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A Review on Genetically Modified Organisms and Foods-Perspective and Challenges

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Abstract
The ratio of the human population and the quantity of the eatable items are inversely proportional. The quantity of food items is decreased due to certain reasons such as, environmental conditions, unavailability of the water for farming, less income of farmers etc. The principal problem, concerning with GMO (Genetically Modified Organism) is the less information available in the public domain. Still the method for development of organism is bizarre for the public. Considering it, this compilation is aimed to sketch out the pitfalls for the implementation of GMO in the real world, and the advantages of GMO for the betterments of human society are listed. This overview will provide the detail information about the listed problems and shed off the myths and also open up the new paths to bring out the solution for the available problem in the area of genetically modified organism.

Keywords: *GMO, GMO crops, Patenting of GMO, Pitfall of GMO.*

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I. Introduction:

It is a general view that humans have always tailored the genome of both plants and animals. This invasive process, which has existed for thousands of years, several times through mistakes and failures, was primarily carried out through the crossing of organisms with enviable features. This was accomplished with the intention of generating and producing new plants and animals that would ultimately benefit humans, in terms of offering better quality food, more opportunities for people to move and transport products, greater returns to work, resistance to diseases, etc. Though, generating GMOs does not carry on without conflicts. There are also conflicts regarding the risks to the environment and human health from using genetically modified organisms. Concerns about the risks to the environment and human health from genetically modified products have been the issue of much debate that has led to the progress of regulatory platform for the assessment of genetically modified crops. However, the absence of a globally accepted has the impact of slowing down technological progress with negative results for areas of the world, which could benefit from novel technologies. Thus, whilst genetically modified crops can provide maximum advantages in food safety and in adapting crops to accessible climate variation, the absence of reforms, as well as the deficiency of harmonization of the frameworks and set of laws about the genetic transformations results in all those anticipated advantages of employing genetically modified crops being suspended. Nonetheless, it is understandable that the evolution of genetically modified products is not going to end. For that rationale, studies on the effect of genetic transformation on medical technologies, agricultural production, commodity prices, and land utilization and on the environment in common, should therefore prolong. The work along these notions and objectives can be well comprehended under following heads:

II. Probable risks of employing genetically modified products

The application of genetic modification allows genetic material to be transferred from any species into plants or other organisms. The introduction of a gene into different cells can result in different outcomes, and the overall pattern of gene expression can be altered by the introduction of a single gene. The sequence of the gene and its role in the donor organism may have a relatively well-characterized function in the organism from which it is isolated. However, this apparent "precision" in the understanding of a gene does not mean that the consequences of the transfer are known or can be predicted [1]. Copies of a gene may be integrated, additional fragments inserted, and gene sequences rearranged and deleted, which may result in lack of operation of the genes instability or interference with other gene functions possibly cause some potential risks [1]. Therefore, there could be a number of predictable and unpredictable risks related to release of GMOs in the open environment. The report prepared by the Law Centre of IUCN, the World Conservation Union (2004), enlists numerous environmental risks likely to occur by the use of GMOs in the field. These major risks are as follows:

