# KNOWLEDGE BASE AND PERCEPTION REGISTERED DIETITIANS HOLD ON THE GENETIC MODIFICATION OF FOODS

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KNOWLEDGE BASE AND PERCEPTION REGISTERED DIETITIAN'S HOLD ON THE GENETIC MODIFICATION OF FOODS (80 pp.)

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The purpose of this study is to determine the knowledge of registered dietitians nationwide on the topic of genetically modified organisms. A secondary purpose of this study is to determine if knowledge affects the perception that dietitian's hold on this topic. A survey was electronically distributed to seven states in all regions of the county, via each state's respective dietetic practice group's list-serv. There were 284 respondents distributed evenly from each of the four regions of the United States. This study utilized a univariate ANOVA based on the dietitian's knowledge versus perception. This study found that dietitians in fact do lack knowledge in the area of genetically modified organisms, with only 22% receiving a score of 70% or higher. Also found was the more knowledgeable a dietitian was on the topic of genetically modified organisms, the more likely they were to oppose the genetic modification of organisms ($P \leq .001$). The results of this study show the lack of overall knowledge held by Registered Dietitians related to the topic of genetically modified organisms, as well as a significant trend of increasing opposition when knowledge is high. These findings suggest that it is essential for the dietetic professionals to be equipped with the latest evidence-based research, in order to best educate and protect clients, consumers, and the overall well being of the public.

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# CHAPTER I

## INTRODUCTION

The complex issues surrounding the application of genetic engineering to food and agriculture have generated a contentious debate among diverse interest groups (Roberts, Struble, Gomez, Wilkins, 2006, Batista, Oliveira, 2009). There are many perceived benefits as well as disadvantages of permitting GMOs into the food supply. In 2003, the number of manufactured foods that contain genetically engineered ingredients was approximately 70% and the number has since then grown (Brown, Ping, 2003). There has been vast polarization, about GMO's between activist groups, environmentalists, scientists, and politicians, leaving the public confused and unaware. Since this topic is extremely controversial, it is important for the public to find unbiased and fair answers to the questions they may have.

Dietitians can play a critical role in increasing public awareness and understanding of genetic engineering. Consumers perceive dietetic professionals as reliable providers of food and nutrition information and services as well as a trusted source of information about agricultural and food biotechnology (Academy of Nutrition and Dietetics 2006, Pew Initiative on Food and Biotechnology, 2004, Santerre, Machtmes, 2002 and Roberts et al., 2006).

There are many reasons for the introduction of genetically modified foods in our food system. Engineered species can grow faster, hold increased nutritional qualities, and reduce the environmental impact of food production (Nordlee, 2006;

Legge, 2010). Much concern have been expressed over the introduction of allergenic proteins into food plants by genetic engineering. Other opposition includes ethical implications, uncertainty in gene transfer, lack of control, and antibiotic resistance giving rise to super bugs (Goodman, Tetteh, 2011; Schumacher at al., 2011; McCullum, 2007; Kaiser, 2002; Juanillo, 2001). The current laws as set by the FDA do not mandate labeling of products that contain organisms that have been genetically modified ("Guidance for industry," 2006). If an individual was seeking to avoid genetically modified organisms for ethical, religious, or health reasoning, there is very little to guide the consumer. This has been a worldwide issue for the past two decades and continues to be the most prevalent agricultural issue in the United States (Halford, Nigel G. 2000).

## Problem Statement

While technology can be a great feature in the advancement of our society, it must be done with a healthful mindset and in the best interest of the public. The topic of GMOs is quite controversial, as it pertains directly to our food supply and diet. Dietitians have an obligation to partake in the development of our nation's regulatory efforts to standardize these products. The Academy of Nutrition and Dietetics (AND) calls for all dietetic professionals to articulate the current science and current regulatory framework about biotechnology without bias (Academy of Nutrition and Dietetics, 2006). The official position statement by the AND, however states that opponents of biotechnology will limit farming practices that may retard environmental stewardship and that being overly cautious with genetically modified

organisms can stifle innovation. They urge health professionals to work together to encourage availability of these genetically modified products in the marketplace (Academy of Nutrition and Dietetics, 2006).

The problem with this stance by the AND is that when dietetic professionals seek knowledge about the genetic modification of foods; the position statement weighs heavily on the potential benefits of this technology without providing much neutral and unbiased information, or information about possible negative consequences. If dietitians are seeking unbiased scientific evidence based information on the genetic modification of food, the Academy of Nutrition and Dietetics does not facilitate this behavior due to its severely slanted position statement.

## Purpose Statement

As this issue spreads and gains more media attention, and as the public seeks more honest answers, dietitians should be on the forefront of explaining the possible health benefits and concerns of this controversial issue. Dietitians should also be able to provide informative and reliable information in an unbiased fashion, providing current scientific research as sources. GMOs are an issue that affect everyone in America because the majority of processed foods contain at least some genetically modified organisms.

The purpose of this study is to determine the knowledge of registered dietitians in eight states on the topic of genetically modified organisms. A secondary purpose of this study is to determine if knowledge about GMOs affects the

perception that dietitians hold on this topic. The proposed hypothesis is that there is a significant knowledge deficit held by Registered Dietitians on the topic of genetically modified foods. The secondary hypothesis is that the more knowledge dietitians hold on the topic, the less likely they are to support the practice.

# CHAPTER II

# REVIEW OF LITERATURE

## Genetic Engineering Defined

Genetic Engineering is defined by Merriam Webster as the group of applied techniques of genetics and biotechnology used to cut up and join together genetic material (especially DNA) from one or more species of organisms and to introduce the result into an organism in order to change one or more of its characteristics (Merriam Webster, 2011). Farmers have been changing plant genes for thousands of years, however according to this definition, genetic engineering is a relatively new technology. The long history of producing new varieties of crop plants by conventional breeding has rarely resulted in forms that have had to be withdrawn from the market because of health concerns (Atherton, 2002). The modern era of genetically engineering crops begin in the 1970's when scientists discovered how to make recombinant DNA (McCullum, 2000). Genetic engineering uses a set of modern biology techniques used to manipulate an organism's genetic endowment by introducing, modifying, or eliminating specific genes. It also allows gene transfer between unrelated species, which means they contain additional or modified characteristics encoded by the introduced genes (Batista et al., 2009). This biotechnology uses either Recombinant DNA (rDNA) technology or "gene splicing" which will later be discussed in detail (Zinnen & Voichick, 1994). Genetically engineered crops were introduced for commercial production in the mid 1990's

(McCullum, 2000). These techniques enable plants, animals, and microorganisms to be genetically modified (GM) with traits beyond what is possible through traditional breeding (Academy of Nutrition and Dietetics, 2006, Halford, Shewry, 2000, Batista et al., 2009). Genes can be derived from the same species, however in most cases, the genes are derived from other species. This may include plants, animals, or microbes and the goal is to introduce new biological properties or activities to the plants (Halford, 2000). The GM foods currently on the market are mainly aimed at an increased level of crop protection through the introduction of resistance to plant diseases caused by insects and viruses, or through increased tolerance towards herbicides (World Health Organization, 2000).

## Recombinant DNA as Related to Genetic Modification

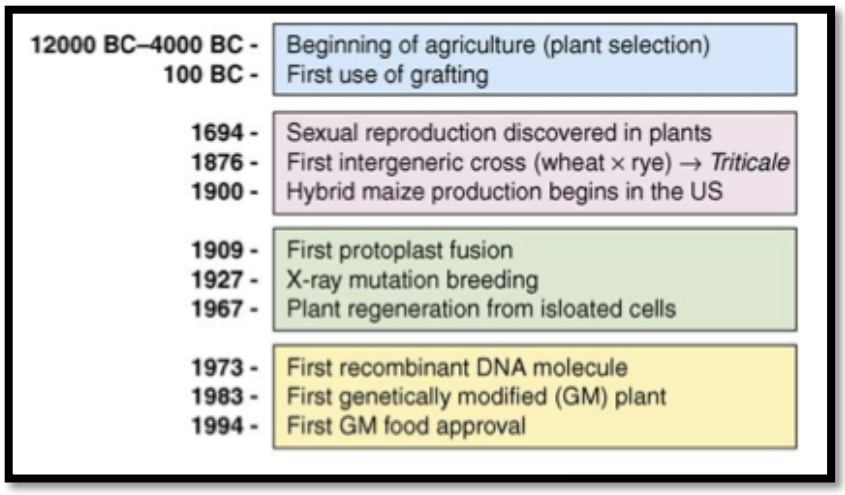
The changes in plants as a result of conventional breeding was considered safe until challenged with the advent of recombinant deoxyribonucleic acid, or rDNA technology in the early 1970's. In 1973, Cohen and Boyer successfully connected two different pieces of DNA and created rDNA (McHughen, 2007). Cross species DNA splicing became a reality, and the gates of scientific advancement became more realistic. There are endless combinations that could be created with this new technology. For example, insect resistance is achieved by incorporating the gene for toxin production from the bacterium Bacillus Thuringiensis into the plant (BT) (Rowe, 2010). This toxin is currently used as a conventional insecticide in agriculture and is safe for human consumption. The purpose of this assimilation of BT genes into plant life is to lower quantities of insecticides needed in specific

situations (World Health Organization, 2000). Other examples of genetic modification range from using flounder genes in tomato plants to prevent frost damage, engineering salmon to grow twice as quickly as usual, and using gene technology to keep apples from turning brown once they have been cut open.

## History of Genetic Engineering

Table 1

*History of Genetic Engineering*




Though biotechnology emerged more than 8000 years ago, public awareness of biotechnology and genetic engineering concepts is a relatively recent phenomenon. Scientists first figured out how to create recombinant DNA in 1973 on the California Coast (Batista et al., 2009).

The first genetically engineered plant was reported in 1983, involving an antibiotic resistance gene and a tobacco plant (Horsch, 1984). The first GM food that was introduced into market was the FlavrSavr™ tomato in 1994, which gained the ability to resist rotting by having the polygalacturonase gene (Smith et al., 1998).

