [22]. Genetic engineering and GM in agriculture aim to create crops with enhanced nutritional content, resilience against emerging diseases and environmental stresses, and the capacity to minimize pesticide usage. As per the International Service for the Assessment of Agri-biotech applications, regulatory approval has been granted in 44 countries for 436 GM events, comprising 33 plant species and 44 commercial traits utilized in food, feed, and cultivation [33]. The most commonly targeted features are herbicide tolerance and insect resistance, followed by improved product quality, a pollination control system, disease resistance, abiotic stress tolerance, and changed growth and yield [35].

The most widely modified plants (by events) are maize (*Zea mays*) - 152, cotton (*Gossypium hirstum L.*), potato (*Solanum tuberosum L.*), soybean (*Glycine max L.*), and Argentine canola (*Brassicanapus*). The top countries that have grown GM plants are being produced in 47 African countries, with South Africa leading the continent in production [7].

2.1.1. Latin America

Latin American nations cultivate 44% of the world's GM crop area, with Brazil and Argentina among the top five GM farming countries. Furthermore, eight Latin American countries, including Brazil, Chile, Colombia, Ecuador, Guatemala, Honduras, Paraguay, and Argentina, have implemented regulatory frameworks for NBTs and are actively engaged in research to develop their own genetically engineered foods and crops [28]. In Brazil, a tomato rich in antioxidants and high lycopene content was developed. Researchers at the University of Costa Rica are employing gene editing in rice, specifically targeting drought tolerance. Similarly, studies in Argentina utilized genetic engineering methods to produce potatoes that resist browning [13]. Ecuador, Venezuela, and Peru prohibit the commercial cultivation of genetically modified crops. While Ecuador permits imports of GM foods if labeled, Announcement 752 in Ecuador established a regulatory framework for "genetically improved organisms" exempting products without foreign genes from risk assessment. Mexico's President banned GMO corn imports and licenses, despite being a major importer of GMO corn and soybeans [17].

2.1.2. Europe

In 2020, Europe cultivated only one biotech crop, GM maize, limited to Spain and Portugal. Renewed authorization was granted for two maize varieties and one oilseed rape for food and animal feed use, along with approval for importing seven GM crops. Although GM cultivation remains illegal in most EU countries, 109 GM events have been approved for import, primarily benefiting from soybean, canola, maize, and cotton imports [32]. New legislation was introduced in the UK to enable researchers to conduct field trials on specific GE plants. Despite this, field studies still require registration via a notification process. The next step involves assessing regulatory definitions of GMOs to exclude species developed through GE or other genetic methods if conventional breeding could have achieved the same for commercial release and cultivation [8].

2.1.3. Africa

Africa holds the highest potential for GM crop adoption. South Africa planted maize, soybean, and cotton on 2.7 million hectares, while Sudan, Malawi, Nigeria, Eswatini, and Ethiopia grew cotton on a combined 2.9 million hectares. Nigeria particularly stands out as a leader in GM crop adoption [34]. The government has allowed the cultivation of Bt-cowpea in 2019 and has now approved the release of drought tolerant and insect resistant maize (TELA) [33]. Africa exhibits the greatest potential for adopting GM crops. In South Africa, maize, soybean, and cotton were cultivated across 2.7 million hectares. Additionally, cotton was grown in Sudan, Malawi, Nigeria, Eswatini, and Ethiopia, totaling 2.9 million hectares. Nigeria notably leads in the adoption of GM crops, highlighting the continent's growing embrace of this technology [7].

2.1.4. North America

The United States has a rich history of developing, commercializing, and using GM plants and, more recently, animals. The Fla-vrSavr tomato, introduced in 1996, marked the first commercially available GM plant in the US. It was among the first countries to establish clear regulatory decisions on unique plant breeding advancements, followed by Canada. With 71.5 million hectares, the US leads in biotech crop cultivation, with over 90% of corn, cotton, and soybeans being genetically engineered. Its robust regulatory framework has significantly contributed to the progress and public acceptance of genetically altered plants [30]. In 2017, GM non-browning apples were offered in US supermarkets. The first TALEN-based Genetic Engineering crop, a soybean with a changed oil content, was harvested on a modest scale in the fall of 2018 [34]. Health Canada has assessed GM foods for over two decades. Golden rice, a GM rice variant, gained commercial approval in Canada in March 2018, while non-browning potatoes were approved in 2016. A list of approved GM events in Canada is available in the ISAAA database. As of 2019, Canada permits the sale of around 140 genetically modified foods [7].

