Krista Cooksey

Genomics and Medicine

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Frankenfoods or Foods of the Future?

Introduction

Since its initial introduction into science, genomics has been regarded as one of the most controversial fields. On one hand, this body of science governs fields of study such as stem cell research, which was originally scorned by religious figures and pro-life individuals but praised by individuals who desperately needed stem cell treatments. On another hand, this body of science also governs genetic modification to animals, plants, and forms bacteria. Since scientists discovered DNA can be transferred between organisms in 1946, they have been using this knowledge to create various crops and vaccines to keep up with increasing population growth and the spread of disease within communities. These techniques have also been used as a means to combat world hunger and starvation in many of the developing countries. Despite these apparent benefits to genetically modified foods, GM is currently the source of public scrutiny; many people are concerned about the effects these foods and products can have on the environment, the animals, and human health. In fact, Proposition 37 was on the California ballot in the 2012 election to call for mandatory labeling of genetically engineered food. Although the

proposition was not passed, it is still a very timey issue to discuss the future of genetically modified foods and how the rise of these products could potentially impact our lives.

History of Genetically Modified Foods

With the works of Gregor Mendel who established the basic laws of heredity using pea plants, geneticists knew that various desirable traits could be selected for though classic selection. By 1953, James Watson and Francis Crick discovered the double-helix structure of DNA, which provided a considerable platform for scientists to understand the genetic makeup of various organisms. [1] Then by the 1970s with the work of Herbert Boyer and Stanley Cohen, scientists first discovered that DNA could be transferred between organisms. This discovery is very important in that it created the basis for gene modifications; scientists now understood DNA structures and knew that DNA could be recombined. So, with this new knowledge, genetic engineers began to create artificial gene combinations by splicing genetic material from bacteria, viruses, and other organisms and injecting this genetic material into plant genomes to create novel traits.[2]

With more and more experimentation, genetically modified organisms and foods became more and more popular. In fact, in 1982, the U.S. Food and Drug Administration approved the first genetically engineered drug Genentech's Humulin, which is a type of human insulin. After this initial support from the F.D.A., scientists began to experiment with more foods and plants,

1" http://americanradioworks.publicradio.org/features/gmos_india/history.html

2" http://www.womenshealthmag.com/health/frankenfish

especially after France began field tests for genetically engineered tobacco in 1986.[3] By 1987, field tests for tobacco and tomatoes had already begun in the United States.[4] With these experiments, came another large breakthrough: the introduction of genetically modified crops into commercial agriculture in 1992 with the approval of Calgene's Favr Savr tomato by the US Department of Agriculture. In fact, in that same year the FDA declared that genetically engineered foods were "not inherently dangerous" and did not require special regulation.[5] By 2000, scientists discovered that genetic modification could be used to enrich foods with increased vitamins and nutrients.[6]

Generally, genetically modified foods were not intended for the reasons that people thought they were made for. On the surface, it appeared that these genetically modified crops were a strategy to develop more nutritious foods and create highly productive crops to better feed "a hungry world".[7] However, many of these companies had created crops with built-in pesticides or herbicide tolerance so that these plants could be protected from bugs and products like Roundup weed killer. Thus, many of the companies did not have these selfless, humanitarian efforts at the forefront of their production. Instead, they were more concerned with increasing

3" http://americanradioworks.publicradio.org/features/gmos_india/history.html

4" Ibid

5" http://americanradioworks.publicradio.org/features/gmos_india/history.html

6" http://www.globalchange.umich.edu/globalchange2/current/workspace/sect008/s8g5/history.htm

7" http://www.womenshealthmag.com/health/frankenfish

profits; essentially the more crops you had that survived pests and chemicals, the more crops that could be sold to consumers. Now, however, there seems to be a balance between increasing profits and humanitarian efforts. For example, some bananas are genetically modified to provide vaccinations for infectious diseases such as hepatitis B while some fish are modified to mature quicker so that they can be consumed faster.

Method of Production

In order to understand the processes of genetic modification, one must keep in mind that every organism contains a genetic code, or DNA, that is responsible for its phenotype, or set of visible traits. With this understanding, scientists are able to learn how to modify and manipulate these genes so that new breeds are somewhat better and have more "ideal" characteristics. First, scientists must first pinpoint the specific gene that codes for the desired trait through gene mapping. Once this specific gene has been identified and isolated, they use polymerase chain reaction (PCR) to copy the gene in large quantities quickly.[8] Once the genes have been replicated, they are then introduced into the plant host using one of three methods a). the plasmid method, b). the vector method, or 3). the biolistic method. After choosing one of these three methods to insert the new genes, scientists are then able to create a new plant. Before any further modifications are made though, scientists must first check to make sure that the inserted gene(s) is functioning properly and that the gene material is being produced by the plant seeds.[9] Success of the insertion of the new gene is defined by the ability of the plant to reproduce the new genes