Intellectual property rights protection expanded in the 1970's and 1980's, which gave seed suppliers patented rights to the seeds they developed. This strengthening initiated a vast amount of research by private companies to invest in seed development and biotechnology. Since 1987, seed producers have submitted nearly 11,600 applications to the USDA's Animal and Plant Health Inspection Service for field-testing of GE varieties (Schneider, 2004). More than 10,700 (92%) have been approved (Fernandez-Cornejo, Caswell, 2006). By 2007, the transgenic crops were cultivated in 23 countries, with numbers predicted to double by 2015 (James, 2007).

## How Genetically Modified Organisms are Used Today

There are three types of genetic engineering that currently exist in the market (World Health Organization, 2000). The first is known as *input trait technology*, which has a goal of reducing the total amount of pesticides used on crops. The traits of these crops include herbicide tolerance, disease resistance, and insect resistance (McHughen, 2007; Batista, 2009). The second type of genetic engineering is known as *output trait technology*. This promises to bioengineer characteristics into seeds to increase nutrient quality and density, improve shelf life, quality, and appearance. The third type is known as *agronomic trait technology*, which is aimed to bioengineer traits to afford additional protection against natural conditions and disasters that may affect farmers in poorer nations (Legge, 2010; World Health Organization, 2000).

**rBST Growth Hormone**

A more notable and recognized topic by the American public is that of the added growth hormone administered to cow's known as recombinant bovine somatotropin (rBST). Somatotropin is a naturally occurring protein hormone produced in the pituitary gland of animals and triggers nutrients to increase growth in young cattle and lactation in dairy cows (Valez, 2004). Artificial BST is produced by genetically modifying organisms using recombinant DNA technology. In 1998, an assessment by *Health Canada*, determined Monsanto's results of their 90-day of rBST hormone injection study caused concerns and reasons for review before approval of rBST (Vande, 2006). This raises concern of the usage of these hormones in our food supply, and to this date no longitudinal study has been completed to test the long-term safety. Today, the European Union, Japan, Australia and Canada have all banned the use of rBST due to animal and human health concerns (Buzby, 2006). However America has yet to place any limits on this practice and rBST is in most dairy sold in stores today.

**Background of Seed Suppliers**

The intellectual property rights protection expanded in the 1970's and 1980's, which gave seed suppliers patenting rights to the seeds they develop (Rowe, 2010). This strengthening initiated a vast amount of research by private companies by investing in seed development and biotechnology. These private companies, which once focused on chemicals, shifted their focus to seeds. A few major chemical companies purchased a large variety of major seed companies, consolidating

agriculture into the hands of a few corporations. Since 1987, seed producers have submitted nearly 11,600 applications to the USDA's Animal and Plant Health Inspection Service for field-testing of GE varieties. More than 10,700 (92%) have been approved (Fernandez-Cornejo, Caswell, 2006).

## Agricultural History of Sharing Seeds

When the U.S. was founded, European settlers borrowed maize seeds from Native Americans when those transferred from Europe failed to grow. In 1980, the Supreme Court decision of Diamond v. Chakrabarty laid the foundation for the privatization of genetics of seeds (Rowe, 2010). In 1996 the first genetically modified seed was patented and planted commercially in the United States. By 1997, farmers in the U.S. planted more than 8 million acres of GM soy and more than 3.5 million acres of GM corn. The privatization of the seed industry led to massive consolidation in the biotech industry (Stein, 2005).

### The Art of Saving Seeds

Natural seeds reproduce themselves indefinitely, and those seeds with successful and desirable traits are replanted the following year to produce a better crop. For thousands of years, farmers saved seeds with the most beneficial characteristics and planted those the following year (Stein, 2005). Until recently the U.S. Department of Agriculture not only freely developed and distributed seeds, but encouraged seed saving by farmers (Stein, 2005; Rowe, 2010). Seed saving is an ingrained part of our agriculture, and the majority of farmers in third world nations save seeds for the cost-benefit, and for economic survival (Stein, 2005).

## Intellectual Property Rights of Patented Genes

The United States policy on intellectual property rights grants a wide variety of patents to private industries for the right to own living organisms. Intellectual property rights (IPR's) have been discussed by the World Health Organization in relation to equal access to genetic resources and the sharing of benefits (Rowe, 2010). The review has considered potential problems of monopolization and doubts about new patent regulations in the field of genetic sequences in human medicine (World Health Organization, 2000). The private seed industry has made substantial commercial gains to promote it's own seeds and increase IPRs, and as a result is now a global $15 billion industry.

Biotech seed companies are given a vast amount power in shaping the policies in IPRs, and the U.S. is seen has having the strongest protection rights world-wide. In 1980, the Supreme Court decision of Diamond v. Chakrabarty laid the foundation for the privatization of genetics of seeds (Stein, 2005). The court ruled that a live, man-made bacterium was patentable; giving the seed industry incentive to develop genetically modified organisms. In 1996 the first genetically modified seed was patented and planted commercially in the United States. By 1997, farmers in the U.S. planted more than 8 million acres of GM soy and more than 3.5 million acres of GM corn (Stein, 2005). Judicial decisions in the United States played a key role in developing IPRs, not only for the U.S. but also for the world. The privatization of the seed industry led to massive consolidation in the biotech industry (Rowe, 2010).

The idea of chemical companies gaining control of the agriculture industry is a growing concern in many groups. These groups fear that an exclusive use of herbicide-tolerant GM crops would also make the farmer dependent on these company's chemicals, which is a trend in agricultural dominance that they consider to be unsustainable (World Health Organization, 2000).

## Federal Regulatory Organizations Overseeing Genetically Modified Organisms

In the United States there are three regulatory organizations that oversee the production, cultivation, and consumption of genetically modified organisms (Rowe, 2010). These federal organizations include the following: United States Department of Agriculture (USDA), Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA) (Konig et al., 2004). There are also international initiatives that regulate genetically modified organisms as well, which include the following: European Food Safety Authority (EFSA), World Health Organization, and the International Service for the Acquisition of Agri-biotech Applications (ISAAA) (Konig et al., 2004).

### United States Department of Agriculture

The USDA regulates the import, interstate movement, field trial release, and commercial release of GM crops under the Federal Plant Pest Act and the Plant Quarantine Act, which are administered by the Animal and Plant Health Inspection Service (APHIS) (Konig et al., 2004; McHughen & Smyth, 2007). Animal and Plant Health Inspection Service (APHIS) regulates certain genetically modified organisms

that may pose a risk to plant or animal health (Rowe, 2010). In addition, APHIS participates in programs that use biotechnology to identify and control plant and animal pests (APHIS, 2007, McHughen & Smyth, 2007). After field-testing, an applicant may petition APHIS for a determination of non-regulated status in order to facilitate commercialization of the product. If after review the crop is deemed safe, it is no longer considered regulated and can be moved and planted without APHIS authorization (Fernandez-Cornejo, Caswell, 2006).

**Food and Drug Administration**

The Food and Drug Administration has authority over human food and animal feed safety, which includes the genetic modification of plants and animals (McHughen, 2007). These regulations are covered under the Federal Food Drug and Cosmetic Act (Rowe, 2010). Foods that have similar composition relative to non-GMO versions of that food item do not trigger FDA review, even if they were produced using rDNA technology. This is the reason why some consider the FDA review to be voluntary, since most GM foods are compositionally identical to their regular counterparts (McHughen, 2007). The FDA has concluded that food and feed derived from GM crops pose no unique safety concerns and should be regulated no differently than comparable products derived from conventional methods or any other genetic modification approach (Konig et al., 2004).

**Environmental Protection Agency**

The Environment Protection Agency is the third agency under Federal regulations that controls the pesticide characteristics of GM foods. They focus

specifically on the threats to human health and the health of the environment. The Environmental Protection Agency reports that they do not regulate genetically engineered foods, but rather the pesticide properties associated with the engineered plant (McHughen & Smyth 2007, Konig et al., 2004, Environmental Protection Agency, 2003). If a plant is engineered to produce a substance that prevents, destroys, repels, or mitigates a pest it is considered a pesticide and is subject to regulation by the EPA (Fernandez-Cornej & Caswell, 2006). For example, the Roundup Ready ™ soybean cultivar is evaluated in combination with the accompanying glycophosphate pesticide. The EPA is also focused on the environmental integrity of the land concerning GMOs, and is quite sensitive to insects and microorganisms developing resistance to the used pesticides. Pests are known to develop resistance to pesticides and antibiotics based on exposure and integrity (McHughen & Smyth, 2007). The ecosystem holds quite a delicate balance and research is essential in order to preserve its veracity.

## Current Regulatory Practices

### United States

The US regulatory framework for GM crops was initiated in 1986 labeled as "The Coordinated Framework for Regulation of Biotechnology" (Konig et al., 2004, US OSTP, 1986). The current system in the United States is based on "voluntary labeling laws", which allows the companies to discern if they want their products to indicate presence or lack of genetically modified organisms. The companies must notify the U.S. Food and Drug Administration of their intent to market GM foods at

least 120 days before launch (Ahmed, 2002, Hardegger, 1999). A company in the United States that chooses to remain GMO-free is able to label their products accordingly.

One of the most important problems related to the lack of studies on the safety assessment of genetically modified plants, is the use of the "substantial equivalence concept". This notion is based on the principle: "if a need food is found to be substantially equivalent in composition and nutritional characteristics to an existing food, it can be regarded as being as safe as the conventional food (Domingo, 2011).

Non-profit organizations exist to help educate and provide a universal labeling system for companies who choose to do so such as the Non-GMO project and The Center for Food Safety. Foods in the United States with labels stating "USDA Organic" are certified free from containing any genetically modified organisms. Scientists have developed a variety of testing methods to determine if there are any products containing genetically modified organisms. Some of these include protein and DNA based methods employing western blots, enzyme-linked immunosorbant assay, lateral flow strips, southern blots, and dilution methods (Fernandez-Cornejo, Caswell, 2006).