2.1.Environmental Hazards

There is strong fact that genetically modified plants appear to interrelate with their environment [1, 2]. Within the past four decades, research has been increasingly drawn toward understanding whether there is a link between the changing human–nature relationship and its impact on people's health. However, to examine whether there is a link requires research of its breadth and underlying mechanisms from an interdisciplinary approach. This article begins by reviewing the debates concerning the human–nature relationship, which are then critiqued and redefined from an interdisciplinary perspective. The concept and chronological history of "health" is then explored, based on the World Health Organization's definition. Combining these concepts, the human–nature relationship and its impact on human's health are then explored through a developing conceptual model. It is argued that using an interdisciplinary perspective can facilitate a deeper understanding of the complexities involved for attaining optimal health at the human–environmental interface. This reflects that genes introduced into genetically modified plants may be moved to other plants or even to other organisms in the ecosystem [3-5]. The potential of genetically modified plants to meet the requirements of growing population is not being recognized at present. This is a consequence of concerns raised by the public and the critics about their applications and release into the environment. These include effect on human health and environment, biosafety, world trade monopolies, trustworthiness of public institutions, integrity of regulatory agencies, loss of individual choice, and ethics as well as skepticism about the real potential of the genetically modified plants, and so on. Such concerns are enormous and prevalent even today. However, it should be acknowledged that most of them are not specific for genetically modified plants, and the public should not forget that the conventionally bred plants consumed by them are also associated with similar risks where no information about the gene(s) transfer is available. Moreover, most of the concerns are hypothetical and lack scientific background. Gene transfer between plants, specifically among interconnected plants, results in genetic contamination and is carried out by the transport of pollen [6,7]. The potential of genetically modified (GM) crops to transfer foreign genes through pollen to related plant species has been cited as an environmental concern. Until more is known concerning the environmental impact of novel genes on indigenous crops and weeds, practical and regulatory considerations will likely require the adoption of gene-containment approaches for future generations of GM crops. Most molecular approaches with potential for controlling gene flow among crops and weeds have thus far focused on maternal inheritance, male sterility, and seed sterility. Several other containment strategies may also prove useful in restricting gene flow, including apomixis (vegetative propagation and asexual seed formation), cleistogamy (self-fertilization without opening of the flower), genome incompatibility, chemical induction/deletion of transgenes, fruit- specific excision of transgenes, and transgenic mitigation (transgenes that compromise fitness in the hybrid). As yet, however, no strategy has proved broadly applicable to all crop species, and a combination of approaches may prove most effective for engineering the next generation of GM crops [7]. Because natural wild plant varieties are probably to have a competitive disadvantage against genetically modified crops, they may not be able to survive, causing in the reduction or disappearance of wild varieties [8,9]. Biotechnology is providing us with a wide range of options for how we can use agricultural and commercial forestry lands. The cultivation of genetically modified (GM) crops on millions of *hectares* of lands and their injection into our food chain is a huge global genetic experiment involving all living beings. Considering the fast pace of new advances in production of genetically modified crops, consumers, farmers and policymakers worldwide are challenged to reach a consensus on a clear vision for the future of world food supply. The current food biotechnology debate illustrates the serious conflict between two groups: 1) Agri-biotech investors and their affiliated scientists who consider agricultural biotechnology as a solution to food shortage, the scarcity of environmental resources and weeds and pests infestations; and 2) independent scientists, environmentalists, farmers and consumers who warn that genetically modified food introduces new risks to food security, the environment and human health such as loss of biodiversity; the emergence of superweeds and superpests; the increase of antibiotic resistance, food allergies and other unintended effects. This article reviews major viewpoints which are currently debated in the food biotechnology sector in the world. It also lays the ground-work for deep debate on benefits and risks of Biotech-crops for human health, ecosystems and biodiversity. In this context, although some regulations exist, there is a need for continuous vigilance for all countries involved in producing genetically engineered food to follow the international scientific bio-safety testing guidelines containing reliable pre-release experiments and post-release track of transgenic plants to protect public health and avoid future environmental harm [9]. Mutating biodiversity worldwide will lead to increased resistance of several species of weeds, others to dominate and others to decline or disappear, therefore, generating a complete and general deregulation in ecosystems [10.11]. Farmland biodiversity is an important characteristic when assessing sustainability of agricultural practices and is of major international concern. Scientific data indicate that agricultural intensification and pesticide use are among the main drivers of biodiversity loss. The analyzed data and experiences do not support statements that herbicide-resistant crops provide consistently better yields than conventional crops or reduce herbicide amounts [10,11]. They rather show that the adoption of herbicide-resistant crops impacts agronomy, agricultural practice, and weed management and contributes to biodiversity loss in several ways: (i) many studies show that glyphosate-based herbicides, which were commonly regarded as less harmful, are toxic to a range of aquatic organisms and adversely affect the soil and intestinal microflora and plant disease resistance; the increased use of 2,4-D or dicamba, linked to new herbicide-resistant crops, causes special concerns. (ii) The adoption of herbicide-resistant crops has reduced crop rotation and favoured weed management that is solely based on the use of herbicides. (iii) Continuous herbicide resistance cropping and the intensive use of glyphosate over the last 20 years have led to the appearance of at least 34 glyphosate-resistant weed species worldwide. Although recommended for many years, farmers did not counter resistance development in weeds by integrated weed management, but continued to rely on herbicides as sole measure [10]. Despite occurrence of widespread resistance in weeds to other herbicides, industry rather develops transgenic crops with additional herbicide resistance genes. (iv) Agricultural management based on broad-spectrum herbicides as in herbicide-resistant crops further decreases diversity and abundance of wild plants and impacts arthropod fauna and other farmland animals. Taken together, adverse impacts of herbicide-resistant crops on biodiversity, when widely adopted, should be expected and are indeed very hard to avoid. For that reason, and in order to comply with international agreements to protect and enhance biodiversity, agriculture needs to focus on practices that are more environmentally friendly, including an overall reduction in pesticide use. (Pesticides are used for agricultural as well non-agricultural purposes [10, 11]. It is a common belief in scientific circles that research needs to be prolonged to assess the risks and benefits of crops more precisely and sufficiently.

