DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Family and Consumer Sciences

FSFCS97

What Are GMOs?

Jamie I. Baum, PhD
Assistant Professor - Nutrition

Amanda McWhirt, PhD
Assistant Professor - Horticulture

João Pedro Marinho Guimarães
Undergraduate Student - Food Science

Ênela Rabelo Silva
Undergraduate Student - Food Science

Brianna Gaines, MS
Former Graduate Research Assistant - Food Science

GMOs (Genetically Modified Organisms)

GMO is a term regularly seen and heard in the news and on television. However, many consumers have limited understanding of what it means for a food product to be GMO and often have misconceptions or are not familiar with what research has been done on the safety of these products [1]. The following information will explain what GMOs are, why they are used and what long-term research regarding their safety has found.

What Are GMOs?

Historically, the creation of new varieties of crops has been done through the selection and crossbreeding of plants that have characteristics the plant breeder desires in the crop. Using this method, the plant breeder relies on visible characteristics in the plants to make choices about which plants to cross and thereby alter the genetics of the next generation of the crop. This method does not immediately or consistently produce the desired results and, as a result, new varieties of crops may take 15 or more years to develop.

Natural DNA recombination is another possibility. For instance, natural DNA recombination happens naturally over presumably even longer periods of time. In the past several decades, scientists have developed techniques to identify the gene or sequence of genes (DNA) associated with a desirable characteristic by looking at the molecular level of the plant's genetic makeup (genome). This method does not require plant breeders to wait to see the characteristic observable in the plant before selecting parent plants. Instead breeders can read an organism's genetic map and then transfer or amend the specific gene or sequence responsible for that desirable characteristic in the crop. This process is capable of more precisely creating plants with desirable characteristics and of producing characteristics that might have otherwise been difficult or impossible to select for with traditional breeding methods.

Crops produced using this method, where genetic material has been altered or changed in a way that does not occur through mating/breeding and/or natural DNA recombination, are referred to as genetically modified organisms or GMOs [2,3]. The technology involved in making GMOs allows single genes to be transferred from one organism of a species into another organism of that same species or may involve transfer of genes between nonrelated species. The process associated with producing GMOs is complicated scientifically, is expensive and requires long-term testing before a crop is released for commercial production.

The United States Department of Agriculture (USDA) refers to the creation of GMOs as a type of agricultural biotechnology [4]. Plants that have been produced using genetic modification (GM) in this way are called genetically modified crops or GM/GMO crops. The food products that result from these crops are then referred to as genetically modified foods, GMO foods or genetically engineered foods. The terms GMO and GE foods are often used

Arkansas Is Our Campus

Visit our web site at:
https://www.uaex.uada.edu

interchangeably; however, there is a difference. A genetically modified organism (GMO) is any living thing that has different DNA than its parents. Genetically engineered foods are created in a laboratory.

Why Are GMOs Produced?

GMO crops are developed because the crops have either some perceived advantage to the farmers who grow the crops or the resulting food product has qualities that are desirable to the consumer [3]. From the grower's perspective, GMO crops have been developed that have strong resistance to disease and insects or are resistant to certain herbicides, which means the herbicide will kill competing weeds that reduce yields but not the crop [3]. The advantages GMO crops may provide to protect the grower from crop loss due to insects and disease are the major reasons for the development and widespread use of GMO crops. However, on the consumer's behalf, GM crops have also been produced that have higher nutritional value and better shelf life [3].

Examples of GMOs on the Market

The first GMO crops were planted in the United States in the early 1990s starting with canola, cotton, corn and soybeans [5]. In 2012, in the United States GMO versions of crops were used in about 88 percent of corn, 94 percent of cotton and 93 percent of the soybeans produced [4]. It is estimated that the United States accounts for 40 percent of the acreage of all genetically modified crops planted globally [5]. As of early 2017, the genetically engineered crops grown in the United States are apples, alfalfa, canola, cotton, corn, potatoes, soybeans, sugar beets, summer squash and papaya.

A majority of these crops are used as raw materials in processed food products, such as cotton and soybeans for cottonseed oil and soybean oil, sugar beets for sugar and corn for high fructose corn syrup. Other crops like alfalfa, field corn and soybeans are used predominately for livestock feed.

The majority of the listed crops are grain and fiber crops. A major misconception among the public is that most fruits and vegetables sold in the U.S. are produced from GMO crops. However, you will notice that very few specialty crops are listed above. In fact, the majority of fruit and vegetable crops available for purchase at your local grocery store or farmers' market are not GMO. If you see an abnormally large fruit or vegetable in your local store, it was likely developed through conventional methods of crop breeding and systems of production that precisely manage fertilizer and water inputs, not through genetic modification. Papaya, summer squash and potato have GMO versions that were developed to be resistant to viruses that can devastate these crops. In fact, the GMO papaya helped to save papaya production in Hawaii, where the papaya ringspot virus (PRV) threatened to eliminate entire papaya plantations [13]. A more recent release is Artic Apples that have been developed to not turn brown after they are cut, which is a characteristic desirable to consumers.

