Understanding Nontraditional and Biotech Horse Feed Ingredients

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Genetically engineered (GE) crops have been part of the agricultural landscape since 1994, when the first genetically modified food, the Flavr Savr tomato produced by Calgene, was introduced into the marketplace and licensed for human consumption. The tomato was genetically modified to have a longer shelf life by inserting a specific gene that delayed ripening. A year later, the first pesticide-resistant crops were approved in the U.S., including *Bacillus thuringiensis* (Bt) potato, corn, and cotton varieties. Not long afterward, herbicide tolerant (Ht) cotton and Roundup Ready soybeans were developed.

What crops grown in the U.S. are genetically engineered? Figures from 2013 speak of the country's use of GE crops: 93% of all corn planted was GE, 90% of all cotton, 93% of all soybeans, 95% of all sugar beet, and 90% of all alfalfa seeds.

In addition to these core crops, much of the canola, papaya, sweet corn, melon, and squash harvests are derived from GE seed stock. Certain crops grown in the U.S. are not genetically engineered, and these include oats, barley, wheat, rice, sorghum, and millet.

Widespread Prevalence of Genetically Engineered Crops

In terms of geographical significance, the total amount of land dedicated to growing GE crops throughout the world has escalated since 1996. In 2013, a record 18 million farmers in 27 countries planted more than 433 million acres of GM crops, a sustained increase of 3% or 12 million acres over 2012. Much of this land is found in the U.S., Brazil, Argentina, India, Canada, and China, in addition to several other countries.

Land allocated for GE crops can be further broken down by specific crop. Between 1996 and 2012, much of the land was apportioned to soybeans (200 million acres), corn (139 million acres), cotton (60 million acres), and canola (23 million acres). In 2012, GE soybeans accounted for 47% of all GE crop area, and 81% of soybeans grown were GE. Eleven countries grew Roundup Ready GE soybeans, with the U.S., Brazil, and Argentina at the forefront.

Much of this GE harvest is imported to the European Union (EU). In fact, about 80% of all livestock feed in the EU is imported. Specifically, 98% of all soybean meal is imported from the U.S., Brazil, or Argentina, and 80% of this imported soybean meal intended for animal use is GE.

Though the technology to genetically engineer plants has been in place for over two decades, are these crops safe for horses?

Types of Genetic Engineering

Crops are genetically modified in one of four ways: (1) traditional breeding, (2) ribonucleic acid (RNA) interference, (3) transgenics, and (4) mutagenesis. In traditional breeding, plants are crossed and selected offspring are used to carry on desired traits in future generations. No safety testing requirements are instituted for the products of traditional breeding. In RNA interference, certain genes are switched off through the use of

RNA. Only one or two genes can be silenced through RNA interference, and safety testing is required of the products. In transgenics, selected genes are inserted using recombinant DNA methods. The precision required of transgenics dictates that desired genes are inserted only at known locations. One to four genes are usually affected during transgenics. Safety testing is required with this type of modification. The final method, mutagenesis, occurs when seeds are exposed to radiation or chemicals. Changes in the genome, or genetic material within the plant, are random and unpredictable, thereby affecting untold number of genes. No safety testing is required of end products achieved through mutagenesis.

Genetically Engineered Traits

Scientists use genetic engineering to instill desirable characteristics in plants. For example, tobacco, corn, rice, and many other crops have been engineered to express encoding for insecticidal proteins from *Bacillus thuringiensis* (Bt). Others have been modified for herbicide resistance, which allows herbicides, such as glyphosate and dicamba, to be used on weeds without injuring crops. Other engineering efforts boost the nutritional value of crops, such as increasing the beta-carotene, or vitamin A, in rice and improving the fatty acid profile in soybeans.

Insect Resistance

The classic example of genetic engineering for insecticide resistance involves Bt corn. Pesticide-resistant corn has been engineered to produce a protein isolated from the bacterium *Bacillus thuringiensis*, known generally as Bt. Each strain of Bt produces a different variation of the protein, known as Cry, each highly specific to a limited number of related insect species. Bt has evolved with these proteins as a key part of the reproductive strategy in which they kill insects that ingest them and then eat nutrients released by the dying host.