2.2. Risks to Human Health

There may be allergenic effects - mostly in people who are predisposed to allergies - or other adverse effects on human health [12]. Biotechnology offers a variety of potential benefits and risks. It has enhanced food production by making plants less vulnerable to drought, frost, insects, and viruses and by enabling plants to compete more effectively against weeds for soil nutrients. In a few cases, it has also improved the quality and nutrition of foods by altering their composition. However, the use of biotechnology has also raised concerns about its potential risks to the environment and people. For example, some people fear that common plant pests could develop resistance to the introduced pesticides in GM crops that were supposed to combat them. Genetic engineering provides a means to introduce genes into plants via mechanisms that are different in some respects from classical breeding. A number of commercialized, genetically engineered (GE) varieties, most notably canola, cotton, maize and soybean, were created using this technology, and at present the traits introduced are herbicide and/or pest tolerance. Gene technology enables the increase of production in plants, as well as the rise of resistance to pests, viruses, frost, etc. Gene transfer is used to modify the physical and chemical composition and nutritional value of food [12]. Gene transfer in animals will play a part in boundless possibilities of improving qualitative and quantitative traits. The yield, carcass composition and meat characteristics are the use of nutritive substances? Not sure what is being said here? and resistance to diseases can be improved. On the other hand, negative effects of gene technology on animals, human, and environment should be considered. An overview is the compilation of various studies that present both positive and negative impacts of genetically modified food on human health [12]. Experimental studies in animals have shown weight gain, changes in the pancreas and kidneys, toxic effects to the immune system, changes in blood biochemistry among other effects [13, 14]. Moreover, the lack of large-scale long-term epidemiological studies, which lead to safe conclusions about the allergenic effects of genetically modified plants, makes researchers doubtful about the use of genetically modified products. This is due to the introduction of a gene that expresses a non-allergenic protein, and does not mean to produce a product without allergenic action. Besides, allergies from genetically modified products may be more intense and dangerous, as the allergenic potential of these foods is stronger than that of traditional plants [15,16].

2.3. Resistance to Antibiotics

It should be noted from the beginning that the use of antibiotic-resistant genes has stopped in most mutated products. The main issue now lies in the widespread use of antibiotics in feed which, as a natural outcome, end up in the human body through taking in the dairy products and meat, and ultimately create resistant germs in the human digestive system [17,18]. Due to the increased demand of animal protein in developing countries, intensive farming is instigated, which results in antibiotic residues in animal-derived products, and eventually, antibiotic resistance. Antibiotic resistance is of great public health concern because the antibiotic-resistant bacteria associated with the animals may be pathogenic to humans, easily transmitted to humans via food chains, and widely disseminated in the environment via animal wastes [17, 18]. These may cause complicated, untreatable, and prolonged infections in humans, leading to higher healthcare cost and sometimes death. In the said countries, antibiotic resistance is so complex and difficult, due to irrational use of antibiotics both in the clinical and agriculture settings, low socioeconomic status, poor sanitation and hygienic status, as well as that zoonotic bacterial pathogens are not regularly cultured, and their resistance to commonly used antibiotics are scarcely investigated (poor surveillance systems) [18]. The challenges that follow are of local, national, regional, and international dimensions, as there are no geographic boundaries to impede the spread of antibiotic resistance. In addition, the information assembled in this study through a thorough review of published findings, emphasized the presence of antibiotics in animal-derived products and the phenomenon of multidrug resistance in environmental samples. This therefore calls for strengthening of regulations that direct antibiotic manufacture, distribution, dispensing, and prescription, hence fostering antibiotic stewardship. Joint collaboration across the world with international bodies is needed to assist the developing countries to implement good surveillance of antibiotic use and antibiotic resistance [18]. Nevertheless, more research and studies are required to determine the distinctions between transgenic plants from conventional plants and whether genetically modified plants present additional risks to the consumer public [19,20].