2.1.5. Asia

In 1992, Asia saw its first commercialized GM crop with a virus-resistant tobacco. India, China, and Pakistan were the leading contributors to GM crop development in 2019. Japan and Australia have recently refined their regulatory frameworks and made initial determinations on several objects. In September 2021, Japan approved Madai, a CRISPR-edited red sea bream with 20% more flesh [31]. The University of Tokyo's researchers developed high-yield canola and rice strains using a technique known as "mito-TALENs." In July 2021, the Philippines allowed the production of Bt eggplant for direct consumption, feed, or processing [16]. Bt-eggplant, a genetically modified variety resistant to the eggplant fruit and shoot borer, promises significant benefits. Recent research indicates a projected 192% increase in marketable yield and a 48% reduction in insecticide usage per hectare upon its commercialization. Bangladesh is undergoing the final regulatory assessment of golden rice, with political leaders like Prime Minister Sheikh Hasina and Agricultural Minister Begum Matia Chowdhury advocating for GM food crop adoption to enhance economic and food security [9].

2.1.6. Australia and New Zealand

Australia has approved 142 GM crop events, with cultivation of GM cotton, canola, and safflower covering 0.6 million hectares. Products lacking foreign DNA are exempt from GMO regulation. Only one GE crop, developed with SDN-1 genome-editing, has been deregulated as a conventional variety. Researchers at Murdoch University used CRISPR to create a low-gluten potato. New Zealand regulates all GE crop varieties under GMO regulations [34]. As of October 2021, no organization in New Zealand has applied for conditional or full-scale release of a GE plant. Nonetheless, the country allows the import of GE food products approved by Food Standards Australia New Zealand (FSANZ). These products, approved for direct human consumption or animal feed, are based on sanctioned GE events [7].

2.2. Status of GMO Production in Ethiopia

As long as agricultural biotechnology is embraced by farmers all over the world, it will have a significant impact on agricultural production, as evidenced by the on-going expansion in the production of biotech crops [13]. African nations like Malawi, Kenya, and Nigeria are progressing from field trial experiments towards granting environmental release approvals for GM crops. Burkina Faso, Ghana, Ethiopia, Nigeria, Uganda, and Eswatini are making significant strides towards multi-location field trials for commercial approval. Tanzania has also expressed interest in GM crops. South Africa and Sudan lead GM crop production in Africa, with Egypt joining them in producing GM crops [31]. At the request of the Ministry of Agriculture, the Ministry of Environment, Forest, and Climate (MEFC) in Ethiopia sanctioned the importation of Bt cotton seeds for field trials and research. Consequently, field trials for Bt cotton are ongoing at various locations within Ethiopia's cotton-producing regions [13]. The Bt Cotton crop is on the concluding stage, which will permit the commercialization of the crop [12]. The Ethiopian Agricultural Research Institute's agricultural biotechnology sector is likely to introduce biotech Bt cotton seed varieties to farmers within the next one to two years. The outcome of this trial will significantly influence the development of other transgenic crops in the country [10].

Ethiopia has permitted the commercial cultivation of genetically modified (GM) cotton and field research on GM maize to boost agricultural productivity and security. After two years of controlled field trials conducted by the Ethiopian Institute of Agricultural Research (EIAR), the Ministry of Environment, Forest, and Climate (MEFC) approved the environmental release of Bt cotton. The two cotton hybrids slated for commercial cultivation underwent rigorous testing to ensure compatibility with Ethiopia's growing conditions. [19]. Ethiopia must thus evaluate the benefits that may arise from the use of biotechnology and the potential difficulties that may be met by the cultivation of GM crops if it is to feed its alarmingly expanding population [14].