The Cry protein found in Bt spores must be activated by a protein-cleaving enzyme found in the host gut and then bind to specific protein on the surface of cells in the digestive system, which Cry then destroys. These enzymes are not found in the guts of animals. The gene used in Bt corn produces a protein that kills Lepidoptera larvae, in particular European corn borer.

The irony of Cry becoming a major bugaboo of the anti-GMO movement involves the fact that, until the gene that produces it was inserted into corn, it was the poster child of a “natural” insecticide, preferred over chemical pesticides because of the potential for extreme host specificity and complete biodegradability. Bt spores were sprayed on crops for decades and are still widely used to control pests by organic farmers.

For instance, Safer Garden Dust is a highly selective biological pesticide that contains *Bacillus thuringiensis* to control leaf-eating caterpillars and worms. After ingesting a treated portion of a leaf, caterpillars stop feeding within hours, and death occurs in a few days. The product will not harm beneficial insects or honeybees, and it is safe to use around children and pets. In fact, it is listed for use by the Organic Materials Review Institute (OMRI), an international nonprofit organization that determines which input products are allowed for use in organic production and processing. OMRI Listed products are allowed to be used in certified organic operations under the USDA National Organic Program. Further, OMRI Canada also lists *Bacillus thuringiensis* as safe for use under the Canadian Organic Standards.

Interestingly, as more and more Bt corn is planted, farmers use less insecticides. In fact, overall insecticide use in the U.S. has declined 0.6% per year since the introduction of Bt corn into the marketplace.

Herbicide Tolerance

Certain plants have been modified so that producers can routinely use herbicides without fear of destroying crops. These are called herbicide tolerant (Ht) crops. A definitive example of this is Roundup Ready soybeans, a series of genetically engineered varieties of glyphosate-resistant soybeans produced by Monsanto, a multinational agrochemical and agricultural biotechnology corporation.

Glyphosate kills plants by interfering with the synthesis of the essential amino acids phenylalanine, tyrosine, and tryptophan. Plants and organisms manufacture these amino acids using an enzyme, called 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), that only plants and lower organisms possess. EPSPS is not present in animals, which instead consume these aromatic amino acids from their diets.

The type of EPSPS is produced by a special strain of a specific bacterium, known as *Agrobacterium*, that has a slightly altered shape. This alteration prevents Roundup from binding, thus allowing the resistant EPSPS to catalyze the amino acid synthesis reaction. The coding region from the bacterial EPSPS gene was cloned and transferred to plants. Plants with bacterial EPSPS can be sprayed with Roundup and take it into their cells without harm, as they have a backup enzyme that gives them the ability to continue making amino acids and, in the end, making them resistant to Roundup.

On the downside, however, plant herbicide resistance is a mounting problem, as more and more weeds are becoming immune to the effects of glyphosate. New GM crops have been created to resist other herbicides, namely 2,4-D and dicamba, and genes are being stacked against multiple herbicides. To exacerbate the problem, no new herbicides are being developed.

Detection of Genetically Modified Organisms

To detect genetically modified organisms (GMOs) in crops, polymerase chain reaction (PCR) technology is used for multiple reasons: (1) for screening purposes, PCR can reveal many GMOs with one test; (2) specific detection of single or multiple GMO events, meaning PCR can identify the presence of unauthorized GMOs, for example; and (3) quantitative PCR can help determine if the GM content of a product is above or below a given threshold.

Testing for GMOs is costly. A three-target general qualitative screen that is fairly nonspecific, for instance, might cost nearly $300. After the qualitative screen, target quantitative screens are available for *each* target at nearly $150, adding up to about $750. Each target after the initial three qualitative is another $75 each. Add in the cost for sample prep, about $25, and it is easy to see that testing for GMOs is an expensive endeavor.

Are Genetically Engineered Feeds Safe for Horses?

The U.S. National Academies of Science reported in a 2010 study of GMOs: “The evidence shows that the planting of GE crops has largely resulted in less adverse or equivalent effects on the farm environment compared with the conventional non-GE systems that GE crops replaced. A key improvement has been the change to pesticide regimens that apply less pesticide or that use pesticides with lower toxicity to the environment but that have more consistent efficacy than conventional pesticide regimens used on non-GE versions of the crops.”