8" (http://www.gm.org/gm-foods/methods-of-genetic-modification/)
(http://library.thinkquest.org/C004367/be9.shtml)

9" Ibid

into the next generation and its ability to develop the novel characteristics contained in the genetic code of the inserted gene. [10]

There are three distinct ways that scientists can insert genes into plant hosts. One of these methods is the plasmid method, which is commonly used to modify organisms like bacteria. First a ring of DNA (plasmid) is placed in a container with restriction enzymes that cut the DNA at a recognizable sequence.[11] These restriction enzymes are then used to treat the DNA sequence to be engineered into the bacteria which creates "sticky ends" that can fuse together.[12] After that, the two separate DNA sequences are introduced in the same container, where the sticky ends allow them to fuse together, creating a ring of DNA with new genetic material. [13]After this, the culture is separated y molecular weight and the heavier molecules have successfully incorporated the new DNA, which means these are then preserved.[14] Next, the newly formed plasmids are added to a culture of live bacteria that will ultimately take up some of the free-floating plasmids and begin to express them.[15] During this process, the DNA will create both instructions for

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10" Ibid

11" Ibid

12" Ibid

13" Ibid

14" Ibid

15" Ibid

making proteins and antibiotic-resistant genes, which can be used to separate the bacteria that have taken up the plasmids from those who didn't.[16] Once again, scientists separate these bacteria by adding an antibiotic; the survivors of the antibiotics definitely possess the new genes. [17]Then, the scientists grow and reproduce the genetically modified bacteria. Once this happens, they can be used in experiments and in industry.

The next method is the vector method. Even though this method is somewhat similar to the plasmid method, the products of this particular method are inserted directly into the genome via a viral vector. In addition to this, portions of the viral DNA must be removed so that the organisms to be re-engineered will not become sick.[18] This is quite advantageous because this allows more space to insert new genes. Once the new viral genomes have been created, they are allowed to synthesize protein coats and reproduce.[19] Next, the viruses are released into the target organism, infects the target cells by inserting its genome, ultimately expressing a new sequence. [20]Using marker genes as well, scientists are able to test for the successful uptake and expression

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16" Ibid

17" Ibid

18" Ibid

19" Ibid

20" Ibid

of the new genes. Some limitations of this particular method is that it is highly unpredictable and could potentially interfere with the function of the organism's existing genes. [21]

The third and final method of gene insertion is the biolistic or the gene-gun method. With this particular method, pellets of metal coated with the desirable DNA are fired at plant cells. Whichever cells take up this DNA are allowed to grow into new plants and can also be cloned to produce more genetically identical crops.[22] This particular method is typically associated with the production of genetically modified foods.

Arguments in support of GM Foods

Currently, there are many arguments in favor of genetically modified foods such as enhanced taste and quality for crops, improved resistance to disease, pests, and herbicides. However, some of the main arguments for genetically modified foods rest in their potential to control world hunger, their ability to provide vaccinations to human populations through the foods, and their positive impacts on the environment.

First, genetically modified foods have extremely important benefits for the world's poor populations, especially in developing countries with some of the highest rates of malnourishment. For example in Asia, large numbers of people rely on a single staple: rice, which does not provides these individuals with adequate vitamins and minerals.[23] So, scientists

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21" Ibid

22" Ibid

23" http://www.pbs.org/wgbh/harvest/exist/arguments.html

are looking to the technology of genetic engineering to create foods such as "golden rice," which stimulates our bodies to generate vitamin A in order to supply these vital vitamins and nutrients. [24]These foods can be very beneficial for the developing world where vitamin-A deficiency kills over 2 million children each year and another 500,000 children are permanently blinded. [25]

Second, genetically modified foods are also beneficial because they can potentially be the source of future vaccines. Currently, genetically modified foods are seen as an environmentally friendly factory that can mass produce various pharmaceuticals. For example, various crops such as bananas are currently being genetically modified to provide vaccinations against infectious diseases such as hepatitis B.[26] Traditional vaccines require a lot of money for production, storage, and usage and this may be close to impossible for developing countries to afford. So, "eatable vaccines,' as developers say, will be easier to ship, store, and administer."[27]

Finally, genetically modified foods may also be beneficial because they offer friendly bioherbicides and bioinsectisides, which are actually much better for the environment. [28] Despite claims that genetically modified foods would increase use of chemical pesticides, genetically modified foods have actually cut the use of such pesticides. Because many of these crops are

24" Ibid

25" Ibid

26" Ibid

27" Ibid

28" Ibid

modified to have these pesticides and herbicides in their new genetic makeup, there has been decreased use of products such as Roundup weed killer.[29] For example, independent studies of commercial grown herbicide-tolerant genetically modified crops have shown nearly a 50% decrease in herbicide use by farmers.[30]

Arguments against GM Foods

On the other hand, as genetically modified foods are becoming more popular and are beginning to dominate food shelves, there is growing concern about the effects genetically modified foods may have on animals, our health, and the biodiversity of various forms of flora and fauna. The main arguments against genetically modified foods are that familiar foods may become allergenic, a few companies may begin to dominate the food industry, and could actually promote antibiotic resistance.

