Contribution of GM Technology to the Livestock Sector

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Updated February 2020 (No. 11)

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Approximately 191.7 million hectares of genetically modified (GM) crops were grown worldwide in 2018. The main GM crops grown commercially are soybean (95.9 mha), maize (58.9 mha), cotton (24.9 mha), and canola (10.1 mha).

The introduction of GM crops has produced significant benefits to both farmers and consumers. GM crops have minimized the use of pesticides and provided higher crop yields; consumers benefited in the form of improved quality products (e.g., canola and soybean with modified oils). Currently, more than 340 GM crop events/lines have been approved for feed use.

GM crops have also benefited the livestock sector as they have increased yields of feed ingredient, have better quality traits, and are safer for livestock. As a source of livestock feed components, the relevant GM crops include corn, canola, cottonseed, soybean, and potato. These crops are principally used in livestock feed rations either as an energy and/or protein source.

Future Demand for Livestock Products and Feed Grains

The demand for livestock products will increase dramatically as population increases. Moreover, with increasing urbanization and rising income in many parts of the developing world, per capita consumption of meat, milk, and eggs is expected to rise by about 2%.[1] Global demand for meat is also forecast to increase more than 55% of current consumption by 2020, with most of the increase occurring in developing countries.[2] Thus the demand for feed grain will increase by 3% per year in developing countries and 0.5% in developed countries. On average, less than 3 kg of feed grain are required to produce a kilo of livestock meat and less than a kilo of feed grain per kg of milk.

Clearly, increased grain production for food and feed has to be generated from increased yield because there is limited opportunity to increase cultivated land area without adverse environmental impacts.

GMO Materials in GM Feed Ingredients

Transgenic crops currently approved for use as animal feed are modified for herbicide tolerance, insect resistance, modified oil content, and virus resistance. Many of the proteins expressed in GM crops have a history of safe usage and/or are similar to naturally occurring proteins. For example, insect resistant transgenic crops express proteins from Bacillus thuringiensis (Bt), a common soil-borne bacterium that has been commercially used worldwide as a microbial insecticide by organic farmers. Expressed proteins (CP4 EPSPS) in glyphosate herbicide tolerant GM crops are similar to endogenous EPSPS already present in foods.[3]

Current Use of GM Feed Ingredients in Livestock Diets

Feed grain usage as a percentage of total crop production ranges from 18% for wheat, 52% for sorghum, 70% for corn, 75% for oats, to more than 90% of oil seed meals.[4] Livestock producers in many parts of the world prefer corn grain and soybean meal for energy and/or protein source in both monogastric and ruminant diets.

About 90 million metric tons of GM corn grains are produced worldwide. Given that 70% of total corn grain production are used for livestock feed, then at least 65 million metric tons of GM corn grains are used in livestock diets annually. In the case of soybean, about 70 million metric tons of soybean meal derived from GM soybean are fed to livestock per annum.[5]

Conclusion

Extensive safety assessments conducted with plant biotech products provide equal or greater assurance of safety for food and feed use. There is a growing body of scientifically valid information that indicates safety of GM crops for feed use. The first generation of GM crops has directly benefited livestock production through safer and more abundant feed source. Future GM crops with enhanced output traits have the profound effect of improving animal productivity and performance. These innovations will contribute to helping feed the growing world population.

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GM Crops Used for Livestock Feed

Feed Crop	Improved Traits	No. of Approved GM Events
Alfalfa	herbicide tolerance, modified product quality	5
Apple	non-browning	3
Argentine Canola	herbicide tolerance, modified product quality, pollination control system	37
Bean	viral disease resistance	1
Chicory	herbicide tolerance, pollination control system	3
Cotton	insect resistance, herbicide tolerance	57
Cowpea	insect resistance	1
Creeping Bentgrass	herbicide tolerance	1
Eucalyptus	volumetric wood increase	1
Flax	herbicide tolerance	1
Maize/corn	modified product quality, insect resistance, herbicide tolerance, pollination control system, abiotic stress tolerance	140
Papaya	disease resistance	2
Plum	disease resistance	1
Polish canola	herbicide tolerance	4
Potato	insect resistance, disease resistance, herbicide tolerance, modified product quality	41
Rice	insect resistance, herbicide tolerance	6
Safflower	modified oil/fatty acid, antibiotic resistance	2
Soybean	modified product quality, herbicide tolerance, insect resistance, altered growth/yield	35
Squash	disease resistance	2
Sugar beets	herbicide tolerance	3
Sugarcane	insect resistance	4
Tomato	modified product quality, disease resistance, insect resistance	11
Wheat	herbicide tolerance	1
Source: ISAAA GMO Approval Database, http://www.isaaa.org/gmapprovaldatabase		

Safety Assessment of GM Products

Extensive testing and a long approval process accompany every GM crop introduction. The approval process includes comprehensive analyses to ensure food, feed, and environmental safety before entering the marketplace. Generally, the first step in any safety assessment of GM-derived products is to determine if the product is substantially equivalent (except for defined differences) to conventional counterpart varieties. Further analysis then focuses on the evaluation of the defined differences. Specifically for evaluating food and feed safety, set of factors are used for assessing potential safety risks of the host plant, gene donor(s), and introduced protein(s).