Though no studies have been completed on horses specifically, multiple studies have been performed on animals to gauge the effects of diets that contain GM ingredients.

In 2012, researchers published a review article in the *Journal of Consumer Protection and Food Safety* that assessed the nutritional effects and safety of animal feeds made from GM plants (Flachowsky et al.). More than 135 studies were taken into consideration in multiple types of animals, including beef cattle, dairy cattle, pigs, poultry, and other animals and fish. The authors found “no unintended effects in composition (except lower mycotoxin concentrations in Bt plants)” among cattle and pigs, and “no significant differences in digestibility and poultry health as well as no biological relevant unintended effects on performance of animals and composition of food of poultry origin.”

A review article was published in the journal *Food and Chemical Toxicology*, titled “Assessment of the Health Impact of GM Plant Diets in Long-term and Multigenerational Animal Feeding Trials: A Literature Review” (Snella et al., 2012). The objective of this systematic review was to collect data concerning the effects of diets containing GM corn, potato, soybean, rice, or triticale on animal health. Of the 24 studies reviewed, 12 were classified as long term (more than 90 days and up to two years in duration), and 12 were multigenerational (two to five generations). Many parameters were examined, including biochemical analyses, histological examination of specific organs, hematology, and the detection of transgenic DNA. The authors summed up their findings, “The studies reviewed present evidence to show that GM plants are nutritionally equivalent to their non-GM counterparts and can be safely used in food and feed.”

A Closer Look at Mutagenesis

As mentioned earlier, mutagenesis occurs when seeds are exposed to radiation or harsh chemicals. Changes in the genome, or genetic material within the plant, are haphazard and sometimes unpredictable, so the number of genes disturbed or changed by mutagenic processes is unknown. Various plants have been exposed to mutagens in an attempt to alter a trait. Apples exposed to gamma rays, for example, had changed skin color, while canola subjected to the chemical ethyl methanesulfonate (EMS), a possible carcinogenic, had altered cooking oil quality.

Unlike RNA interference and transgenics, in which safety trials must be conducted on end products, no safety testing is required of crops achieved through mutagenesis. The example of Clearfield wheat puts into question the current policy of regulatory and safety oversight of mutagenesis.

Clearfield wheat is resistant to the herbicide imazamox. Resistance to imazamox is conferred by an alteration in the acetohydroxyacid synthetase gene. Promotional literature to farmers proudly proclaims that imazamox resistance in Clearfield wheat is not the product of genetic modification, that Clearfield wheat is non-GMO, unlike Roundup-resistant corn and soybeans. However, BASF, the company that holds the patent on Clearfield wheat and sells the seed, created Clearfield wheat using chemical mutagenesis. Researchers exposed the wheat seeds to the chemical sodium azide, a compound that is highly toxic to humans, animals, and bacteria. Human ingestion of small quantities yields effects similar to cyanide intake.

Sodium azide is so toxic to humans that Centers for Disease Control (CDC) recommends not performing CPR on victims following ingestion, as it might cause the CPR provider to be exposed. Moreover, any vomit from the individual should not be disposed of in a sink, as a spontaneous explosion might occur. Skin contact with sodium azide might also cause severe illness or death.

Plants created by mutagenesis, such as that described in the example of Clearfield wheat, are not safety tested or regulated by any government agency.

Conclusion

GM crops represent an important segment of worldwide agriculture, as evidenced by the amount of land used to cultivate them and their widespread use in both human and animal industries. Genetic modification allows desirable traits to be imparted to plants, primary of which are insect resistance (Bt technology) and herbicide tolerance (Ht or Roundup Ready innovation). Because of these technologies, crop losses due to pests have been reduced and insecticide use continues to fall. Genetic modification of plants through Bt and Ht methods is heavily regulated by government agencies, and a preponderance of scientific evidence has proven these GMOs safe for use in humans and animals. By informing horse owners of the technology involved in creating and thoroughly testing GMOs, they can be reassured of their safety.

References

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