**Global Regulation**

The European Union (E.U.) has the strictest regulations in the world for the presence of GMOs in the food and feed. They require labeling of GMO food and feed with a level for non-approved GMOs at zero percent, and any shipments containing

GMOs will be returned or destroyed. The E.U. has required labeling laws for all products containing genetically modified organisms (Davidson, 2010, European Commission, 2010). These strict regulations and labeling laws are provided to give consumers an informed right to choose – which is a huge difference from the United States.

European attitudes toward GM crops and food have been influenced by a variety of extraneous factors. These include a major food safety crisis (mad cow disease), the lack of confidence in food regulations, different cultural attitudes toward food and farms, widespread media coverage of the issue, and activism by politically influential environmental, consumer and anti-globalization groups (Pew initiative, 2002). The general European public shows strong opposition to the cultivation of GM crops. They view the technology as risky and not beneficial enough to implement. Due to this view on GE products, very few of these products are found on the European grocery shelves (Fernandez-Cornejo & Caswell, 2006).

An agreement called the "Cartagena Biosafety Protocol" puts into effect rules that govern the trade and transfer of GMOs across international borders. This can include shipments of GM food commodities. Also, this allows governments to prohibit the import of GM food when there is concern over its safety (Ahmed, 2002, Gupta, 2000). The current lack of harmonization of policies across countries also makes GM food labeling an international trade issue (Teisl, Garner, Row & Vayda, 2003).

**Academy of Nutrition and Dietetics Stance on Food Biotechnology**

Professional health organizations here in America have taken specific stances or positions on the topic of genetically modified organisms.

The Academy of Nutrition and Dietetics (AND) has released a position statement on agricultural and food biotechnology as follows:

> *It is the position of the Academy of Nutrition and Dietetics that agricultural and food biotechnology techniques can enhance the quality, safety, nutritional value, and variety of food available for human consumption and increase the efficiency of food production, food processing, food distribution, and environmental and waste management. The AND encourages the government, food manufacturers, food commodity groups, and qualified food and nutrition professionals to work together to inform consumers about this new technology and encourage availability of these products in the market place (Academy of Nutrition and Dietetics, 2006).*

The AND position statement on biotechnology was initiated in 1992, updated in 1995, and again in 1998. The American Medical Association has stated that they find no scientific justification for the general labeling of genetically modified foods. The American Heart Association, American Cancer Society, and National Institute of Health have not taken a public stance on the issue of biotechnology (Teisl et al., 2003).

## Controversy In Popular Culture

The complex issues surrounding the application of genetic engineering to food and agriculture have generated a contentious debate among diverse interest

groups (Roberts, Struble, Gomez & Wilkins, 2006) (Batista & Oliveira, 2009). With the vast amount of controversy surrounding the genetic modification of foods, polarization is occurring in activist groups, environmentalists, scientists and politicians. According to multiple polls including media outlets, websites, and phone polling, over 90% of American's want to have foods that contain genetically modified foods labeled (Center for Food Safety, 2011). However this is not being done because many large biotechnology corporations are fighting for the right to remain label-less in order to not "mislead or confuse" consumers on this topic.

## The Potential Benefits of Genetically Modified Organisms

With the world's population rising at a staggering rate, demand for food has never been more elevated. Agricultural biotechnology has enormous economic and humanitarian potential: "the great hope for genetically engineered crops is that they will feed the world" (Stein, 2005). Concerns are rising as to how this will be possible to meet the needs without causing large-scale environmental problems. Genetic Modification of foods has been gaining attention over the past two decades due to the potential benefits that accompany them. Farmers and companies alike can potentially benefit from GE crops. Most farmers who have switched to GE varieties of the crops did so mainly to increase yields though improved pest control. Other documented reasons for switching was to save management time, make other practices easier, and decrease pesticide input costs (Fernandez-Cornejo & Caswell, 2006). Consumers may also indirectly benefit from GM foods. Biotechnology developers and seed firms benefit by charging technology fees and seed premiums

to adopters of GE varieties. Consumers may end up paying lower prices on their vegetables that result from increased supplies (Fernandez-Cornejo & Caswell, 2006, Prince et al., 2003).

## The Potential Consequences of Genetically Modified Organisms

The complex issues surrounding the application of genetic engineering to food and agriculture have generated contentious debate among diverse interest groups in government, academia, industry, and the general pubic. The public holds varying perceptions of risks and benefits of genetic engineering, which causes a distinct divide in opinion (Roberts et al., 2006). The public may consider scientific reviews of genetic modification, but their assessment also includes broader social values such as ethics, morality, (Juanillo, 2001), and source credibility (Growth, 2003, Trettin & Musham 2000).

Many consumers frequently question the direct personal benefits of genetically modified foods. They more quickly accept biotechnology in medicine since it's directly beneficial to their health. Since there is no apparent direct consumer benefit (i.e. lower prices, better quality, higher nutrition), public attention has focused on the risk side of the risk-benefit equation (World Health Organization, 2000).

Prominent risks that the public doesn't know about or understand include the disruption or silencing of existing genes, activation of silent genes, and formation of new or altered patterns of metabolites. Another fear is the creation of new allergies or harmful toxins that the body is ill prepared to handle, causing

sickness and death among vulnerable populations. Some also see that a rise in antibiotic resistance in humans could occur as a result of gene splicing. Ecologically there is a possibility of cross-pollination with wild relatives and competition with other species (Legge, 2010).

Outcrossing is the movement of genes from GM plants into conventional crops or related species in the wild, as well as mixing with crops derived from conventional seeds with those grown using GM crops, and the public doesn't know that it may have an indirect effect on food safety and food security (World Health Organization, 2000; Stein, 2005).

Gene transfer from GM foods to cells of the body or to bacteria in the gastrointestinal tract would cause concern if the genetic material adversely affects human health (World Health Organization, 2000). This could relate to antibiotic resistant genes, which condition human's to be less sensitive to current antibiotic treatments (Stein, 2005).

GM foods can also contaminate the food supply, causing a variety of complications. In 2000, Starlink™ corn was a GM variety of corn containing an insecticidal protein derived from the bacterium Bacillus Thuringiensis (Bt). The Environmental Protection Agency approved this variety of yellow corn in 1998, but only for use as animal feed. The EPA also set the a zero-tolerance level for its use in human food based on the fact that our digestive tracts have a difficult time breaking down this variety of Bt. Another worry was this variety of Bt was also allergenic to a percentage of the human population. In September 2000, Starlink™ corn was

detected in taco shells (Segarra, 2000). This caused some to question the split regulation the FDA and EPA granted for use in animal feed and not human consumption, since contamination is so prevalent. Several unknowns regarding genetically modified foods, no scientific confirmation that these foods are safe, which is why many countries and are adamantly opposed to the marketing of GMO's (Stein, 2005).

## Public Health Concerns

Genetically modified foods have not been properly tested for human safety. The only study that has been published to directly study the effects GM foods have on humans has not been fully finished (Reese W., 2004). Usually the response to safety concerns regarding public health is that people have been consuming these genetically modified products for ten plus years with no adverse effects. However, since genetically modified foods are not labeled, it is nearly impossible to track any disease or environmental factor that may be affected by them (Pusztai A., 2006). In order for an adverse effect of a GM food to be recognized, it would have to happen directly after consumption. We don't know the long-term effects of consuming these products, nor are we able to single out the effects GM foods directly have on the body without studies to prove their safety, or lack thereof.

### Animal Studies

Although studies on humans have not been completed; there have been some studies that have examined the effects of GM foods on laboratory animals. In one study, rats fed GM tomatoes developed stomach ulcerations (Malatesta M., 2003).

Another study showed a correlation of GM consumption in lab mice and disruption of their livers, pancreases, and testes (Malatesta M., 2002). GM potatoes fed to rats caused excessive growth of the lining of the gut similar to pre-cancerous conditions (Pusztai A., 2006). These are also studies that show organ disturbances in lab animals fed foods that have been genetically modified, and these studies are increasingly on the rise.

## Possible Allergenic Effects of Genetically Modified Foods

Another issue that needs to be addressed in GM food safety is that potential allergens or toxins may be unintentionally introduced due to plant metabolism and up regulation of genes (Batista et al., 2009). By transferring specific proteins cross-species, it has been suggested that consumption of GM foods could lead to increase in toxicity and allergies in the human population (Halford, Shewry, 2000). Assessing potential allergens is especially important for dietitians to comprehend due to the potential for fatal allergic responses patients may encounter when consuming these products (Rowe, 2010).

Allergies to nuts are among the most common food allergies (Ademola, 2011). Concern has been expressed about the introduction of allergenic proteins into food plants by genetic engineering (Goodman & Tetteh, 2011, Schumacher et al., 2011). The soybean is an almost complete protein with the exception of the protein methionine. Genetic engineers have extracted the 2s albumin protein from a Brazil nut and have inserted the DNA into the soybeans, as well as tobacco plants, oilrape seed, and legumes (Nordlee, et al., 1996). A study was completed to determine the

potential adverse effects of the soybeans containing the brazil nut protein. Researchers used a skin prick test to determine the allergenic effects on those who were already allergic to brazil nuts. Results concluded that these individuals had adverse effects to the transgenic soybean, however they could not ethically assess the effects of the potential allergen, as to do so could cause severe harm to the participants. In conclusion, the research findings support the idea that it is prudent to assess the allergenicity of proteins in transgenic foods if those proteins have been derived from sources that are commonly allergenic (Nordlee et al., 1996).

**The Impact on Insects in the Environment**

Insects that feed on cotton, corn, and other crops may eventually develop resistance to the naturally occurring insect toxin *Bacillus Thuringiensis* (Bt). Some scientists worry that such resistance will speed up the evolution of pests resistant to Bt. Once resistance develops, the use of this natural insecticide will be lost to famers (including many organic farmers), who use this to control pests (Kaiser, 1996). There have been other research findings that suggest pollen dispersed from Bt corn may cause damage to non-target organisms such as the monarch butterfly (Losey, Rayor & Carter, 1999, Birch et al., 1999, Halford & Shewry, 2000).