2.3. Challenges and Opportunities of Genetically Modified Crops

Biotechnology is revolutionizing science, offering hope for addressing hunger, malnutrition, and reducing reliance on animal and plant-based industrial resources. Despite its promise, concerns persist about biosafety, particularly regarding the potential unforeseen and harmful impacts of GM crops on human health, the environment, and both target and non-target organisms [22]. Many countries are adopting international and national biosafety regulations to address potential issues. America, Brazil, Belgium, China, and India are prominent users of GM crops globally, while Egypt, Sudan, South Africa, and Burkina Faso lead GM crop production in Africa. Ethiopia has established its own policy and biosafety regulations for biotechnology products, recognizing the importance of GM crops in enhancing agricultural quality and output [33]. Bt cotton, which contains a toxic protein from *Bacillus thuringiensis*, was recently introduced to Ethiopia and is expected to fundamentally alter how fibers are produced for the textile industry [13]. It will also have a significant impact on how modern biotechnological science will be used in the country in the coming years. The introduction of Bt cotton is a typical example worth mentioning here which shows a relative flexibility of the current Ethiopian biosafety regulation [6].

2.4. Bio Policy for Biotechnology Products, Regulatory Frameworks of Governments

Regulatory frameworks play a crucial role in overseeing the development and sale of biotechnology products. They typically involve a comprehensive evaluation to determine effectiveness, safety, and potential risks. This assessment includes details on intended use, manufacturing, composition, and environmental impact. Pre-market evaluations, possible clinical trials, and post-market surveillance are common components of this process [22].

2.4.1. Risk Assessment and Management on Genetically Modified Crops

Bio policy underscores the necessity of conducting thorough risk assessments for biotechnology products. It involves evaluating potential risks to the environment, animal welfare, and public health, followed by implementing risk management strategies to mitigate or eliminate identified hazards. These strategies may include labeling regulations, adverse event monitoring systems, containment protocols during research, and procedures for addressing unintentional releases or contamination [21].

2.4.2. Ethical Considerations

Bio policies address moral dilemmas arising from biotechnology use, including informed consent in human subject research, genetic privacy, equal access to medical technology, and cultural and biodiversity preservation. Ethical standards guide the development and implementation of biotechnological advancements, ensuring they align with human rights, social equity, and environmental conservation [12].

2.4.3. Intellectual Property Rights

Bio policy often addresses intellectual property rights (IPR) concerning biotechnology products. These rights grant the assignee or inventor full control over the invention's development, production, and marketing. While IPR protection promotes investment and research in biotechnology, it also raises concerns about equitable access to essential technologies, healthcare product costs, and benefit distribution [10].

2.4.4. International Cooperation and Harmonization

International cooperation and policy alignment are vital in the global landscape of biotechnology. Nations collaborate through entities like the WHO, FAO, and WTO to create unified standards, regulations, and guidelines. Harmonization initiatives aim to streamline trade, ensure uniform safety protocols, and overcome regulatory barriers that could impede the advancement and acceptance of biotechnology products [7].

2.4.5. Public Engagement and Communication

Bio policies acknowledge the significance of public engagement and communication in shaping the development and acceptance of biotechnology products. Governments and regulatory bodies aim to engage stakeholders, including scientists, industry representatives, consumer groups, environmental organizations, and the public, in decision-making processes. Transparent communication about risks, benefits, and regulatory decisions builds trust, addresses concerns, and encourages informed public debate [17].

2.5. Intellectual Property Rights

Protecting the inventions and investments made by businesses and individuals in the field of biotechnology is essential for modern biotechnology goods [18]. As biotechnology continues to advance rapidly, intellectual property rights become increasingly important to incentivize innovation, ensure fair competition, and enable the commercialization of biotech products. These rights provide exclusive control over the use and exploitation of the protected creations, allowing the creators to benefit from their work and prevent others from using it without permission [11]. In the context of modern biotechnology products, there are several types of intellectual property rights that can be utilized:

2.5.1. Patents

Patents are a widely employed method of safeguarding intellectual property in biotechnology. They afford the owner exclusive rights to an invention for typically 20 years. Various biotech products, like novel genes, GMOs, and diagnostic methods, are eligible for patents. Through patents, innovators can prohibit unauthorized creation, use, sale, or importation of their innovation. An invention must meet criteria of novelty, inventive step, and industrial applicability to qualify for patent protection [11].

2.5.2. Copyright

Copyright protection extends beyond traditional creative works to include software utilized in genetic analysis and bioinformatics within the biotechnology domain. This protection grants authors exclusive rights over their work for a specified duration, allowing them sole authority to reproduce, distribute, display, perform, and modify it [13].