III. Benefits of using genetically modified products

3.1. Hunger Elimination

One of the arguments set forth by advocates of genetically modified products is to remove world hunger, a perception that has encountered various reactions [21-23]. Commercial potential of biotechnology is immense since the scope of its activity covers the entire spectrum of human life. The most potent biotechnological approach is the transfer of specifically constructed gene assemblies through various techniques [23]. However, this deliberate modification and the resulting entities thereof have become the bone of contention all over the world. Benefits aside, genetically modified organisms (GMOs) have always been considered a threat to environment and human health. In view of this, it has been considered necessary by biosafety regulations of individual countries to test the feasibility of GMOs in contained and controlled environments for any potential risks they may pose. This overview describes the various aspects of risk, its assessment (**Figure 1**), and management which are imperative in decision making regarding the safe use of GMOs. Efficient efforts are necessary for implementation of regulations. Importance of the risk assessment, management, and precautionary approach in environmental agreements and activism is also discussed [23]. A series of extensive and long-term research has shown that the benefits of growing genetically modified crops in the fight against global food shortages and hunger have been noteworthy. The steady augmentation in the global population has led researchers to focus on the advantages of developing genetically modified products, rather than the potential risks they present each time [24,25]. Besides, biofortification through plant breeding is a sustainable approach to improve the nutritional profile of food crops. The majority of the world's population depends on staple food crops; however, most are low in key micronutrients. Biofortification to improve the nutritional profile of pulse crops has increased importance in many breeding programs in the past decade [25]. The key micronutrients targeted have been iron, zinc, selenium, iodine, carotenoids, and folates. In recent years, several biofortified pulse crops including common beans and lentils have been released by Harvest Plus with global partners in developing countries, which has helped in overcoming micronutrient deficiency in the target population. Recently, an overview has focused on recent research advances and future strategies for the biofortification of pulse crops [25].