**WikiLeaks – U.S. Targets E.U. Over Genetically Modified Crops**

A recent Wikileaks article was released stating "the US embassy in Paris advices Washington to start a military-style trade war against any European Union country which opposed genetically modified (GM) crops". This was in response to a move by France to ban a Monsanto GM corn variety in late 2007. The U.S.

ambassador, Craig Stapleton, asked Washington to penalize the European Union and in particular countries that did not support the use of GM crops. WikiLeaks also indicated that the U.S. State Department's special advisor on biotechnology lobbied at the Vatican to overturn the negative stance the Pope held on genetic engineering (Adams, 2010). Political presence, as powerful as these examples, further complicates and obscures this debate. The debate surrounding GMOs is not contained to the U.S. and the E.U. Countries around the world have policies and regulations that restrict the use and import of seeds and GMOs.

## Recent Changes in Public Policy

### Hungary

In the last few years, Hungary has made an effort to rid the country of genetically modified organisms, and in March 2011, the country took another step towards that goal. A new regulation stipulates that all imported seeds must be checked for genetic modification prior to being introduced to the market. When fields were found to contain genetically modified organisms, Hungary destroyed the crops, which included over 1000 acres of their own maize (Save, 2011).

### Peru

Peru's Congress announced November 2011, that it overwhelmingly supported a 10 year ban on imports of genetically modified organisms trying to safeguard the country's biodiversity. The ban bars GM seeds, livestock, and fish from being imported or raised locally. The head of Peru's Consumer Agency, Jaime

Delagdo states that ten years should be a long enough period to adequately test the effects GMO's have on people and the environment (Agence, 2011).

**India**

With ongoing public debate surrounding the field of biotechnology in India, stakes have been raised higher in 2011. The National Biodiversity Authority of India (NBA) has decided to sue Monsanto, the St. Louis, MO-based biotechnology powerhouse, and the company's Indian partners who developed the Bt eggplant (Pentland, 2011). The lawsuit sprouted after the United States biotech company Monsanto developed a patented gene in an eggplant species indigenous to India without prior approval. Indian politicians are stating that one cannot take an indigenous species, change the DNA, patent it, and sell it back to the country at an elevated cost. While the lawsuit remains active, this is the first record of biopiracy the agricultural biotechnology industry has experienced thus far (Infowars.com, 2011).

**Mendocino County, California**

The county of Mendocino, California became the first county in America to support a ban on growing genetically modified organisms. "Measure H" as the legislation was called, was supported by a majority of 57% of the town's people. While this ban prohibits GMO's from growing in the county, consumers can still buy them at the supermarket in commonly eaten foods from across the nation. Measure H was also designed not to have any impact on medicine, or the sale of medicine. The intent of the majority vote was to protect the pristine reputation of the

wineries, fisheries, agriculture, and local environment. It was the local farmers and community members who supported maintaining the integrity of the county, by placing the law on the ballet (Meadows, 2004).

## Public Perception on the Topic of Genetic Modification

Because Genetic Engineering is a fairly new science that is quite controversial, and consumers should be able to exercise informed choice by having clearly labeled products (Halford, 2000). In most studies completed, consumers around the world report being willing to pay more for non-GE foods or to avoid foods containing GE ingredients (Lusk, 2003, Li et al., 2001). For instance, in a Pew Initiative, 27 percent of American's favor the introduction of GE foods while 47 percent oppose this introduction (Fernandez-Cornejo, Caswell, 2006).

## The Labeling of Genetically Modified Foods in the United States

Two "Right to Know" bills – HR3377 and S2080 – have been introduced in congress that would require the labeling of any product containing genetically modified ingredients. In addition to the federal level, legislation in at least seven states have debated labeling and marketing requirements for GM foods at the state level (Teisl et al., 2003, Pollack, 2001). If these labeling laws took effect, the proposed label that would be put on the package is a double helix stating the following: "this product contains genetically engineered material, or was produced with genetically engineered material". Though there is some Congressional support, there has also been heavy opposition from industry lobbying groups including the Grocery Manufacturers of America and the National Food Processors Association.

The belief of these lobbying groups is that the labeling will confuse consumers (Holm, Kildevang, 2006, Teisl, 2003).

**Call for Dietitians to Educate and Evaluate Risks of GMO's**

Dietitians play a critical role in increasing public awareness and understanding of genetic engineering. With the rise of media attention on the topic, people are searching for sound scientific based answers to their questions. When the FDA finalizes its proposed guidelines for voluntary labeling of genetically engineered foods, an educational opportunity for dietitians familiar with the science and its regulations will emerge. (Brown, 2003, Frewer, Howard & Shepard, 1996)

Knowledge and attitudes of dietitians relative to genetically engineered foods could have an effect on information provided to clients or affect the food purchasing decisions of the institutions in which dietitians work (Wie, 2003). Consumers perceive dietetics professionals as reliable providers of food and nutrition information and services and as a trusted source of information about agricultural and food biotechnology (Academy of Nutrition and Dietetics 2006, Pew Initiative on Food and Biotechnology, 2004, Santerre & Machtmes, 2002, Roberts et al., 2006). Consumer education is critical to developing awareness and knowledge about biotechnology, and dietitians should use skills in nutrition education to develop and deliver programs in this area (American Dietetics Association, 2006, Roberts et al., 2006).

# CHAPTER III

# METHODOLOGY

## Purpose

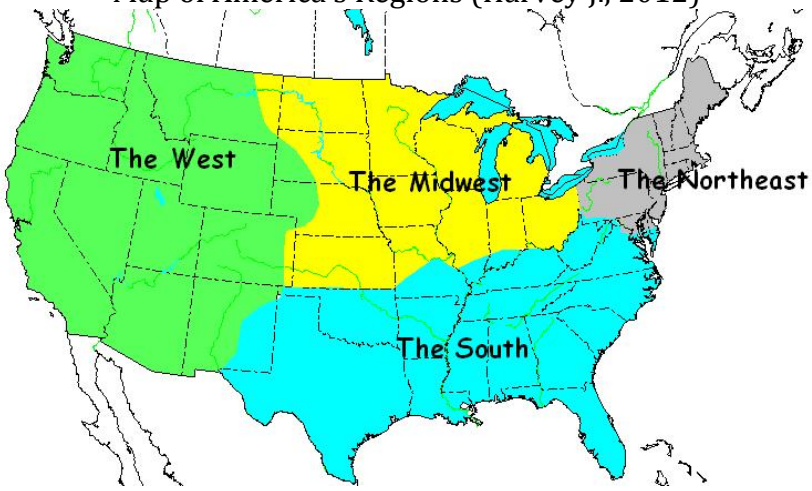
The purpose of this study was to determine the previous knowledge that Registered Dietitians hold on the technology of genetically modified organisms. A secondary purpose of this study was to determine if knowledge of genetically modified organisms influenced perception. Knowledge and perception were assessed through a series of multiple choice and likert scale questions. The primary hypothesis of this study was that dietitians do not hold a high knowledge base on the topic of genetically modified organisms. A secondary hypothesis of this study was that dietitians with more knowledge on the topic of genetically modified organisms would hold a different perception than those with less knowledge. According to a survey completed by the American Dietetic Association, the public trusts dietitians to deliver sound and scientific based answers to the topic of GMO's and the current study was designed to investigate the potential educational gap and controversy that surrounds this topic.

## Subject Selection

The participants in this study included subjects from varying states in different geographical regions of the United States. The states included in this survey were Arizona, Georgia, Kansas, South Carolina, South Dakota, Ohio,

Pennsylvania, and Vermont. These states were chosen to represent a portion of each geographical region of America.

Map of America's Regions (Harvey J., 2012)




Each state has a dietetic practice groups known as "Eat Right", and each state's group was initially asked to participate to ask for their participation in this study. 30 "Eat Right" dietetic practice groups were contacted for possible administration of the survey, and eight replied with interest in participating. Surveys were electronically released within the same week to every dietitian who is on the list-serv of their respective state's dietetic practice group. The dietitians were able to click a link to participate in the survey. This action was completely voluntary. The survey contained both knowledge and perception questions pertaining to genetically modified organisms, and took about 15 minutes to complete. The participants were able to discontinue the survey at any point without any consequences. This study received IRB approval from Kent State University's Internal Review Board in May of 2012.

## Survey Design: Knowledge

This survey assessed the participant's knowledge on genetically modified organisms through a series of 18 questions. These questions were multiple-choice in design, with only one citable correct answer. The knowledge questions were ordered in a specific manner to avoid giving the subjects any context clues to aid in answers for the questions to follow. The most basic definition-based questions were asked first, finishing with the more complex science-based questions. The answers used a face and content validity to ensure accuracy. Any survey which received a 70% or above, was classified as "knowledgeable" while any survey under 70% was classified as "not knowledgeable" about the topic of genetically modified organisms.

## Survey Design: Perception

Knowledge and perception questions were intermixed within the survey. The perception section of the survey was completed using a five point Lickert scale, ranging from strongly agree, agree, neutral, disagree, and strongly disagree. The participant also had the option to choose "I don't know" to any question – which will be counted as "not knowledgeable".

The perception questions on the survey were strategically assorted in order to not to provide any information via question content. This allowed for the answers to be more accurate and not be influenced by any other question that may alter subject perception. Once a survey question was answered, the subject was not allowed to return to it, which helped to reduce fraudulent answers.

## Procedure

Surveys were distributed through an emailed link sent out by the practice group of each participating state, and the survey was completed through the online survey website known as "Survey Monkey". Only surveys completed by Registered Dietitians were included in this study. The knowledge questions were used to determine the familiarity of the participant on the topic of genetically modified organisms. Taking into account the subject's overall perception of the issue while comparing it to the assessed knowledge levels provided an opportunity to use parametric statistics. The subject's knowledge level was assessed, it was then compared with their perception scores to investigate any potential relationship significance.

