Genetic Engineering

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Introduction

The United Nations Food and Agriculture Organization (UNFAO) estimates that one out of every five citizens of the developing world, nearly 828 million people, chronically suffers from severe undernourishment. Recent developments in science, particularly genetics, have determined how to optimize specific genes and traits in plants to provide even greater benefits while reducing or eliminating undesirable features. This innovative concept is based on recombinant DNA (rDNA) and is called Gene Slicing, Genetic Engineering (GE), or Genetic Modification (GM) (Paarlberg). The Food and Drug Administration's (FDA) statistics show that approximately 60% of all processed foods in U.S. supermarkets contain GM ingredients (Degnan). However, the greatest need for improved crop production lies in the developing countries. They currently contain 18% of all transgenic crops worldwide (Altieri). The problematic diffusion of GM food in the global market is due to misunderstanding, misinformation, and confusion about this technology. A basic understanding of the techniques and goals of biotechnology research is important for deciding the merits of concerns and proposed solutions.

Background

The progress in modern technology began in the early 1970s with American scientists Herb Boyer and Stan Cohen developing recombinant DNA (rDNA), or gene slicing, in which fragments of DNA are joined together to create a new genetic combination. DNA is the hereditary "molecule of life" that carries the cells of bacteria, plants, and animals, including humans. DNA carries the genes, which hold genetic information. A gene is a unit of genetic information. It tells the cell how to make a specific protein. It is the presence or absence of the specific protein that gives an organism a trait or characteristic. Many common genes are already shared by different species, and rDNA allows us to transfer genes from one organism to another, even across the usual species barriers faced by conventional breeders ("Genetically modified").

Arguments against GM food

The issue surrounding the use of GM food has been debated for some time in countries around the world, including most of Europe and many Asian countries. Opponents of GM food argue that their use could pose a threat to human health and the environment and maintain that GM foods are being rushed through without adequate time to test the technology and ensure that they are safe. The reports of harm to the immune system and causing cancer and other diseases have been based on unpublished evidence of work of Aberdeen on GM potatoes into which the lectin gene was introduced (Lachmann).

Critics of GM food fear that the environment might be hurt if engineered crops are released into rural tropical settings where wild relatives of food plants can often be found. If an engineered herbicide resistant trait breeds into a weedy wild relative, the result might be a hard to manage "superweed." Widespread planting of Bacillus thuringiensis (Bt) corn, a pest-killing toxin, might trigger an evolving population of "superbugs" resistant toxin (Beringer). Greenpeace and other international organizations have promised to heighten their campaigns against GM foods and have accused the U.S.

government of backing businesses such as Monsanto and DuPont through its trade policy (Barton).

While genetically engineered food is a flashpoint for protest and bans in Europe and Japan, only 27% of U.S. consumers think it poses a health problem, according to a 1999 Gallup poll (Laget). The controversy over genetically modified foods begun to have a greater effect in the United States when two major international companies, such as McDonalds's Corp. and Proctor & Gamble Co., announced they would not accept genetically altered potatoes for manufacturing french fries and potato chips. Two other food producers, Kellogg Co. and Philip Morris Cos. Inc., faced protests at their annual meeting from environmental activists who asked them to stop using GM corn. Internet groups such as the Campaign to Ban Genetically Engineered Foods, the Alliance for Bio Integrity and Mothers for Natural Law provide continuous bulletin boards for opponents to post information about GM foods (Spencer).

In the meantime, the European and Asian backlash against U.S.-grown GM crops could generate sharp conflicts in several international settings, including the World Trade Organization (WTO) and the Convention on Biological Diversity (CBD). Within the WTO, the Sanitary and Phytosanitary (SPS) Agreement permits nations to restrict imports in the name of health or environmental protection. But an unresolved question is whether governments can restrict imports under conditions of scientific uncertainty on a precautionary basis. The SPS agreement allows import restrictions only on a provisional basis while governments seek additional information (Paarlberg).