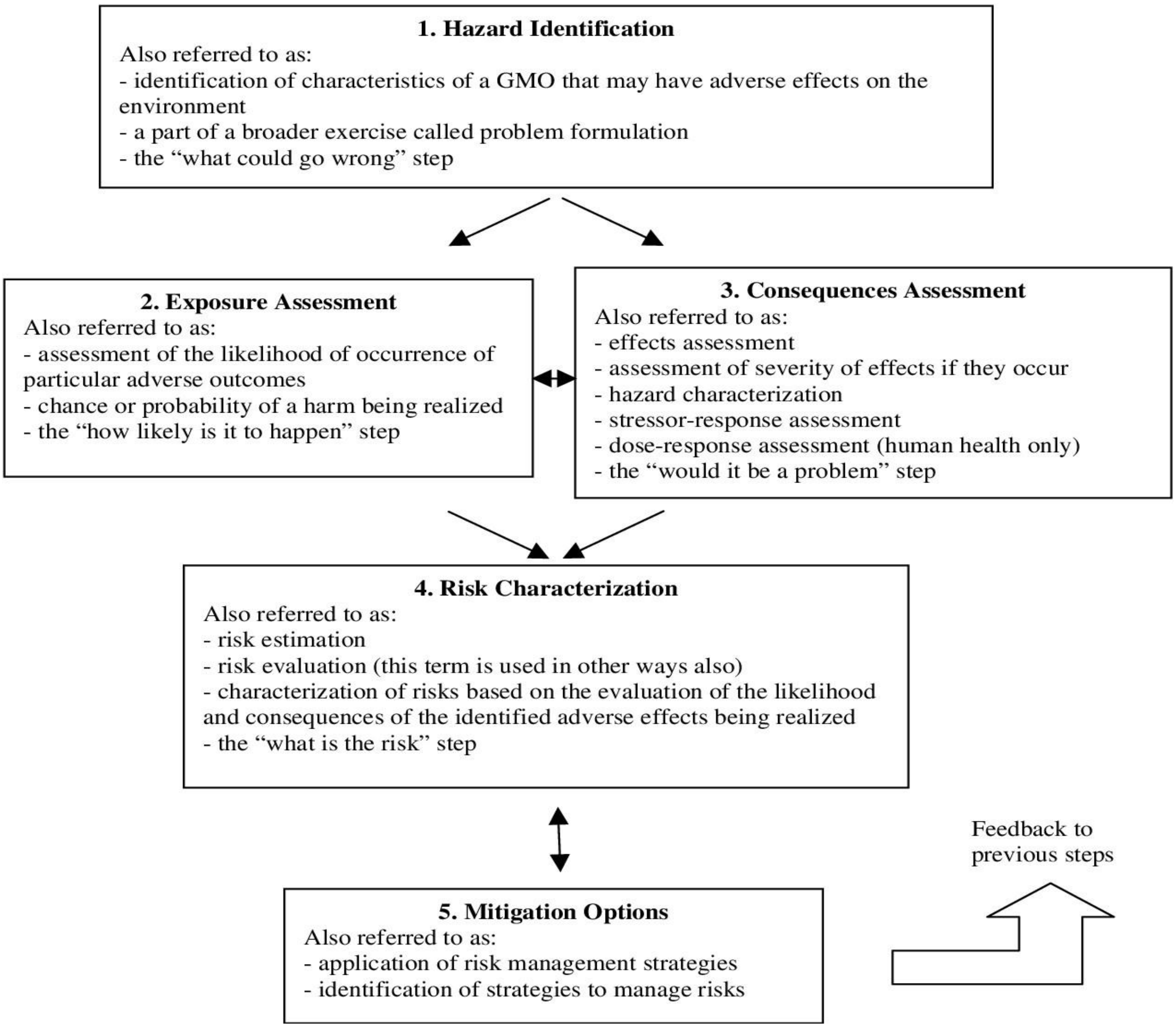

Figure 1: The top down approach for designing the risk assessment process in genetically modified organism. (https://www.semanticscholar.org/paper/Conceptualizing-risk-assessment- methodology-for-Hill/82f8005c3f6787b669ab3ba9efe7998ced4365aa/figure/0)

3.2. Economic Benefits

Genetic modification in plants was first recorded 10,000 years ago in Southwest Asia where humans first bred plants through artificial selection and selective breeding. Since then, advancements in agriculture science and technology have brought about the current GM crop revolution. GM crops are promising to mitigate current and future problems in commercial agriculture, with proven case studies in Indian cotton and Australian canola. However, controversial studies along with current problems linked to insect resistance and potential health risks have jeopardised its standing with the public and policymakers, even leading to full and partial bans in certain countries. Nevertheless, the current growth rate of the GM seed market at 9.83–10% CAGR along with promising research avenues in biofortification, precise DNA integration and stress tolerance have forecast it to bring productivity and prosperity to commercial agriculture [26]. A number of studies reveal the economic benefits of using genetically modified products. During 1996 to 2011, farmers' income worldwide enhanced by $92 million from the use of genetically modified crops. The maximum economic benefits have been achieved in the US, Argentina, China and India, meanwhile, production costs have fallen sharply [26].

IV. Basic concepts related to genetically modified products

4.1. The Notion of Substantial Equivalence

The concept of substantial equivalence has been introduced in the debate on genetically modified products to ensure that these foods are safe [27]. Genetic modification is a special set of gene technology that alters the genetic machinery of such living organisms as animals, plants or microorganisms. Combining genes from different organisms is known as recombinant DNA technology and the resulting organism is said to be 'Genetically modified (GM)', 'Genetically engineered' or 'Transgenic' [27]. The principal transgenic crops grown commercially in field are herbicide and insecticide resistant soybeans, corn, cotton and canola. Other crops grown commercially and/or field-tested are sweet potato resistant to a virus that could destroy most of the African harvest, rice with increased iron and vitamins that may alleviate chronic malnutrition in Asian countries and a variety of plants that are able to survive weather extremes [27]. There are bananas that produce human vaccines against infectious diseases such as hepatitis B, fish that mature more quickly, fruit and nut trees that yield years earlier and plants that produce new plastics with unique properties. Technologies for genetically modifying foods offer dramatic promise for meeting some areas of greatest challenge for the 21st century. Like all new technologies, they also pose some risks, both known and unknown. Controversies and public concern surrounding GM foods and crops commonly focus on human and environmental safety, labelling and consumer choice, intellectual property rights, ethics, food security, poverty reduction and environmental conservation. With this new technology on gene manipulation what are the risks of "tampering with Mother Nature"? The principle of substantial equivalence holds that if the genetically modified product contains substantially equivalent ingredients present in the conventional product, then no further safety rules are desired. In this way the principle of substantial equivalence is a tool of evaluating genetically modified products and finding negative factors (such as allergens due to the presence of new proteins) [27-29].