The geographical region was also compared to the knowledge and perception levels to determine if location had any influence over these factors. The overall goal was to find any correlations of the dietitian's perception versus overall knowledge of genetically modified organisms.

## Analysis

The survey used to measure data was sent out to each state's practice group respectively, began with demographic questions in order to correctly categorize the participants. The demographics included year born, sex, educational background, and field of dietetics. Choosing participants from varying areas of the United States ensured fairness in assessment of the participating dietitian's knowledge base. The survey took into account regional viewpoints that may vary from state to state due

to their agricultural, ethical, and moral viewpoints. The results were then entered into SPSS 14.0 for analysis. This study utilized a univariate ANOVA based on the dietitian's knowledge versus perception to analyze the data for significance.

# CHAPTER IV

## RESULTS

A total of 358 online surveys were completed during the three-week time window. The survey presented 53 questions assessing the dietitian's knowledge (N=18) and perception (N=21) of GMOs. Demographic data was also collected, such as gender, age, occupation, and years of practice. Upon completing the survey, participants were able to leave comments and remarks about the topic and the study. Surveys that were less than 75% completed, were not counted and discarded from the results (N=46). If 75% of the survey was completed, then all of the knowledge questions were completed – seeing as the last 25% of the survey consisted of perception and demographic questions. This ensured that the knowledge assessment of the dietitians was not effected by the incompleteness of the survey. Of the total amount of surveys received, N=284 met the criteria for inclusion. Before entering the survey, the participants were asked to confirm if they were a registered dietitian, and if the answer was "no", they were unable to participate in the survey. Those initially disqualified did not count towards the total number of surveys received.

The participant's sex was not a required selection, and therefore was left blank by some respondents (N=11). Demographics of the participants were asked following at the end of the survey; including year of birth, field of occupation, sex, and geographic region (Table 2).

Table 2

*Demographics*

| **Category** | **N** | **%** |
|---|---|---|
| *Sex* | | |
| Male | 8 | 2.9 |
| Female | 265 | 97.1 |
| | | |
| *Occupation** | | |
| Clinical | 147 | 44.3 |
| Community | 81 | 24.4 |
| Business | 20 | 6.0 |
| Policy | 7 | 2.1 |
| Educator | 44 | 13.3 |
| Other | 33 | 9.9 |
| | | |
| *Region* | | |
| West | 75 | 26.4 |
| Midwest | 59 | 20.8 |
| Northeast | 77 | 27.1 |
| South | 73 | 25.7 |

* Respondents can choose more than one occupation

The majority of dietitians who participated in the survey were "clinical dietitians", followed by "community dietitians", then "educational dietitians". The rest were categorized in "business", "policy", or the "other" category. The average age or participants was 43.4± 12.9. The diverse geographic regions of dietitians were also taken into account, and categorized into West, Midwest, Northeast, and the South.

## Dietitian's Knowledge of Genetically Modified Organisms

Table 3

*Dietitian's Knowledge of Genetically Modified Organisms*
*N= 284*

| Knowledge Question | Number Responded Correctly | Correct (%) |
|---|---|---|
| The Term Genetic Modification means: | 183 | 63.9 |
| The word transgenic in relation to food is equivalent to | 153 | 53.5 |
| Most transgenic foods are grown in: | 154 | 53.8 |
| Genetically altered foods are currently only produced: | 224 | 78.3 |
| Food manufacturers in the USA that use genetically modified ingredients | 148 | 51.7 |
| As a result of a genetically modified organisms, pesticide use has | 79 | 27.6 |
| While using gene technology, scientists: | 12 | 4.2 |
| After a genetically modified organism has been released in the public food supply for consumption, it is retested for safety: | 62 | 21.6 |
| Genetically Modified Foods: | 152 | 53.1 |
| What percent of Soybeans in America have been genetically modified? | 98 | 34.2 |
| How many genetically engineered crops have been approved for use by the FDA? | 51 | 17.8 |
| What is BT corn? | 132 | 46.1 |
| When were GMO's first available for public use? | 95 | 33.2 |
| Will insects develop resistance to the toxins produced in Bt corn? | 59 | 20.6 |
| How much of our supermarket food contains genetically modified ingredients? | 55 | 19.2 |
| Who is responsible for the mandatory testing of genetically modified foods once released into the market? | 65 | 22.7 |
| Studies have been implemented to test the impact of Genetically Modified Organisms on? | 54 | 18.8 |

GMO = Genetically Modified Organisms
BT Corn = Bacillus Thuringiensis Corn

Table 3 examines each knowledge question independently, and displays the total number and percentage of responding correctly. Summaries of knowledge questions are listed in Table 4 by geographical region. The maximum number possible of correct knowledge questions for each respondent is 18. Those who scored above 70% were considered to be "knowledgeable" on the topic" (N=63).

The results indicate the staggeringly low number of dietitians that are familiar with genetically modified organisms (n=22%). Geographically the knowledge questions had no significance in variation when compared by region as evidence by (P > .05). The majority of dietitians across the country who participated in this survey, regardless of location, received a failing grade (n=78%).

Table 4

*Depth of Knowledge Responses (X ± 3.8) by Geographic Region*
*N=284*

| Region | N | Mean | Std. Deviation | Significance |
|---|---|---|---|---|
| West | 75 | 9.8 | 3.1 | P > .05 |
| Midwest | 59 | 9.2 | 3.1 | |
| Northeast | 77 | 10.0 | 3.1 | |
| South | 73 | 10.0 | 3.1 | |
| Total | 284 | 9.8 | 3.1 | |

## Dietitian's Perception on Genetically Modified Organisms

The total number of perception-related questions (n = 21) are found in Table 5. Perception questions were intentionally varied in stance to avoid respondent bias. The perception questions were organized once the results were received to ensure all answers complied to either a supportive stance or an unsupportive stance

on the issue. No relationship (P = .44) was found between the geographical region of the respondent and their overall perception on genetically modified organisms (Table 5). The available responses to the perception based questions were as follows: Strongly Agree = 1, Agree = 2, Neutral =3, Disagree = 4, Strongly Disagree = 5. A respondent with an overall more supportive stance would have a lower perception score number than a respondent who disagrees with this issue.

Table 5

*Registered Dietitian's Perception of Genetically Modified Organisms*

| **Questions** | **1 Strongly Agree (%)** | **2 Agree (%)** | **3 Neutral (%)** | **4 Disagree (%)** | **5 Strongly Disagree (%)** | **6 I Don't Know (%)** |
|---|---|---|---|---|---|---|
| GM foods are completely safe to eat. | 7.7 | 21.7 | 30.1 | 24.8 | 5.2 | 9.8 |
| I would buy and/or eat foods that have been genetically modified. | 12.6 | 30.4 | 27.3 | 16.8 | 6.3 | 5.9 |
| The benefits for those who consume genetically modified foods outweigh the risks. | 7.7 | 17.5 | 29.7 | 23.8 | 7.3 | 13.3 |
| Scientists cannot predict future outcomes of genetically modified foods | 23.8 | 36.7 | 18.9 | 10.5 | 1.7 | 7.7 |
| I would prefer to have genetically modified foods labeled for customer convenience | 53.1 | 30.1 | 8.0 | 2.8 | 2.1 | 3.1 |
| Genetically modified organisms will forever change our natural environment. | 27.6 | 38.5 | 15.4 | 4.9 | 1.4 | 11.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Humans using genetically modified organisms better manage the ecosystem of organisms. | 2.8 | 12.2 | 25.5 | 29.7 | 8.4 | 20.6 |
| Genetically modified organisms may have the potential to disrupt our current ecosystem. | 23.1 | 46.2 | 12.6 | 4.9 | 1.4 | 11.2 |
| I am worried about unknown effects of genetically modified foods. | 31.1 | 38.5 | 16.4 | 8.4 | 2.4 | 2.4 |
| The genetic modification of plants is the equivalent of crossbreeding plants | 5.6 | 25.5 | 12.9 | 30.8 | 10.8 | 13.6 |
| The potential environmental benefits of genetically engineered crop improvements, such as reduced need for fertilizers, irrigation, and pesticides, far outweigh any possible risks. | 2.8 | 16.4 | 25.9 | 28.7 | 10.8 | 14.7 |
| I'm worried that the increased use of genetically engineered crops in agriculture will lead to loss of biodiversity in our food and agriculture systems. | 21.3 | 36.0 | 22.4 | 8.0 | 3.1 | 8.4 |
| I am willing to pay more for food that is healthier. | 31.1 | 50.7 | 11.2 | 2.1 | 0.3 | 3.8 |
| With a growing population, the genetic modification of foods is necessary to keep up with the increasing demand for food | 6.3 | 21.7 | 26.2 | 25.2 | 9.4 | 10.5 |
| Genetically modified foods in the United States are not widely used. | 0.3 | 5.9 | 8.0 | 47.6 | 23.8 | 13.6 |
| Genetically Modified foods are still quite experimental. | 6.6 | 23.1 | 14.0 | 34.6 | 10.1 | 10.8 |
| I feel that the regulatory government agencies would not allow the release of genetically modified organisms unless they were tested adequately and considered to be safe. | 7.0 | 23.8 | 16.4 | 27.3 | 18.2 | 6.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| I believe consumers have the right to know what they are feeding themselves and their families - therefore genetically modified organisms should be labeled. | 55.2 | 32.9 | 4.5 | 1.0 | 1.4 | 4.2 |
| I trust USDA, FDA, and/or EPA will continually test genetically modified foods to determine the safety of their long-term effects. | 5.9 | 24.5 | 18.2 | 25.5 | 16.8 | 8.4 |
| I feel consumers with certain religious, ethical, or philosophical beliefs have the right to know which foods contain genetically modified ingredients. | 47.9 | 39.9 | 6.3 | 1.0% | 0.7 | 3.5 |
| I believe that if a company patents a “genetically modified” seed, they should be given intellectual property rights to this living organism. | 5.9 | 16.4 | 22.7 | 21.0 | 13.6 | 19.6 |
| As a professional, I feel dietitians should be well versed in the current research regarding genetically modified foods. | 32.5 | 53.5 | 8.0 | 1.4 | 0.3 | 3.5 |
| It is the role of professional organizations such as The Academy of Nutrition and Dietetics to take a UNBIASED position on genetically modified foods. | 29.7 | 34.6 | 9.8 | 11.5 | 5.9 | 7.7 |
| It is the role of The Academy of Nutrition and Dietetics to be involved in food biotechnology. | 26.2 | 46.2 | 12.9 | 7.3 | 1.4 | 5.2 |
| The Academy of Nutrition and Dietetics should facilitate in open dialogue about the use of genetically modified organisms. | 33.9 | 55.2 | 4.5 | 0.3 | 1.0 | 4.2 |
| I feel adequately informed on the topic of genetically modified organisms. | 3.5 | 9.4 | 10.8 | 47.9 | 24.5 | 3.1 |