Arguments in favor of GM food

Safety of GM food

Overall, many thousands of Genetic Modified Organisms (GMOs) have been generated and tested in labs and fields trials around the world since the mid-1970s. These include many plant, animal, and microbial species modified with a range of different genes from diverse sources. Only a small proportion of these were intended for commercial release. Most were developed to examine the environmental and health safety of the process and the products. In spite of considerable efforts to find evidence of harm from the genetic modification process, none was found. Certainly some products were identified as potentially hazardous, for example the allergenic Brazil nut storage protein gene in GM soybean was clearly a health hazard to those allergic to Brazil nuts. But in each case, the hazard was due to the nature of the specific new trait, not to the process by which it was made. New foods are vigorously tested to minimize risk. Plant breeders spend eight to twelve years analyzing and evaluating prospective new varieties. In addition to the usual measures of seed yield, maturity, response to disease infection, and other farmer-oriented traits, they also do chemical analyses to ensure that quality characteristics are preserved. The new lines are scrutinized for the presence of naturally occurring but undesirable compounds, like cyanogenic glycosides. Prospective new foods, whether produced by conventional or modern biotechnology, are eliminated if they show any sign of unmanageable potential hazard (Feldbaum).

The U.S. Department of Agriculture (USDA), US Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA) have declared GM products as not inherently hazardous. GM food has been manufactured for over a quarter of a century and been grown on more than 100 million acres and consumed by 300 million North Americans. There are no documented cases of harm attributable to the process by which the GM crops are bred ("Report calls").

In early 2000, the Organization for Economic Cooperation and Development (OECD) invited 400 world experts, including academic researchers and representatives of government and industry as well as environmental activist groups, to a conference on the safety of GM foods. Groups who adamantly opposed GM foods were given the chance to present evidence to support their claims. They were unable to cite any cases of harm from GM foods (Altieri).

In April 2000, the House of Representatives Committee on Science, Subcommittee on Basis Research, chaired by Representative Nick Smith, released a report titled "Seeds of opportunity: an assessment of the benefits, safety oversight of plant genomics and agricultural biotechnology", which concluded that there is no significant difference between plant varieties created using agricultural biotechnology and similar plants created using traditional cross breading. In the same month, the US National Academy of Sciences released a report of its blue-ribbon group (Committee on Genetically Modified Pest-Protected Plants) to study the matter and issued its own statement, which concluded that the committee was not aware of any indications that foods on the market are unsafe to eat as a result of genetic modification. (Beach)

Before the approval of the first transgenic Bacillus thuringiensis (BT) corn in the U.S., the Department of Agriculture (USDA) conducted an environmental assessment in 1995 that analyzed data on risks to insects beneficial to agriculture and other non-target insects at risk. The USDA concluded that the data showed no significant potential to adversely affect organisms other than the targeted pest that destroys corn. Researchers continued to examine transgenic corn, such as scientists who explored the impact on beetles, flower bugs, and lacewings, all of which feed corn bores. In a paper published in April 1997 researchers reported they found no harmful effects on the beneficial insects (Krimsky). As for the safety of transgenic corn and other biotech crops, the US Food and Drug Administration (FDA) undertook its own comprehensive studies and concluded in 1992 and again in 1995 that was not aware of information that would distinguish genetically engineered foods as a class from foods developed through other methods of plant breeding. Results of all studies by the USDA, FDA, and the Environmental Protection Agency, the three US agencies charged with monitoring biotech crops and foods, are produced with public input and available for perusal when completed (Feldbaum).

In addition, according to the Environmental Protection Agency, in 1999 growers in states using high amounts of Bt cotton sprayed 21% less insecticide than usual on the crop. That's a "dramatic and impressive" reduction, says Stephen Johnson, an administrator in the EPA's Office of Pesticide Programs (Milmo).

Benefits of GM food

Genetic technology has also given us better medical treatments. For example, the standard hepatitis B vaccine was derived from blood pooled from people who had hepatitis B. The problem was that before AIDS was recognized as a blood-borne disease, some donors might also have had the virus that causes AIDS (HIV) in their bloodstream. Because hepatitis B vaccines from modern rDNA technology are not derived from human blood, unknown blood infections cannot contaminate the rDNA vaccines. Over the past quarter of a century, genetic modification, or rDNA technology, has given us lifesaving drugs such as Humulin (human insulin) and Pulmozyme (dornase alpha), a breakthrough treatment for cystic fibrosis (Lachmann).