4.1. The Precautionary Principle

According to the preventive principle, any novel genetically modified product should not be made available to consumers unless there is first-hand evidence that the product is safe or if there are critical conflicts and conflicting opinions of researchers on the safety of the product in question [30, 31]. One of the priorities to address food security is to increase the access of farmers to biotechnology, through the application of scientific advances, such as genetically modified organisms and food (GMF). However, the spread of (mis)information about their safety strengthens the clamor for mandatory GMF labeling [31]. A relevant overview of food labeling policies, has been noticed to consider the principles suggested by the Codex Alimentarius Commission, and analyzes the consequences for the world food security of the Brazilian labeling policies compared to developed countries [30, 31]. Certain researchers, however, have argued that the preventive principle can act as a disincentive to the evolution of science and society, as it may stop or delay any novel technology that is capable of solving environmental or economic issues [30]. It should be noticeable, however, that criticisms have been raised about the utility and the manner the preventive principle works [31].

V. Conclusions

Recently there has been extensive technological advancement in the creation of genetically modified organisms. There is no doubt that in the future there will be a continuum that will be influenced by both scientific developments and public attitudes towards genetically modified organisms. Creating genetically modified organisms, however, does not proceed without conflicts; there are the disputants of genetically modified organisms who see their production as a manipulation of life, as well as conflicts regarding the risks to the environment and human health. Even though, it is obvious that the evolution of genetically modified crops is not going to stop. In any case, there should be inflexible and enforceable rules for the use of genetically modified organisms and understandable references to the effects and the results of genetic transformation, on the environment as well as on human health.

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References

[1]. Tencalla FG, Nickson TE, Garcia-Alonso M (2009). Environmental risk assessment.*In*: **Environmental Impact of Genetically Modified Crops**; Ferry N, Gatehouse AMR (ed): CAB International, Wallingford; 61-73. http://doi.org/10.1079/9781845934095.0000.

[2]. Seymour V (2016). The human- nature relationship and its impact on health: A critical review. **Front. Public Health 4**: 260. http://doi.org/10.3389/fpubh.2016.00260/

[3]. Wilkinson MJ, Sweet J, Poppy GM (2003). Risk assessment of GM plants, avoiding gridlock. **Trends Plant Sci. 8**: 208-212. https://doi.org/10.1016/S1360-1385(03)00057-8.