Table 6

*Means and Standard Deviations (X ± 3.1) of Perception Scores*

| Region | N | Mean | Std. Deviation | Significance |
|---|---|---|---|---|
| West | 75 | 71.2 | 17.9 | P > .406 |
| Midwest | 59 | 70.0 | 13.8 | |
| Northeast | 77 | 73.3 | 16.5 | |
| South | 73 | 68.9 | 16.9 | |
| Total | 284 | 70.9 | 16.5 | |

Those who scored higher on the knowledge portion of the survey (n=63) had a mean perception score of 79.3 ± .98. Those who scored lower on the knowledge portion of the survey (n=221) had a mean perception score of 68.5 +/- 3.1 (Table 6). Therefore dietitians who scored higher on the knowledge portion had a significantly stronger opposition towards the genetic modification of organisms ($p \leq .001$), which is listed in Table 7.

Table 7

*Sum of Perception Related (X ± 16.5) to High Versus Low Knowledge Levels*

| Knowledge Level | N | Mean | Std. Deviation | Significance |
|---|---|---|---|---|
| Low | 221 | 68.5 | 16.3 | P ≤ .001 |
| High | 63 | 79.3 | 14.4 | |
| Total | 284 | 70.9 | 16.5 | |

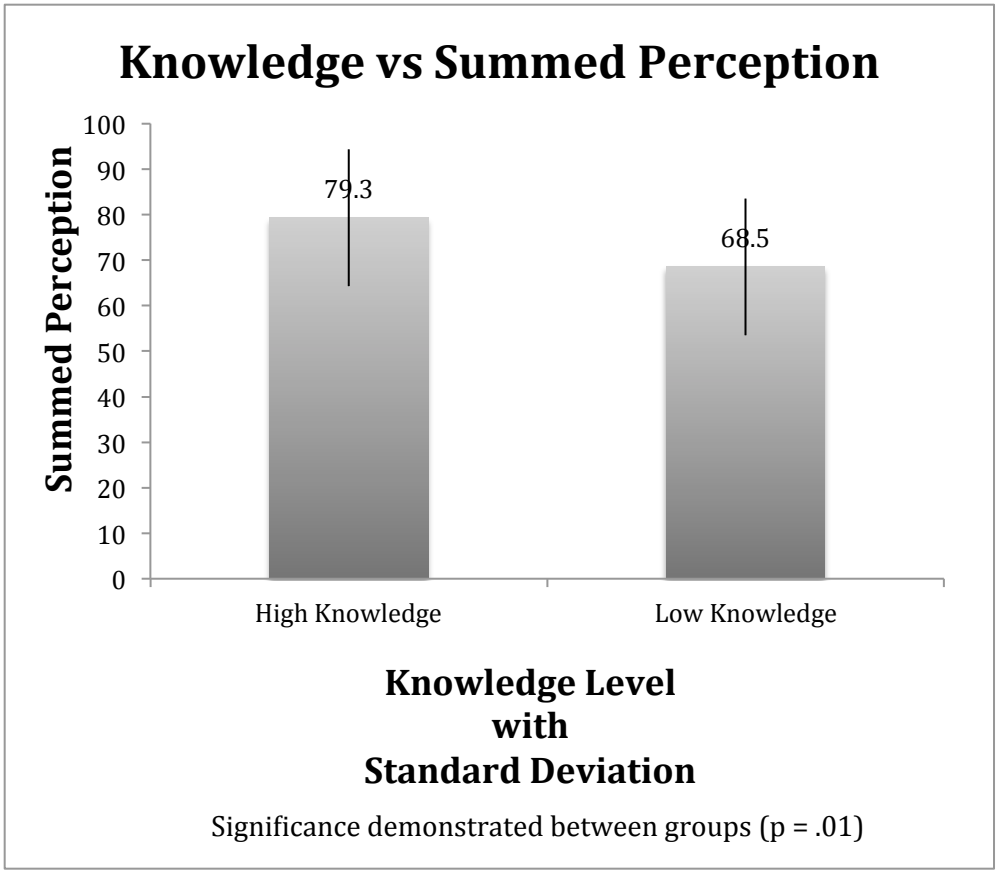



*Figure* 1

Summed Perception Related to Knowledge of Genetically Modified Organisms

# CHAPTER V

# DISCUSSION

To date, there has been little research conducted in relation to Registered Dietitians knowledge and perception of genetically modified organisms. Most research completed in this area is related to the public's viewpoints or perception of this topic. Therefore, the purpose of this study was to determine the knowledge of registered dietitians nationwide on the topic of genetically modified organisms. A secondary purpose of this study was to determine if knowledge affects the perception that dietitian's hold on genetically modified organisms.

As hypothesized, the results of this study indicate a knowledge deficit in Registered Dietitians on the topic of GMOs, showing that the first hypothesis of this study as true. Also those dietitians who were considered more knowledgeable on the topic of GMOs had a significantly more apprehensive perception than those with less knowledge. Therefore, the second hypothesis of knowledge affecting dietitian's perception of GMOs was also accepted.

## Dietitian's Knowledge of Genetically Modified Organisms

The survey was made up of eighteen knowledge questions on genetically modified organisms. After data analysis in the current investigation, those who scored above 70% were considered to be "knowledgeable" on the topic. Of the 284 respondents, only 22% of the dietitian respondents (n=63) were considered knowledgeable when compared to these standards. This investigation demonstrated

that dietitians do not have considerable knowledge on the topic of genetically modified organisms. This indication of low knowledge about GMOs held by the vast majority of surveyed dietitians (n=221), shows the need for a further implementation of continuing education. A hypothesized reason for this lack understanding is related to inadequate education during undergraduate and graduate training as well as the lack of continuing education resources. When consulting the Academy of Nutrition and Dietetics' Evidence Analysis Library for current research, there is no mention of the genetic modification of agriculture (Academy of Nutrition & Dietetics, 2012). The lack of awareness and knowledge presented on the Academy's website could stifle dietitians from further educating themselves on such a prominent and important topic. A study conducted in 2006 evaluated Dietetic professional's viewpoints on GMOs concluded with the outcome that dietitians hold divergent viewpoints related to areas surrounding the current discourse of genetically engineered foods and crops (Roberts et al., 2006). Therefore it is important for dietitians who are interested in this area, look outside of the Academy's resources.

It was hypothesized that some dietitians were vaguely knowledgeable about GMOs, which explains the higher frequency of correct answers pertaining to the basics of this technology. The knowledge based questions that were most often

answered correctly related directly to basic definitions of GMOs. Dietitians were most likely able to recall the definition for the term genetic modification

(64%). They were also quite accurate when asked which major crops were currently being genetically modified on a widespread basis (78.3%). With regards to where the GMO crops were grown, dietitians were most likely to answer "in America" (53.8%).

The more intricately and deeply the question delved into the technology behind the genetically modified organisms, the less likely the dietitians were able to answer correctly. When asked about the total number of genetically modified crops currently available on the consumer market, most respondents were likely to answer incorrectly (83.2%). When asked which percentage of certain crops, such as soybeans, were genetically altered, only a small portion of dietitians were able to answer correctly (34.3%). Alarmingly however, the question that relates to the percentage of supermarket foods that currently contain genetically modified ingredients was overwhelmingly answered incorrectly (81.8%). If over eighty percent of dietitians do not realize that a large majority of our supermarket foods contain GMOs, then it is impossible to correctly educate clients or advocate on food safety practices related to this technology.

The amount of knowledge held by dietitians was not influenced by their geographical location within the United States. This relation is hypothesized to be attributed to the overall low familiarity with genetically modified organisms. Previous studies have demonstrated that the general consumer awareness of GMOs in their foods is fairly low (48%), which reveals the lack of in-depth knowledge on a nationwide level (Pew Initiative on Food and Biotechnology, 2006).

**Dietitian's Perception of Genetically Modified Organisms**

The perceptions captured by the variety of Registered Dietitian's who participated in this study were widely varied, however the majority of the respondents had a tendency to lean more towards being cautious of this biotechnology. When asked, dietitians were more likely to remain neutral or disagree on the safety of genetically modified foods (60.1%). When asked if they thought the benefits of GMOs were more likely to outweigh the risks, most dietitians were hesitant to accept this (60.8%). They also believed that scientists were unable to accurately predict the future outcomes of GMOs (62.3%). Also found was that the majority of dietitians (69.6%) were worried about the unknown effects of genetically modified organisms.

It is curious that Registered Dietitians are not very knowledgeable on this topic, but are still overall quite worried about genetically modified organisms. Previous research states that when a short informational session on the potential benefits and risks of GMOs is given to the public, the more accepting they are of this technology (Costa-Font, M., Gil, 2008). However, according to the results of this study the opposite is true. The more a dietitian is familiar with the topic the more they are to opposed to this technology. It is hypothesized this is related to the extensive understanding dietitian's hold in the human sciences, gained from their undergraduate studies. The general public is generally not as fluent in science as a health professional, such as a dietitian. Similarly, GMOs may become an issue to consumers when they are convinced that this technology provides no additional

value to them or to the general public, and may only have advantages for producers and the industry (Siegrist, 2008).