In late 1999, the world's population exceeded six billion, having doubled in only 40 years, and it continues to rise, and is projected to reach between eight to ten billion by the year 2050. Nearly 80% of the world's population live in developing countries. The population density in the developing world is expected to nearly double from approximately 142 persons per square mile at present, to 269 persons per square mile. The Declaration of Human Rights, Article 25 (1) concludes that everyone should have the right to a standard of living that includes adequate health, food, clothing. Nevertheless, according to UNFAO, over 800 million people in the developing world do not have enough food. Children suffer most from undernutrition, which leaves them susceptible to disease and hinders their full physical and mental development. The rate of progress in addressing food insecurity in the developing countries is below that set at the World Food Summit in 1996, which demanded that 20 million people per year be removed from the condition of persistent hunger. Regional inconsistencies are also of concern. While some regions have seen significant improvement, sub-Saharan Africa is regressing, with the actual number of Africans suffering from insufficient nutritional intake increasing since 1992 (Altieri).

Present and future access to sufficient food depends not just on increasing crop yields, but also on a chain of other complex factors. The most important of these are the price and availability of agricultural products, access to employment, and the income or purchasing power of any given individual or entire country. These in turn are determined by large and small scale economic factors, international trade policies, and uncontrollable parameters such as weather patterns (Paarlberg).

The GM food revolution can have a life-changing and even life-saving effect in developing countries. Poor soil, extreme moisture, heat, and droughts, and a plentitude of pests and disease that attack crops cause poor farmers, especially in tropical Asia and Africa, to lose much of their crop production every year, often exceeding 30% of the loss to insects and plant disease (Beringer). GM technology carries special promises for this problem. It can engineer plants and animals with highly specific pest and disease resistance. For example, poor farmers in Kenya today lose 15-45% of their maize to stem bores and other insects (Altieri). If they could plant maize seeds engineered with a pest-killing toxin, such as Bt, they could reduce their losses without reliance on chemical sprays. Similarly, transgenic virus-resistant potatoes could help small-scale farmers in Mexico who suffer substantial crop damage. The World Bank panel has estimated that transgenic technologies could increase rice production in Asia by 10-15% within the next decade. Without such gains, increasing demand from a growing population could price rice beyond the reach of the poor (Paarlbeg).

Biotechnology earned its place on the global environmental agenda at the United Nations Conference on Environment and Development (UNCED) held in 1992. Agenda 21, the plan of action that grew out of UNCED, specifically called upon the community of nations to ensure the safe and sustainable use of emerging biotechnologies. This rapidly expanding area of science, with widespread applications in agriculture, mining, pharmaceuticals, manufacturing, and human diagnostics, was of special concern both for its potential benefits and its potential risks. Two recent reports- *Enabling the Safe Use of*

Biotechnology: Principles and Practice, by the World Bank, and *Appropriate Oversight for Plant with Inherited Traits for Resistance to Pests*, endorsed by the elected leadership of 11 scientific societies and distributed by the Institutes of Food Technologies in Chicago- attempt to provide guidance to nations seeking to carry out UNCED's Agenda 21 by developing protocols for the safe use of biotechnology (De Greef).

Some commentators in the industrialized states currently believe there is enough food in the world and that it just needs to be better distributed. That is seriously misleading. It is a delusion to seriously consider that the surpluses of the industrialized nations can or will be sustained indefinitely to feed the present and future population of the developing world. It is estimated that keeping pace with growing demand will require a 70% increase in agricultural productivity by the year 2025. Agriculture is the foundation of human nutrition and health and the major economic activity in most developing countries (Milmo).

The scale and urgency of the situation is compounded by several factors. Increased crop production in the developing countries has traditionally been achieved by bringing more land under cultivation. For example, the area committed to cultivation of the tropical root crop cassava has increased 43% since 1970, while production per hectare has risen by only 20% over the same time. Carving out new cropland from desert or rain forest is not a sustainable or desirable practice and will result in severe depletion of the world's remaining natural ecosystem. Indeed, most of the world's high-quality farmland is already under cultivation, especially in Asia, where land and population pressure is greatest. In some regions the amount of available farmland is actually decreasing, as prime agricultural areas are lost to urban sprawl, soil erosion, and desertification (Paarlberg).

Demographic transitions within the developing countries add another twist to the overall picture. Throughout developing countries, migration to urban areas is increasing dramatically. In the coming decades, the FAO predicts that the rural population will remain roughly at present levels, and more than 90% of population growth will take place in the burgeoning cities of the developing countries. Thus, significant changes are occurring in the types of demand in a manner that requires transportation infrastructure, storage facilities, and post-harvest technologies that are underdeveloped in many tropical countries. Loss of this resource to unchecked expansion of agriculture would have disastrous consequences for future crop improvement and pharmaceutical discoveries (De Greef).