[4]. Verma C, Nanda S, Singh RK, Singh RB, Mishra S (2011). A review on impacts of genetically modified food on human health. **The Open Nutraceuticals Journal 4**: 3-11. http://doi.org/ 10.2174/1876396001104010003
[5]. Oliver MJ, Li Y (2013. **Plant Gene Containment**. Oliver MJ, Li Y (eds): Wiley-Blackwell Press, Iowa; 10.1002/9781118352670.
[6]. Maghari BM, Ardekani BM (2011). Genetically modified foods and social concerns. **Avicenna J. Med. Biotech. 3 (3)**: 109-117.
[7]. Kapuscinski RA, Li S, Hayes KR, Dana G (2007). Environmental risk assessment of genetically modified organisms. **Methodologies for Transgenic Fish Vol 3;** Kapuscinski RA, Li S, Hayes KR, Dana G (eds): CAB International Press, Oxford.
[8]. Schutte G, Eckerstorfer M, Rastelli V, Reichenbecher W, Restrepo-Vassali S, Ruohonen-Lehto M, Wuest Saucy A-G, Mertens M (2017). Herbicide resistance and biodiversity: Agronomic and environmental aspects of genetically modified herbicide resistant plants. **Environ. Sci. Eur. 29**: 5-16. http://doi.org/ 10.1186/s12302-016-0100-y.
[9]. Mishra S, Singh RB (2013). Physiological and biochemical significance of genetically modified foods: An overview. **The Open Nutraceuticals Journal 6 (1):** 18-26.
[10]. Metcalfe D (2002). Allergenicity of foods produced by genetic modification. **Genetically Modified Crops: Assessing Safety**; Atherton KT (ed): Taylor and Francis, London; pp. 94-109. https://doi.org/10.1201/9780203212356.
[11]. Kieran MT, Rowlandand IR, Rumsby PC (2002). Biosafety of marker genes, the possibility of DNA transfer from genetically modified organisms to the human gut microflora. *In*: **Genetically Modified Crops, Assessing Safety,** London: Taylor and Francis; pp. 94–109.
[12]. Ntona AA, Arvanitogiannis IS (2009). Genetically modified food and health impact, review. *In*: **Database Greek Med**. **26**:727-740.
[13]. Arjó G, Portero M, Piñol C, et al. (2013). Plurality of opinion, scientific discourse and pseudoscience: an in depth analysis of the Séralini et al. study claiming that Roundup™ Ready corn or the herbicide Roundup™ cause cancer in rats. **Transgenic Res. 22**:255-267. 10.1007/s11248-013-9692-9
[14]. Flachowsky G. (2014). **Animal Nutrition with Transgenic Plants**: Flachowsky G (ed): CABI Press, Braunschweig.
[15]. Manyi-Loh C, Mamphwelli S, Meyer E, Okoh A. (2018). Antibiotic use in agriculture and its consequential resistance in environmental sources: Potential public health implications. **Molecules 23**: 795-842. http://doi:10.3390/molecules23040795.
[16]. Smith JM. (2007). Genetic roulette: the documented health risks of genetically engineered foods. Smith JM (ed): **Yes! Books**, Iowa.
[17]. Carter AC, Moschini GC, Sheldon I. (2011). **Genetically Modified Food and Global Welfare**. Carter AC, Moschini GC, Sheldon I (eds): Emerald Group Publishing Limited, Bingley UK.
[18]. Thompson RP. (2011). Agro-technology: A philosophical introduction: Thompson RP. (ed):Cambridge University Press, Cambridge. 10.1017/CBO9780511977541.
[19]. Steier G. (2018). Advancing food integrity, GMO regulation, agroecology, and urban agriculture: Steier G. (ed): CRC Press, New York; 2018. https://doi.org/10.1201/b22381.
[20]. Prakash D, Verma S, Bhatia R, Tiwary BN. (2011). Risks and precautions of genetically modified organisms. **ISRN Ecology:** Article ID 369573, 13 pages. http:// doi.org/10.5402/2011/369573.
[21]. Jha AB, Warkentin TD. (2020). Biofortification of pulse crops: Status and future perspectives. **Plants 9**: Article ID 73, 29 pages. http://doi.org/10.3390/plants9010073.
[22]. Jones PJ. (2017). Assessing the potential economic benefits to farmers from various GM crops becoming available in the European Union by 2025: results from an expert survey. **Agricultural Sys**. **155**: 158-167. 10.1016/j.agsy.2017.05.005.
[23]. Raman R. (2017). The impact of genetically modified (GM) crops in modern agriculture: A review. **GM Crops & Food 8**: 195-208. http://doi.org/10.1080/21645698.2017.1413522.
[24]. Han L. (2010). Genetically modified microorganisms, development and applications. **The GMO Handbook, Genetically Modified Animals, Microbes, and Plants in Biotechnology**; Parekh RS. (ed): Humana Press, Totowa; pp. 29-51.
[25]. Tranier M-S, Prognant-Gros J, Reynaldo De la CQ, Gonzalez CNA, Matielle T, Roussos S. (2014). Commercial biological control agents targeted against plant- parasitic root- knot nematodes. **Braz. Arch. Biol. Technol**. **57 (6)**: 831-841. http://doi.org/10.1590/S1516-8913201402540.
[26]. Nyarko-Fosu J, Jones GKM. (2015). Application of biotechnology for nematode control in crop plants. **Adv Bot Res**. **73**: 339-376. https://doi.org/10.1016/bs.abr.2014.12.012.
[27]. Varshney S, Hayat S, Alyemeni MN, Ahmad A. (2012). Effects of herbicide applications in wheat field- Is phytohormones application a remedy? **Plant Signaling & Behavior 7 (5)**: 570-575. http://dx.doi.org/10.4161/psb.19689
[28]. [28] Duke SO, Lydon J, Koskinen WC, Moorman TB, Chaney RL, Hammerschmidt R. (2012).
[29]. Glyphosate effects on plant mineral nutrition, crop rhizosphere microbiota, and plant disease in glyphosate-resistant crops**. J. Agric Food Chem. 60**: 10375-10397. http:// dx.doi.org/10.1021/jf302436u.
[30]. Bawa AS, Anilakumar KR. (2013). Genetically modified foods: Safety, riska and public convent- A review. **J. Food Sci. Technol**. **50 (6)**: 1035-1046. doi: 10.1007/s 13197- 012- 0899-1.
[31]. Mahgoub E, Salah O. (2016). Genetically modified foods: basics, applications, and controversy: Mahgoub E, Salah O. (eds): CRC Press, Florida; https://doi.org/10.1201/b18642.