Many perception questions found that, the majority of dietitians were more likely to be apprehensive about the biotechnology used to create genetically modified organisms. The final perception question asked the dietitians if they felt "adequately informed on the topic of genetically modified organisms". The vast majority stated they either disagreed (47.9%) or strongly disagreed (24.5%) on their comfort of GMOs.

In previous studies completed on the perception of GMOs, the majority of participants both supporting and discerning the technology, agreed that it is the right of consumers to know what they are eating. The same results were discovered in this survey, with 88.1% of dietitian's either strongly agreeing or agreeing with the consumer's right to know what they are purchasing through mandatory GMO labeling laws (Roberts, 2006).

## Dietitian's Perceptions of GMOs Related to their Knowledge

The study proved that dietitians have varying degrees of responses and opinions on this controversial issue, however their perception was directly related to their amount of comprehension and knowledge. Findings in the administered survey indicate, with a significance of ($P = < .001$), that GMO knowledge directly affects the perception held by dietitians. The higher the dietitian scored on the knowledge portion of the survey the more precautionary they were towards the

controversial topic of genetically modified organisms. Conversely, the lower the dietitian scored on the knowledge portion of the survey the more tolerant they were concerning genetically modified organisms. This shows that when dietitians fully comprehend the intricacies and potential dangers of this technology, that they are less likely to support it. It is postulated that this technology is not regarded as dangerous by those dietitians who know less about GMOs because of their lack of comprehension relates to its complexity.

These findings are significant because as indicated previously, public consumers trust dietitians on the topic of genetically modified organisms. Yet, as indicated by the survey results, many dietitians are not completely familiar with this topic. The majority (72.4%) of dietitians who took this survey did not feel adequately informed on the topic of genetically modified organisms.

## Limitations

The first limitation to this study would be that only seven states participated in the survey. This could give some geographical regions an incorrect summarization of their knowledge and perception. A second limitation would is bias in participation from Registered Dietitians who may have an interest or previous knowledge base on this topic. Since this survey was voluntary and the participants were aware of the topic prior to deciding to engage in participation, that may have affected their decision to take it. A third limitation to this study

relates to the overall strength of it. While it has face and content validity, further investigations need to address the vigor of the survey due to the survey being self developed and administered. Some questions were used with the permission of the author, from previous surveys on the genetic modification related to consumer's perception (Roberts, 2006).

A final limitation to this study is that it was only administered to those who are registered and active members of their state's dietetic association. Since there is a yearly fee associated with this membership, not all Registered Dietitians are active members of their state's organization. This study used a convenience sample, and those who chose to take the survey were more likely to be interested in the topic of genetically modified foods. This did not allow for a completely random sample from each chosen state.

## Application for Dietitians and Health Care Professionals

GMOs are gaining recent media attention in California, related to the proposition 37 or "Right to Know" Act, which would require mandatory labeling of GMO products. This has spurred much public attention related to GMOs, and focus has been brought to the Academy's 2006 position paper, which generally supported this technology. The most recent release from the Academy states:

> "The Academy does not have a position on issues pertaining to labeling of genetically modified organisms (GMOs) or genetically engineered (GE) foods.

> The inaccurate information has led to confusion and an inaccurate portrayal of in the media and community of the Academy and its state affiliate, the California Dietetic Association" (MacMunn, 2012)

This shows that the Academy has since changed their stance since their first release of a position paper in 2006. As an evidence-based organization, the Academy extensively analyzes relevant scientific studies before taking a position on any issue and systematically reviews and updates its positions as needed. A new position paper that will address GMO and GE foods is expected to be published in 2013.The complex issues surrounding the application of genetic engineering to food and agriculture have generated a contentious debate among diverse interest groups (Roberts, Struble, Gomez, Wilkins, 2006) (Batista, Oliveira, 2009). This study has proven that Registered Dietitian's in varying geographical regions of the United States are not knowledgeable on the topic of Genetically Modified Organisms. However those dietitians who hold more knowledge are more likely to have a negative perception of the issue.

There has not been a wide variety of scientific research done regarding the long-term safety of GMOs and their effects towards human consumption and environmental wellness. The public may consider scientific reviews of genetic modification, but their assessment includes broader social values such as ethics and morality (Juanillo, 2001) as well as source credibility (Groth, 2003, Trettin, Musham 2000).

The respondents were asked after finishing the survey, if they felt adequately

informed on the topic of GMOs, and the vast majority (72.4%) of dietitian's said they disagree or strongly disagree. This overwhelming uncertainty is shown in the data collected in the knowledge portion of the survey. Participation in an open dialogue on genetically engineered foods and crops that encourages critical thinking and respects differing viewpoints, can foster a more cooperative working relationship between groups (Roberts, 2006). Derived from the survey results, 89.2% of the dietitians who took the survey do believe that the Academy of Nutrition and Dietetics should participate in open dialogue about the use of genetically modified organisms, and 72.4% believe it is the role of the Academy to be directly involved in food biotechnology.

Of those participating in the survey, an overwhelming 86% of Registered Dietitians believe that we need to be well versed in the current research regarding GMOs. As nutrition professionals, we need to be ready with research-based information when questions and concerns arise. Dietitians can play a critical role in increasing public understanding of genetic modification. With the rise of the media attention, people will be searching for sound scientific based answers to their questions. Dietetics professionals need to be conscious that consumers will come from a variety of perspectives and will be anticipating well-rounded research-based scientific explanations to this complex topic.

**What Can Dietitians Do on an Individual Basis?**

While there are discrepancies over which, if any, political actions should be

taken, there are actions individual dietitians can take to further educate themselves or advocate for others. With this issue being very controversial, educational materials can sometimes be overshadowed by a specific bias. However there are a variety of non-partisan websites that focus on unbiased education for those who are interested in learning more about genetically modified organisms.

The World Health Organization has an extensive question & answer section, dedicated to explaining answers to the twenty most common questions regarding GMOs (World Health Organization, 2002). Another website that collaborates all the recent media and legislative news is GMOcompass.org. It is important for dietitians to consider all of the recent science based research, or lack thereof, in order to provide evidence-based answers to concerned clients. It is also imperative for dietitians to recognize that most sources will contain some bias, and investigating several will help form personalized opinions, and increase accurate knowledge on this issue.

If dietitians feel strongly about this issue, and think the public deserves the right to know what they are eating, public advocacy is an effective option. Contacting their local representative through the U.S. House of Representative's Website (http://www.house.gov/representatives/find/), can ensure that health professionals, such as dietitians, voice's be heard. It is the right of every U.S. citizen to voice their opinion on issues they feel passionately about, especially when the issue directly relates to the field of dietetics and the health of our nation.

## Protecting the Integrity of our Food Systems

The Food and Drug Administration, an agency of the US Department of Health and Human Services has an annual budget of $2.3 billion to regulate more than $1 trillion worth of consumer goods. These goods range from food, dietary supplements, drugs, vaccines, biological products, medical devices, cosmetics and other such products. The FDA establishes and maintains food standards and sets the requirements for nutrition labeling of most foods (Holst-Jensen, 2009, McHughen, 2007).

The agricultural industry claims genetically modified organisms are rigorously tested and represent no risks to human health. However, since GMOs are tested for safety only by the agricultural companies themselves and effectively fall outside of FDA regulation, such claims hold much bias. The FDA never examines the original studies conducted by companies, but rather only the company's summary assessment of its own research (Holst-Jensen, 2009). Once the GMO product is released into the market post-self regulation, the FDA considers the product to be equivalent to conventional non-GMO crops.

Food safety should be the utmost concern for our nation. Tampering with the genes of our base agricultural crops on such a widespread scale without proper labeling and regulation could prove to be collectively detrimental. Dietitians should be educating consumers on this new technology, so the consumers are aware of exactly what they are putting into their bodies. With knowledge comes power, and

as a nation we deserve the right to know where our food comes from, how it is grown and altered, and understand the potential consequences of eating certain products.

If the FDA finalizes guidelines for voluntary labeling of genetically engineered foods, an educational opportunity for dietitians familiar with the science and its regulations will emerge (Brown, 2003, Frewer, Howard, Shepard, 1996). The role of dietetics professionals and professional societies, such as the Academy of Nutrition and Dietetics should be to lead thoughtful dialogue and critical thinking related to the social, environmental, economic, ethical, and technical aspects of incorporating genetically engineered foods and crops into the food system (Roberts et al., 2006). Knowledge and attitudes of dietitians relative to genetically engineered foods could have an effect on information provided to clients or affect the food purchasing decisions of the institutions in which dietitians work (Wie, 2003). Consumers perceive dietetics professionals as reliable providers of food and nutrition information and services and as a trusted source of information about agricultural and food biotechnology (Hefferson, 2002, Position of the American Dietetic Association, 2006). This study proves the necessity for further education of Registered Dietitians, to help maintain their reputation as national nutrition professionals by providing current research on the controversial subject of genetic modification.

## Conclusion

The results of this study show the low overall knowledge held by many Registered Dietitians related to the topic of genetically modified organisms, as well as a significance of increasing opposition to GMOs when the knowledge base is high. These findings suggest that it is essential for dietetic professionals to be equipped with the latest evidence-based research, in order to best educate and protect clients, consumers, and the overall well being of the public.

# APPENDIXES

# APPENDIX A

# LETTER OF CONSENT

APPENDIX A

Letter of Consent

THE KNOWLEDGE AND PERCEPTION REGISTERED DIETITIANS HOLD ON THE GENETIC MODIFICATION OF ORGANISMS

By completing this survey you are also consenting to the terms of the study. The purpose of this study is to examine the knowledge base that Registered Dietitians have on genetically modified organisms. A secondary purpose of this study is to determine if there is any relationship between the knowledge and perception in Registered Dietitians in relation to genetically modified organisms. There has been little information pertaining to this subject previously studied on a national level. This research is important because GMO's are likely to be an upcoming trend in consumer awareness and dietitians need to be on the frontline ready with information for a confused public.