One of the major reasons for consumer reluctance to buy genetically modified foods is because they are worries that these modified foods may introduce new allergens. Through new gene combinations, "genetic engineering can introduce known or unknown allergens into a food that previously did not contain it."[31] For example, a soybean modified to contain Brazil nut genes was found to produce allergic reactions in people with nut allergies.[32] In cases like these, allergic

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29" Ibid

30" http://www.agbioworld.org/biotech-info/articles/biotech-art/in_favor.html

31" http://www.ru.org/science/the-case-against-genetically-modified-foods.html

32" Ibid

reactions can be very serious and sometimes fatal. More importantly, testing individuals for their allergenic potential can be extremely difficult; when gene modifications cause a given food to start producing allergens that were not originally present, it may be impossible to know who is allergic to this food. [33]

Another concern about the gaining popularity of genetically modified foods is the effects this may have on control of the various industries. Because genetic modifications must be completed by scientific communities, this means that the production of these genetically modified foods will be solely concentrated in the hands of a few, large communities. Consequently, small farmers will have to speak to these big firms. For instance, Monsanto, which is one of these large companies, is currently suing North American farmers because they claim that these small farms have grown genetically modified crops without paying for the right to do so. [34] Additionally, this control by few corporations may also prove to be detrimental in developing countries. Because these crops are so expensive, they may not be able to afford to grow genetically modified foods, which will further widen the gaps between rich and poor. Finally, this may also be detrimental to developing countries because they will essentially have to rely more and more on industrialized countries such as the United States to provide them with these genetically modified foods, which may cause them to digress further from truly becoming developed.

Finally, there is concern about genetically modified foods because it is believed they will actually promote antibiotic resistance. During genetic engineering, many of the scientists insert

33" Ibid

34" http://www.pbs.org/wgbh/harvest/exist/arguments.html

antibiotic resistant genes in order to identify the cells that have just been injected with the new genes. So, the cells that have incorporated these new cells survive because they are resistant to antibiotics.[35] This is extremely problematic because it further exacerbates the growing issue of antibiotic resistance in disease causing bacteria. Now that more antibiotics are used in medical treatments and agriculture, strains of bacteria in diseases such as pneumonia, tuberculosis, and salmonella are non-responsive to antibiotics. By adding more and more antibiotic resistant genes to our foods, we are ultimately worsening an issue that has plagued public health prior to the development of these genetically modified foods.

Proposition 37

One of the most recent debates in the field of genetically modified crops is California's Proposition 37, which calls for the mandatory labeling of genetically modified food. In fact, if it had passed, the proposition would have, amongst other things, required labeling on raw or processed foods that have been modified genetically in any way and prohibited labeling of these foods as "natural." The table below gives a comprehensive account of the logistics for Proposition 37.

- Requires labeling on raw or processed food offered for sale to consumers if made from plants animals with genetic material changed in specified ways.
- Prohibits labeling or advertising such food, or other processed food, as "natural."
- Exempts foods that are: certified organic; unintentionally produced with genetically engineered material; made from animals fed or injected with genetically engineered material but not genetical engineered themselves; processed with or containing only small amounts of genetically engineere ingredients; administered for treatment of medical conditions; sold for immediate consumption su

35 http://www.ru.org/science/the-case-against-genetically-modified-foods.html

as in a restaurant; or alcoholic beverages. [36]

Some of the arguments in favor of the proposition include expressing one's right to know what is in their food, knowing this information could provide physicians and scientists information about developing allergies in patients, and the United States is one of the only countries that does not label their foods; labeling of genetically modified foods began in 2000 in 130 countries at the Convention on Biological Diversity in Canada. [37] Secondly, proponents argued that the mixing of these "frankenfoods" with weeds means that more herbicides are needed to kill them, worsening the effects on the environment.[38] Alongside donors such as Joseph Mercola, various donors such as the Organic Consumers Fund, Mercola Health Resources, and Kent Whealy gave over 50,000 to the "yes" campaign for Proposition 37. Total campaign cash in support of Proposition 37 totaled $8,700,000. Despite large funding in support of the proposition, many sources claim that faulty strategies were the demise of the proposition. For example, the "No on 37" campaign listed the American Council of Science of Health (ACSH) as well as the Food and Drug Administration (FDA) as supporters for their campaign without proper authorization. Because these organizations have typically been criticized for such controversial "industry-friendly"