United States Legislation Regarding GMOs

The regulation of GM products is currently controlled by the following three agencies [5]:

- Food and Drug Administration (FDA; involved with food consumption for humans and animals).
- Environmental Protection Agency (EPA; controls the use of herbicides and pesticides).
- Animal and Plant Health Inspection Service (APHIS; a branch of the United States Department of Agriculture (USDA) that evaluates the safety of biotechnology techniques).

Until recently, laws in the U.S. have been flexible and open to the release of new GM crops and foods into the national food supply. In 2016, a bill was passed by the U.S. Congress that will establish national standards for labeling food products that contain ingredients which are GMO. This bill requires food companies to disclose whether their products contain GMO ingredients, but they do not have to print this information on the packaging label [6]. Instead, this information can be made available through a QR code on the package that consumers can scan while grocery shopping. The USDA has two years to establish the details of the new labeling scheme.

What Are the Benefits of GM Crops and Food Products?

The benefits that farmers may receive from the use of GM crops include:

- A reduction in the use of pesticides due to increased crop resistance to harmful insects and diseases [5].
- Ability to grow crops that previously were threatened by viral pathogens [12].
- Ability to more easily combat weeds that compete with crops through the development of crops that are resistant to herbicides [5].
- Ability to grow in harsher environmental conditions, enabling increased global crop yield [8].

Some benefits that consumers may receive from GM food crops, include:

- Increased nutritional value of food products that have higher micronutrient content [5, 7].
  - The main benefit to consumers is a potential for increased micronutrient consumption and thus a healthier diet [9].
  - For example, Golden Rice is genetically engineered rice with an increased vitamin A content [7], which could greatly increase vitamin A consumption and decrease vitamin A deficiencies, which are more common in developing countries and may result in blindness or high rates of child mortality.
- Increased shelf life of food products [5].
- Other potentially beneficial GM crops in development include potato with altered fatty acid composition to reduce the production of trans fats during processing and decrease acrylamide formation. Acrylamide is a potential cancer-causing toxin that forms when some foods are fried at high temperatures [9].

Many of the benefits of GM products are recognized by farmers and food manufacturers but may not be understood by the public [1], so a lack of understanding may contribute to the public's distrust of GMOs. There is often a perception that GMOs are not "natural" because genes may be inserted from one species into another species or genes are changed using molecular techniques. To date, extensive research has been done to evaluate how the process of genetic modification of food crops has impacted human health over the last 25 years and concerns about safety have not been upheld.

Safety Assessment of GM Food

Safety assessments of GM foods over the last 25 years have generally focused on how changing the genetic material of the crop might change the nutritional value of the crop, the potential of the crop to induce an allergic reaction, the stability of the inserted gene, nutritional effects associated with genetic modification and any unintended effects which could result from gene insertion [3].

What Are the Health Benefits and Risks Associated With GM Foods?

Any new food product should undergo extensive research before being considered safe for human consumption. A recent report that evaluated the results of more than 130 research projects over a 25-year period found that biotechnology, in particular GMOs, carried no additional risk as compared to conventional breeding technologies [10].

Based on a recent report by the U.S. National Academy of Sciences, there is no evidence of health risk due to consumption of GM foods [9]. The World Health Organization (WHO) has also concluded there is no conclusive risk for humans associated with the consumption of GM food products [3]. There is some concern that GM crops might increase food allergies; however, the National Academy of Sciences [9] did not find a relationship between consumption of GM crops currently on the market and an increase in food allergies. No scientifically rigorous studies have found correlations between the consumption of GMO food crops and cancer incidence in animals or humans.

While some animal-based studies have shown adverse health effects on animals when they consumed GM foods, the goal of these studies was to determine at what level GM foods might become toxic to the animal and required the animals to consume high doses of the food, far exceeding amounts normally consumed by humans. GM soybeans and corn are often fed to livestock, and results of over 100 studies evaluating the effect of feeding genetically engineered crops to these kinds of animals have not found differences in the nutritional value of these crops compared to the conventionally bred versions for the animal [14] nor any difference in the animals health or the quality of the resulting animal products [11]. Additionally, once animals consume the GM food crop, that genetic material is processed by the animal in the same way as the non-GMO food crops and no genetic material gets passed on to the animal's meat or milk [12].

Are There Risks of GM Crops and GM Food Products to Farmers?