This survey is completely anonymous and confidential. This survey poses no known risks to your health, and your name will not be associated with the results. No personal identifying information will be collected during the survey collection.

**Taking this survey is completely optional. If you feel uncomfortable at anytime, or wish to discontinue the survey, you may do so. There is no penalty for refusing to participate, or for stopping at anytime throughout the survey. By continuing to the first question of the survey you hereby implying consent. The survey only takes a few minutes.**

**If you are curious or would like to learn more about this research, please call me (330.990.6109) or email me (cvoglian@kent.edu). This thesis has been approved by Kent State University. IF you have any questions or would like to learn more about Kent State University's rules for research, please contact Kent State.**

Natalie Caine-Bish, Ph.D., RD, LD
Assistant Professor and Advisor (330 672-2197)
School of Family and Consumer Studies
Kent State University

# APPENDIX B

# IRB APPROVAL

APPENDIX B

IRB Approval

August 10th, 2012
Laurie Kiehl

RE: Protocol #12-355 - entitled "The Genetic Modification of Foods"

I am pleased to inform you that the Kent State University Institutional Review Board has reviewed and approved your Application for Approval to Use Human Research Participants as Level I/Exempt research. This application was approved on August 10, 2012. Your research project involves minimal risk to human subjects and meets the criteria for the following category of exemption under federal regulations:

- Exemption 2: Research involving the use of educational tests, surveys, interviews, or observation of public behavior.

If any modifications are made in research design, methodology, or procedures that increase the risks to subjects or includes activities that do not fall within the approved exemption category, those modifications must be submitted to and approved by the IRB before implementation. Please contact the IRB administrator to discuss the changes and whether a new application must be submitted. It is important for you to also keep an unstamped text copy (i.e., Microsoft Word version) of your consent form for subsequent submissions.

Kent State University has a Federal Wide Assurance on file with the Office for Human Research Protections (OHRP); FWA Number 00001853.

If you have any questions or concerns, please contact me by phone at 330-672-2704 or by email at Pwashko@kent.edu.

**Respectfully,**
**Kent State University Office of Research Compliance**
**224 Cartwright Hall | fax 330.672.2658**

Kevin McCreary | Research Compliance Coordinator | 330.672.8058 | kmccrea1@kent.edu
Laurie Kiehl | Research Compliance Assistant | 330.672.0837 | lkiehl@kent.edu
Paulette Washko | Manager, Research Compliance |330.672.2704| Pwashko@kent.edu

# APPENDIX C

# DISTRIBUTED EMAIL

Appendix C

Distributed Email

**Email Released by State Dietetic Boards**

Hello Eat Right (State) Dietitians,

My name is Chris Vogliano, and I am currently a graduate student at Kent State University in Ohio. I am conducting an anonymous 15-minute survey for my thesis study on the topic of *Genetically Modified Organisms*. The purpose of this study is to determine the knowledge and perception that Registered Dietitian's have on the genetic modification of foods. I believe this to be an up and coming issue that is pertinent to our field, and would appreciate your participation.

If interested, there will be access to more information on genetically modified organisms upon the completion of the survey.

Click the link below to access the survey:

I thank you for your time and participation,
Chris Vogliano

*Chris Vogliano*
*Kent State University*
*Dietetic Intern & Graduate Student*
*The Ohio State University, BS*
*(330) 990-6109*

# APPENDIX D

# SURVEY

APPENDIX D

Survey

Are you a Registered Dietitian? (Yes/No*)

*If no – not able to continue

What State do you currently reside in? (drop down list)

1. The term genetic modification means:
    a. Cloning different species of plants and animals
    b. Using hormones to help livestock grow faster
    c. Splicing DNA from one species to another
    d. The act of crossbreeding species of plants and/or animals
2. When I hear the word transgenic foods I think of:
    a. Cross-breeding foods
    b. Food from foreign countries
    c. Food sprayed with pesticides
    d. Genetically altered food
3. Most transgenic foods are grown in:
    a. Brazil
    b. Europe
    c. United States
    d. Mexico
4. Genetically altered foods are currently only produced:
    a. For animal consumption only
    b. For human consumption only
    c. For animals and human consumption
    d. Still in preliminary laboratory testing
5. Genetically modified foods:
    a. Occur through natural processes only

b. Occur in nature and are also man made
c. Are only man made
d. Are not in existence yet (still hypothetical)

For the following questions please rate on a scale from 1 – 5.
(1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5- strongly agree)

6. GM foods are completely safe to eat.
7. The benefits for those who consume GM foods outweigh the risks.
8. Scientists cannot predict future outcomes of GM.
9. I would buy and/or eat foods that have been genetically modified.
10. I would prefer to have genetically modified foods labeled for customer convenience
11. I think the foods that are the most genetically modified are:
    a. Baby foods and infant formulas
    b. Cheese and tomatoes
    c. Beef and chicken
    d. Corn and soybeans
12. Food manufacturers in the USA that use genetically modified ingredients:
    a. Are required to put a symbol indicating the items contains GMOS
    *b.* Are required to state *"this product may contain ingredients that have been genetically modified"*
    c. Are not required to specify any difference between products
    d. Put labels on foods, but do so voluntarily
13. As a result of a genetically modified organisms, pesticide use has:
    a. Gone up a small amounts
    b. Gone down dramatically
    c. Stayed the same
    d. Gone down a small amount

14. While using gene technology, scientists:
    a. Precisely enter genes into the desired species of plant
    b. Insert genes into the proper chromosome, but have some room for movement
    c. Have a general idea as to where the gene will go
    d. Have little idea where the gene will end up
15. After a genetically modified organism has been released in the public food supply for consumption, it is retested for safety:
    a. Every month
    b. Every year
    c. In three year increments
    d. Never re-tested

For the following questions please rate on a scale from 1 – 5.
(1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5- strongly agree)

16. Genetically modified organisms use will forever change our natural environment.
17. Genetically modified organisms may have the potential to disrupt our current ecosystem.
18. I am worried about unknown effects of genetically modified foods.
19. The genetic modification of plants is the equivalent of crossbreeding plants.
20. The potential environmental benefits of genetically engineered crop improvements, such as reduced need for fertilizers, irrigation, and pesticides, far outweigh any possible risks.
21. I'm worried that the increased use of genetically engineered crops in agriculture will lead to loss of biodiversity in our food and agriculture systems.
22. What percent of Soybeans in America have been genetically modified:

a. 0%
b. 20%
c. 60%
d. 90%

23. How many genetically engineered crops have been approved for use by the FDA?
    a. 5 or less
    b. 13
    c. 25
    d. 40+
24. When were GMO's first available?
    a. 1970's
    b. 1990's
    c. 2000's
    d. Not available to public at this time
25. What is BT corn?
    a. Corn that has higher niacin levels to help prevent deficiencies
    b. Corn that produces more kernels per ear
    c. Corn that has built-in insect and weed control
    d. Corn that resists draught for developing countries
26. Will insects develop resistance to the toxins produced in Bt corn?
    a. It is unlikely that insects will develop resistance to Bt corn.
    b. It is almost certain that insects will develop resistance to Bt corn.
    c. Some insects are already resistant to the toxins produced in Bt corn.
    d. It is not known if insects will develop resistance to the toxins produced in Bt corn.
27. How much of our supermarket food contains genetically modified ingredients?
    a. None of it contains genetically modified foods

b. 10%
c. 50%
d. 80%

28. Who is responsible for the mandatory testing of genetically modified foods released into the market?
    a. Food and Drug Administration (FDA)
    b. United States Department of Agriculture (USDA)
    c. Environmental Protection Agency (EPA)
    d. No agency has this responsibility

For the following questions please rate on a scale from 1 – 5.
(1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5- strongly agree)

29. Price has an effect on the nutritional value of the food I purchase
30. With a growing population, the genetic modification of foods is necessary to keep up with the increasing demand for food
31. Genetically modified foods in the United States are not widely used
32. Genetically Modified foods are still quite experimental.
33. I feel that the regulatory government agencies would not allow the release of genetically modified organisms unless they were tested adequately and considered to be safe
34. I believe consumers have the right to know what they are feeding themselves and their families; therefore genetically modified organisms should be labeled.
35. I trust USDA, FDA, and/or EPA will continually test genetically modified foods to determine the safety of their long-term effects.
36. I feel consumers with certain religious, ethical, or philosophical beliefs have the right to know which foods contain genetically modified ingredients.

37. I believe that if a company patents a “genetically modified” seed, they should be given intellectual property rights to this living organism.
38. Corporations that make genetically modified organisms are conscientious, and I trust that if they are in the marketplace, then they are safe.
39. As a professional, I feel dietitians should be well versed in the current research regarding genetically modified foods.
40. It is the role of professional organizations such as The Academy of Nutrition and Dietetics to take a position on genetically modified foods
41. It is the role of The Academy of Nutrition and Dietetics to be involved in food biotechnology.
42. Dietetics professionals and professional societies, such as The Academy of Nutrition and Dietetics, should facilitate an open dialogue about the use of genetically modified organisms as well as other changes in the food system.
43. I feel adequately informed on the topic of genetically modified organisms.

DEMOGRAHPICS

In what year were you born?

_____

Highest level of education you have completed

Bachelors Degree or Equivalent

Post Graduate

Master’s Degree

Doctorate

Other Professional Degree

Dietetic Career

- Dietitian Clinical, Community, Business, Policy, Educators, other

Years of practice

a) 0-5
b) 5-10
c) 10-20
d) 20+

Have you heard of GM foods previously? If so, where? (Check all that apply)

- Newspapers, internet, radio, television, lectures, magazines, books, have not previously heard of it, other _____

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