36" http://ballotpedia.org/wiki/index.php/California_Proposition_37,_Mandatory_Labeling_of_Geneti_27cally_Engineered_Food_(2012)

37" http://americanradioworks.publicradio.org/features/gmos_india/history.html

38" http://livinggreenmag.com/2012/11/20/green-business/keep-your-government-hands-off-my-genetically-modified-food-whats-next-after-prop-37/

stances on these issues, some say that these "questionable tactics" were one of the main reasons why the proponents of Prop. 37 lost credibility. [39]

Conversely, there are many opponents of Proposition 37. Some of the arguments against it include the fact that this would add more government bureaucracy, increase taxpayer costs, increase food costs by $400 for families annually, and create new frivolous lawsuits between small farmers and large corporations.[40] Secondly, the opponents of the proposition state that allegations that genetically modified foods have adverse effects on humans are untrue; many of these studies are still inconclusive. Additionally, arguments include the fact that there are still many exemptions, or "special-interest loopholes"[41] to these labeling mandates. For these very reasons, there was much more opposition to the proposition; total campaign cash in opposition of Proposition 37 totaled over $45,600,000.

In the November 6, 2012 election in California, 53% of the voters voted against proposition 37 while 47% of the voters voted in support of the proposition.

Future for GM Foods/ Policy

Although proponents of Proposition 37 did not win in the election, this election was quite important. Had the proposition passed, California would have been the first state to authorize labeling of genetically modified foods. As of today, it is estimated that 70-80% of all processed

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39" Ibid

40" Ibid

41" Ibid

foods sold in the United States are made with genetically modified ingredients such as corn and soybeans. [42] Because this percentage is so high and consumers are becoming more aware of these products, it is believed that this will result in an "increased public demand in health and food science education."[43] So, "yes on 37" was just an introduction to the future of policy to regulate information about genetically modified foods to the public. In fact, one of these sources said "...the "Yes on 37" camp is not going to back down. Anticipate campaigns and future ballot initiatives for years to come."[44] In fact, Stacey Melken, spokeswoman for Prop.37, said that she believes supporters of the labeling debate will win in the long run; even though the proponents were outspent 5:1, they still managed over 4.2 million votes. [45]

More importantly, the Obama administration's stance on genetically modified foods and organisms may also have important impacts in the years to come. Many people thought that the Obama administration was against labeling when he approved Monsanto's proposal to introduce its newest genetically modified corn into the American food supply without any governmental regulations. [46]In addition to this, he appointed former top executives of Monsanto Tom Vilsack and Michael Taylor to Secretary of Agriculture. However, after recent campaigning at the

42" Ibid

43" Ibid

44" Ibid

45" http://www.sfgate.com/news/article/Prop-37-Genetic-food-labels-defeated-4014669.php

46" http://www.cornucopia.org/2012/01/wholesale-approval-of-genetically-engineered-foods-obama-administration-disappointsangers-public/

University of Pennsylvania, it has been noted that Obama is very passionate about his promise to label genetically modified food and was highly supportive of California's "right to know" slogan.[47] It was only taking more time to claim a stance because labeling is such a complex issue and Obama wanted to completely understand both sides of the issue.[48] So, now that Obama has expressed his support of labeling, it is expected that we will indeed see more favorable policies on genetically modified foods during his second term.

Conclusion

Although genetically modified foods are becoming more prevalent and have the potential to solve many of the world's problems such as malnutrition, the future of genetically modified foods will truly be in the hands of government agencies such as EPA, USDA, and the FDA. Each of these agencies adheres to a set of policies to determine the safety of genetically modified foods. The Environmental Protection Agency (EPA) evaluates genetically modified foods and plants based on their impact on the environment, the USDA determines whether or not these plants are safe to grow, and the FDA determines whether or not these plants are safe to eat.[49] If, at any time, the technologies of genetically modified foods do not meet the guidelines as outlined by these government agencies, then developments will cease.

47" http://www.deathrattlesports.com/archives/9798/obama-official-comments-on-administrations-gmo-labeling-stance/

48" Ibid

49" http://www.csa.com/discoveryguides/gmfood/overview.php

Even though these foods may temporarily solve some of the world's problems, we must consider the long term as well. We must take into consideration the health of populations across the world and the impact these foods may have on the environment. As enthusiasm for genetic modifications technology increases and technology becomes even more powerful, keeping these questions at the forefront will be imperative.