2.5.3. Trade Secrets

Trade secrets are confidential information that offer a competitive edge to businesses, especially in biotechnology. These secrets encompass proprietary formulas, manufacturing methods, research findings, customer lists, etc. Unlike patents or copyrights, trade secrets don't need registration or disclosure for protection. Instead, safeguarding secrecy and implementing reasonable measures to prevent unauthorized access or disclosure are essential [18].

2.5.4. Plant Variety Protection (PVP)

Plant Variety Protection (PVP) is a specialized form of intellectual property protection used to safeguard new, uniform, and stable plant species. It provides plant breeders with exclusive rights to develop, market, and distribute the protected plant variety for a specified duration. PVP is vital in modern biotechnology as it enables the protection of crops or plants that have undergone enhanced breeding techniques [20].

2.5.5. Trademarks

Despite not being explicitly related to biotechnology products themselves, trademarks are crucial for branding and differentiating items in the market. Trademarks can be used to protect the names, logos, phrases, and other distinctive signs associated with biotech products. They help consumers distinguish between diverse brands and provide legal protection against unauthorized usage or intellectual property violation [14].

2.6. Intellectual Property Rights and Patents

Biotechnology intellectual property laws address various issues, including patentability of genes, gene sequences, and derived parts from humans, animals, plants, and microorganisms. The main types of intellectual property rights (IPRs) in agricultural biotechnology are patents, material transfer agreements, and plant breeder's rights. Patents offer robust protection for genetically modified plants and associated processes. Material transfer agreements govern the exchange of biological materials for research purposes [12].

2.7. Agreement on Trade-Related Intellectual Property Rights (TRIPS Agreement)

The TRIPS Agreement sets the minimal requirements for intellectual property protection at the global level. According to the TRIPS Agreement, which specifies the circumstances under which patents must be awarded; nations are required to do so for all technological sectors, including biotechnology [14]. The TRIPs agreement was a significant step towards making international intellectual property systems legally binding [32]. The TRIPS Agreement acknowledges seven types of intellectual property rights (IPRs), encompassing copyright, trademarks, geographical indications, industrial designs, patents (including plant varieties and layout-designs), and protection of confidential information. It suggests the potential for a sui generis regime to safeguard indigenous knowledge databases, thereby protecting traditional knowledge [24].

The issue of intellectual property protection on a worldwide scale has caused conflict between wealthy and developing countries. The protection of IPRs in agricultural biotechnology is the most recent example of the confrontation between industrialized and developing countries accusing one another of bio-piracy [18]. During the WTO's Uruguay Round negotiations, poor countries reluctantly backed the TRIPS Agreement. The global significance of intellectual property rights (IPRs) in agriculture emerged through the establishment of international structures like the CBD and WTO, and the signing of ITPGRFA. TRIPS includes clauses on competition law, allowing members to limit licensing practices that may abuse IPR and harm competition, while requiring new product creation for partial patent utilization [23].