Technical advances over the last five years have pushed genetic engineering into new areas by demonstrating the possibility of simultaneously transfering as many as 12 genes into the genome of a plant. In some future GM food products, naturally occurring allergenic and antinutritional compounds will be reduced and eliminated (Beales). Improved qualities of foods are coming to less fortunate peoples. Over 180 million children, mostly in developing countries, suffer from Vitamin A deficiency; some two million die from it each year. Approximately one billion people suffer from anemia from iron deficiency. Genes producing beta-carotene, a precursor of vitamin A, have been inserted into rice, the most important crop species in the developing world, but one deficient in this crucial nutrient. The GM rice produces beta-carotene, giving it a bronze-orange appearance, hence the name "Golden Rice." It also has genes to increase iron content. This nutritionally enhanced GM rice, generated by a team led by Swiss researcher Ingo Potrykus, is being distributed, free of charge, to public rice breeding institutions around the world. Local breeders will incorporate the new rice trait into local rice varieties for growing by local farmers. Millions of people who are at risk of anemia from iron deficiency, as well as blindness or other manifestations of vitamin A deficiency, will soon be able to greatly reduce their risks of these disabling conditions at little or no additional cost (Paarlberg).

GM food plants are also being developed to deliver vaccines. Poor people in developing countries suffer unnecessary afflictions because they lack easy access to immunizations. Conventional vaccines are often difficult to deliver because they require expensive production, sterilization, and refrigerated transport mechanisms. Tropical fruits such as bananas or even temperate crops such as potatoes and tomatoes can be genetically enhanced to produce vaccines, and they might be grown locally and more easily transported for local consumption. The current cost for delivery of a conventional vaccine injection into a patient in remote areas is about $125 per dose. The estimated cost for a banana-delivered vaccine is about $0.02. Vaccinating against hepatitis, typhoid fever and cholera would dramatically improve the lot of many people. Moreover, vaccines delivered via GM fruits might be more efficacious and also easier to deliver for the very young or elderly for whom conventional vaccination systems are less effective (De Greef).

Diffusion of GM food

However, employing biotechnology to enhance the standard of living and overall economic development in these countries is problematic. Lack of complete understanding of tropical and subtropical crop species certainly provides a challenge, but the major obstacle to applying biotechnology that fits the needs of developing countries are less biological in nature and more economic and political. The rapid adoption of transgenic crop plants in the industrialized North represents the most successful application of a new technology in the history of agriculture. Transgenic crop plantings have risen from zero in 1995 to 39.9 million hectares in 1999. In just one year, between 1998 and 1999, the area committed to transgenic crops increased by 44%. The present market for transgenic crops is estimated at $2.3 billion per year and is estimated to reach $25 billion by 2010 (Altieri).

Most genetically engineered crops are cultivated in North America, with the United States and Canada harvesting 73% of the planted acreage. In the developing world this first generation of transgenic crops has had less impact, in part because these products were conceived, developed, and marketed specifically for release within the economic realities of the industrialized countries rather than to address the requirements of developing countries. Nevertheless, enthusiastic adoption of transgenic maize and soybeans by farmers in countries such as Argentina, China, Mexico, and South Africa show that they can be of relevance in at least some scenarios. Using biotechnology to sustain food security requires targeting the specific needs of small farmers in the tropical and subtropical regions (Alieri).

Concluding remarks

Thus, the world seems increasingly divided into those who favor GM foods and those who fear them. Skeptics contend that GM crops could pose unique risks to the environment and to health. Taking this position, many European countries are restricting the planting and importation of GM agricultural products. As this paper asserts, growing genetically altered crops greatly benefits the environment and eating GM foods is perfectly safe. Moreover, genetic engineering, which can induce plants to grow in poor soils or produce more nutritious food, if applied properly, will soon become an essential tool for helping to feed the world's growing population. The new biotechnology allows breeders to select, transfer, and modify single genes, thereby enhancing the agricultural sector. A milestone of GM regulation is the *International Biosafety Protocol* that provides regulation for international trade of GM organisms and was approved by representatives of 130 countries at a meeting in Montreal, Canada in 2000. This agreement initiates a global step forward by both proponents and opponents of transgenic crops (Laget). Thus, there is hope that the future of biotechnology will be advanced by unique innovations and flexible regulations that in turn will be a blessing for the world.

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