Safety concerns on the use of GM crops as feed ingredients relate to the following questions:

- Are GM crops safe as feeds for livestock?
- Is animal performance affected by GM crops?
- Could transgenic materials be transferred to and accumulate in milk, meat, and eggs?

Nicolia et al. (2013) conducted a meta-analysis of 1,783 scientific studies on safety of GM crops published from 2002 to 2012. Three hundred twelve (312) of the papers were focused on GE food/feed consumption. The main concerns about GE food/feed consumption were as follows: safety of the inserted genes, safety of proteins encoded by the transgenes and safety of the intended and unintended change of crop composition. Here are some key points in the study:

- Transgenic DNA is enormously diluted by the total amount of ingested DNA (from 0.00006% to 0.00009%) and is digested like any other DNA. Furthermore, processing usually lead to DNA degradation.
- No study have shown that DNA absorbed in the digestive tract can be transferred into the cells of the host organism.
- RNA has the same history of safe use as DNA, since it is a normal component of the diet.
- The proteins are degraded during digestion, leading to loss of activity.
- Evaluation of GE crops includes determination of substantial equivalence wherein the GE crop must be as safe as their conventional counterparts.

Based on the findings, there were no significant hazards directly linked with the use of GE crops.[12]

University of California scientist Alison Van Eenennaam reviewed the results of animal-feeding studies involving genetically engineered feeds.[13] Based on the 15-year history of GE feed use, it was proven that there are no unique risks associated to GE feeds. Thus, whole food/feed animal feeding studies on GE crops should be done only for GE crops where the new trait results in a sensible food safety concern that remains unanswered following all other analyses.

The expert also stressed that indiscriminately requiring long-term and target animal feeding studies is not scientifically justified and will have an inhibitory effect on the development and commercialization of potentially beneficial GE feed crops in the future. International GE regulations have focused on potential risks linked with GE technology. This leads to high regulatory compliance expense, slowing adoption of GE crops in developing countries. She recommended regulatory frameworks that would consider the benefits in addition to any unique risks associated with GE technology.

Feeding trials have been conducted to examine the safety and efficacy of GM feeds for farm livestocks.[6] Based on these studies, there is no evidence of significantly altered nutritional composition, deleterious effects, or the occurrence of transgenic DNA or protein in animal products derived from animals fed with GM feed ingredients. Animals perform in comparable manner when fed biotech feed ingredients as compared to conventional products. Feeding of GM crops has not shown any negative effects of feed intake, whole tract digestibility or animal productivity in studies with chickens, pigs, sheep, beef cattle, and dairy cows.[6]

Scientific studies have also demonstrated that transgenic DNA and/or protein expressed in GM crops are not detectable in the raw food products derived from animals fed with transgenic crops.[7,8] Animal digestive systems rapidly degrade DNA and proteins. Moreover, studies have shown that ensiling and feed processing results in DNA fragmentation.[5] Based on the safety analyses required for GM crops, consumption of milk, meat, and eggs derived from farm animals fed with transgenic crops could be considered as safe as traditional counterparts.

Future GM Feed Crops

GM feed ingredients of the future will benefit livestock with improved feed qualities. Future GM feed crops will have enhanced nutritional characteristics.[9,10]

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Current research is aimed at manipulating levels of proteins, amino acids, oil, and carbohydrates in major feed crops. GM crops being developed with improved nutritional characteristics include higher concentration of methionine and increased protein digestibility of lupins, increased lysine content in canola and soybean, increased levels of free and protein-bound threonine in lucerne, and reduced phytate content in corn grain.[10] Researchers are also looking for ways to improve digestibility of wheat, rye or barley. Many of these biotech crops are already under field evaluation.

The use of insect protected corn is already improving feed quality by decreasing mycotoxin contamination. The presence of mycotoxins in feed grains or ingredients makes them unfit for animal (or human) consumption and can cause serious health risk. GM crops expressing antigens from various microbes are also being developed. Edible vaccines delivered via feeds have the potential to control economically important diseases in livestock.