GMO Production across Different Regions in the World

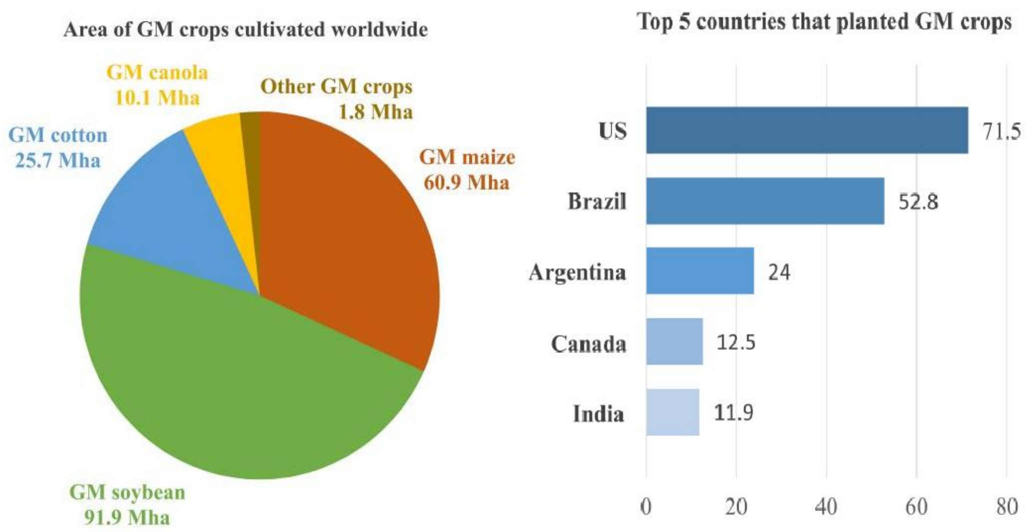

Figure 2. *GMO across different regions in the world [7].*

Since GMOs entered the market, global studies on public perception of genetic engineering have increased. Scientific advancements in genetic engineering have reignited public interest in biotechnology. About 69% of respondents worldwide support biotech use in crops, with 58% of Americans favoring it in food. However, 33% in the US oppose its application [29].

Research in Latin America indicates varying levels of acceptance based on context. For instance, in Brazil, genetic modification for drug and vaccine production is more widely accepted (87%) than for crops (81%) or food (66%). Similarly, in Jamaica, 58% of respondents support using genetic engineering to enhance crop plants [8]. Costa Ricans generally perceive little to no harm from consuming genetically engineered food. However, 21% express concern about potential health and environmental risks. In Mexico, over 60% view GM food as a solution to world hunger, while 39% fear risks to future generations' safety, 35% see potential harm, and 46% worry about disrupting the natural order [22]. While European society acknowledges the benefits of biotechnology in medicine, acceptance of GM products, particularly GM plants, remains lower. Resistance to consuming GM food in Europe declined from 86% in 1999 to 60% in 2019. In Norway, attitudes toward genetic engineering prioritize reducing pesticide use (68%), climate adaptation of crops (65%), and enhancing animal and fish health (58-60%) [22]. In Sweden, 69% of men and 54% of women hold favorable or neutral attitudes toward genetically modified organisms (GMOs). In the UK, 45% believe genetic engineering offers new solutions to global issues. However, 46% disagree, expressing concerns about the risks associated with genetic engineering [31]. In Italy, a 2019 study found that 54% of the general public and 81% of scientists believed GM foods were safe to consume. No perception studies on Genetic Engineering have been done in African nations, but several papers on GMO perception focus solely on GM food and crops. In South Africa, 41% felt that consuming GM food contradicted their religious beliefs, while 30% disagreed [7].

In Uganda, 86% of farmers said they would plant GM maize that was resistant to insects, drought, or both because they saw it as a way to reduce crop loss. 75% of respondents in a 2016 survey in South Africa agreed with the assertion that GM food products should be marked [15]. Asian countries, which comprise 59.76% of the global population, vary in their acceptance and views on plant genetic technologies. In China and South Korea, individuals with higher education levels tend to use more deliberate reasoning and are less receptive to GM foods. In Japan, molecular biology experts hold the most favorable views on benefits and the least concern regarding risks compared to non-experts [30]. In China, about 40% perceived GM foods as safe, 26% perceived them as unsafe, and 35% did not know whether GM foods are safe [7]. Approximately 73% of consumers believe they've consumed GM foods unknowingly. Both GMO and non-GMO labels are deemed important by consumers, with 89% and 83% respectively considering them significant. In South Korea, 36% expressed willingness to buy biotech-produced fresh fruit, the highest among surveyed nations. In Turkey, 80% expressed a strong desire for GMO labeling, with 65% finding the information on food packaging unconvincing [4]. In Singapore and India, public backing for novel food labeling was linked to concerns about food safety and awareness of novel food-related news. In Malaysia, where 54% of Muslim respondents participated, there was little belief that contemporary biotechnology posed a substantial threat to the natural order. However, 75% agreed that modern biotechnology could bring significant societal benefits [7].

Public support for labelling was strongly associated only with public support for outlawing novel foods in Singapore and India, where attention to food safety and news about novel foods was also connected with public support for labelling. Modern biotechnology was not seen as posing a significant threat to the natural order of things, according to studies done in Malaysia (N = 434), where the majority of participants were Muslims (54%) [35]. According to a poll (N = 210) conducted in Iran, religiosity and moral and ethical convictions were the best predictors of social risk perception. In the Australian surveys, a greater awareness of hazards than advantages were frequently linked to a more negative attitude towards GMOs. Recent surveys on GM rice found that 69% of respondents were willing to eat the grain if it was insect-resistant, compared to about 60% for herbicide-resistant rice [2].