According to a recent report by the National Academy of Science [9], after reviewing the status of GM crops, they concluded the two primary negative effects GM crops have are related to lack of enhanced yield as expected and increased herbicide use.

- Although certain insect-resistant GM crops have been shown to save farmers money on insecticides, overall GM crops have not been shown to increase yields. The companies that produce GM crops often advertise GM technology as a necessary means to feed the world's growing population. However, thus far the GM technologies that have been developed have not been proven to have an impact on increasing yields of major grain crops compared to regions where non-GM versions are grown [9].
- Since the implementation and widespread use of herbicide-tolerant GM crops, there has been an associated increase in the amount of herbicide used in these crops, and farmers are now experiencing an increase in the prevalence of weeds developing resistance to herbicides. These weeds now require more aggressive systems of management to control them.

Conclusion

Farmers have benefited from being able to reduce insecticide use when growing GM crops that are resistant to diseases and insects and reduce crop loss associated with these pests. Crop loss to disease and insects can be economically devastating to growers worldwide, and GM crops that provide protections from such losses continue to be desirable to growers. GM crops that help address nutritional needs or consumer preferences will likely continue to be produced in the future as the latest research has shown GMO ingredients and products are safe to consume and are associated with very little to no health risk to the public. However, consumer acceptance is still low and many feel consumers have a right to know if there are GMO ingredients in their food and want them clearly identified on food labels. Soon consumers will be able to identify when a product contains GMOs.

We hope this fact sheet will help you to make informed personal decisions about buying and consuming products that contain genetically modified organisms.

References

1. Wunderlich, S., and K. A. Gatto. (2015). Consumer perception of genetically modified organisms and sources of information. *Advances in Nutrition* 6:842-851.
2. http://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732. Accessed January 26, 2017.
3. http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/. Accessed January 26, 2017.
4. https://www.usda.gov/wps/portal/usda/usdahome?navid=AGRICULTURE&contentid=BiotechnologyFAQs.xml. Accessed January 26, 2017.
5. Halford, N. G., and P. R. Shewry (2000). Genetically modified crops: methodology, benefits, regulation and public concern. *British Medical Bulletin* 56(1): 62-73.
6. http://www.npr.org/sections/thesalt/2016/07/14/486060866/congress-just-passed-a-gmo-labeling-bill-nobodys-super-happy-about-it. Accessed January 26, 2016.
7. Paine, J. A., C. A. Shipton, S. Chaggar, R. M. Howells, M. J. Kennedy, G. Vernon, S. Y. Wright, E. Hinchliffe, J. L. Adams, A. L. Silverstone and R. Drake (2005). Improving the nutritional value of Golden Rice through increased pro-vitamin A content. *Nature Biotechnology* 23: 482-487.
8. Ronald, P. (2011). Plant genetics, sustainable agriculture and global food security. *Genetics* 188(1): 11-20. Doi: 10.1534/genetics.111.128553.
9. National Academies of Sciences, Engineering and Medicine. 2016. *Genetically Engineered Crops: Experiences and Prospects*. Washington, DC: The National Academies Press. doi: 10.17226/23395.
10. http://ec.europa.eu/research/biosociety/pdf/a_decade_of_eu-funded_gmo_research.pdf
11. Autmaire, A., K. Aulrich, A. Chesson, G. Flachowsky and G. Piva. 2002. New feeds from genetically modified plants: Substantial equivalence, nutritional equivalence, digestibility, and safety for animal and the food chain. *Livestock Production Science*, 74: 223-238.
12. Van Eenennaam, A. Genetic Engineering and Animal Feed. http://anrcatalog.ucanr.edu/pdf/8183.pdf
13. Gonsalves, D., C. Gonsalves, S. Ferreira et al. Transgenic virus resistant papaya: From hope to reality for controlling papaya ringspot virus in Hawaii. *APSnet Feature*, July 2004.
14. Snell, C., A. Bernheim, J.-B. Bergé, M. Kuntz, G. Pascal, A. Paris and A. E. Ricroch (2012). Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: a literature review. *Food and Chemical Toxicology* 50: 1134-48.

Printed by University of Arkansas Cooperative Extension Service Printing Services.

DR. JAMIE I. BAUM is assistant professor - nutrition with the Department of Food Science, University of Arkansas System Division of Agriculture in Fayetteville. **DR. AMANDA McWHIRT** is assistant professor - horticulture with the University of Arkansas System Division of Agriculture in Little Rock. **JOÃO PEDRO MARINHO GUIMARÃES** and **ÊNELA RABELO SILVA** are undergraduate students in the Food Science Department, University of Arkansas, Fayetteville. **BRIANNA GAINES** was formerly a graduate research assistant in the Food Science Department, University of Arkansas, Fayetteville.

FSFCS97-PD-7-2017N