2.8. The Outcome of Public Perception of Biotechnology and Related Biopolies

The results of the investigation also suggest that public attitudes on food biotechnology are heavily influenced by people's confidence in and trust in the government, the scientific community, and the public image of biotechnology corporations. The public's acceptance of biotechnology in food production is influenced positively by their trust in scientists and the government, and negatively by their distrust of biotechnology corporations and lack of faith in the government's ability to effectively control genetically modified (GM) products [17]. Similar findings were reported in terms of popular acceptance of genetically modified organisms. Recent study has demonstrated popular skepticism of the biotechnology sector, as well as a lack of trust in the authorities as a defender of the common good. Based to a recent Eurobarometer survey, only 30% of Europeans believe that "the industry developing new products through the use of biotechnology does a good work for society." According to the findings of De Witt et al. [4], a lack of trust in private and public organizations associated with biotechnology can have major negative consequences for public acceptability of food biotechnology [2].

Important moral, theological, and ethical questions have been raised in the public debate over biotechnology. Some biotechnology skeptics argue that modern genetic research has pushed humanity into territory that only God should regulate. Many people regard genetic alterations, particularly gene transfer across species, as violating Natural Law. Gastrow *et al*. [9] found that those who are less religious are more optimistic about biotechnology and its application to plants than those who attend church on a regular basis. Unlike those who are more dedicated, they no longer approve of its use in animals. Social liberals appear to be less enthusiastic about biotechnology and its applications, including in plants. Furthermore, our findings show that attitudes towards the use of genetic technologies in food production vary significantly by gender and race. On the other hand, this study finds no regional difference in the acceptance of biotechnology. Additionally, factors like income, family size, occupation, and marital status don't seem to have a big impact on whether people accept food biotechnology [4].

3. Conclusion and Future Perspective

The results of the public perception of biotechnology products showed that among all regions of the world have very rigorous regulations concerning GMO and GM food/ feed. Among all regions of the world the European public seems to hold the strongest negative attitudes toward GM foods. All regions of the world should have their own biosafety policy, regulations and intellectual property rights for each biotechnology products (GMO) and the technology used to produce these products in order to improve the public perception towards GMO product and minimize the risks of modern biotechnology products. However, we still concluded a few suggestions for how we can facilitate the comparison of different regions with each other and increase the positive perception of plant gene technologies. Based on the above conclusion I forward the following future perspective.

1) Labelling GM products is important and necessary since consumers want information about the kind of genetic technology applied to produce food.
2) The research community should aim for a standardized assessment of public perceptions of genetically modified products. To address how the various cultural backgrounds, as well as different legal situations, may lead to differences in public perception.
3) The engagement of scientists and experts in public debates about the future of GM products is crucial and may motivate scientists to take more action in public debates regarding the benefits of GM and Genetic Engineering products. During the research, scientists representing social sciences and humanities (SSH) should be involved.
4) Community-based approach to scientific problems and working with communities to answer their scientific questions. Use social media and popular blogs for reliable science communication about biotechnology in general and GM and GE food in particular.
5) Improve awareness, understanding and monitoring changes in the acceptance of genetically modified products and their technologies by the public; it is important for scientists, policymakers and entrepreneurs create opportunities for the public to participate.
6) The government should have strong bio policies and regulations regarding GMO products.

Abbreviations

GMO	Genetically Modified Organism
GM	Genetically Modified
GE	Genetic Engineering
TRIPS	Trade-Related Aspects of Intellectual Property Rights
MEFC	Ministry of Environment, Forest and Climate
WHO	World Health Organization
FAO	Food and Agriculture Organization

WTO	World Trade Organization
FSANZ	Food Standards Australia New Zealand
NABDA	National Biotechnology Development Agency

Author Contributions

Amare Melese Dessie: Conceptualization, Data curation, Formal Analysis, Methodology, Writing – original draft

Zemenu Birhan Zegeye: Conceptualization, Data curation, Formal Analysis, Methodology, writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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