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Animal feeds from transgenic crops: a biosafety perspective

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ABSTRACT

There are many biosafety issues pertaining to transgenic crops. Long-term implications of the transgenics for livestock and human health need to be identified and addressed. Researchers dealing with transgenic crops have brought to the fore many of their advantages and disadvantages. All possible effects of transgenic feeds must be tested before the transgenic crops are utilized to derive feeds from them for livestock feeding. Human health can be affected directly through consumption of foods from transgenic crops as well as through livestock products if feeds are derived from these crops. This paper attempts to examine some pertinent issues relating to possible effects of feeding livestock with feeds from transgenic crops and presents a perspective on how to evaluate such feeds to ensure biosafety when transgenic crops or their residues are used as feeds.

Key words: Animal feeding, Feeds, Feed evaluation, Health, Transgenic crops

Transgenic crops are on way to occupy significant cover in agriculture in the foreseeable future. In 2013, the total field area under GM crops in the world rose to 174 million ha of which soybeans, maize, cotton and rapeseed shared 79, 32, 70 and 24%, respectively (GMO Compass 2013). India has the fourth largest area under GM crops with a total of 11.6 million ha in 2014 surpassing China's 3.9 million ha (Indian Express 2015). India is working on 111 transgenic crop varieties of various vegetables, fruit, spices, cereals, bamboo etc. (Pathania and Sharma 2012).

Transgenic crops being introduced and those at the verge of introduction are stalked with the apprehension of numerous adverse impacts on public health (Singh *et al.* 2014). The public health issue is also linked with the health of livestock. Livestock products are safe for consumption when they are produced by healthy livestock and health is largely an attribute of feed quality. The overall impact of feeds on some physiological parameters of livestock would help us understand the status of animal and biosafety concerns of human health.

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Brief review of transgenic foods and human health

Postlethwait (2015) presents a fascinating review of the wrecks of life revealing how genetic variants were vetted by natural selection. With our traditional diet, we normally ingest gram quantities of DNA and RNA daily. Relatively high concentrations are usually present in edible offals and animal muscle tissues, whereas plant-derived foods contain lower concentrations. Consumption of excessive quantities of RNA and to a lesser extent DNA, is considered to be a risk factor for gout (Jonas *et al.* 2001). Some of the biosafety-related aspects (Jonas *et al.* 2001) of DNA in food are as follows:

(i) All DNA including recDNA is composed of the same four nucleotides; (ii) In view of the variability of dietary intake of DNA, consumption of foods derived from GMOs does not measurably change the overall amount of DNA ingested through the diet; (iii) Taking into account the natural variations of DNA sequences, the present use of recombinant techniques in the food chain does not introduce changes in the chemical characteristics of DNA; (iv) There is no difference in the susceptibility of recDNA and other DNA to degradation by chemical or enzymatic hydrolysis; (v) The metabolic fate of DNA digestion products is not influenced by the origin of DNA; (vi) There is no indication that ingested DNA has allergenic or other immunogenic properties that would be of relevance for consumption of foods derived from GMOs; (vii) Uptake, integration and expression of any residual extra-cellular DNA fragments from foods by microorganisms of the gastrointestinal tract cannot be excluded. However, each of these circumstances is a rare event and would have to happen sequentially; (viii) *In vivo* uptake of DNA fragments by mammalian cells after

oral administration was observed. However, there are effective mechanisms to avoid genomic insertion of foreign DNA. There is no evidence that DNA from dietary sources has ever been incorporated into the mammalian genome.

Plant-animal-human links and biosafety

Biosafety considerations have assumed serious proportions ever since the advent of the Bt cotton (Singh *et al.* 2014). Now a number of food crops are waiting for clearance for release provided biosafety related issues get to conclusive resolution. The Bt gene *Cry-1A* from *Bacillus thuringiensis,* coding for an insecticidal Bt protein, was inserted in several varieties of maize and other food crops to render them resistant to the attack of several insect pests. The toxins will pass from plants to human directly or they will first enter into the animal and then into human beings consuming animal products, through the food chain mechanism.

Plant-animal-human links are vital for biosafety and health. Ever since their origin through genetic manipulation between two or more different species, the transgenic crops have shot into controversy. Their proponents and the business sector promoting these crops were showered with criticisms from around the world. The debate on the various aspects of these crops appears not to come to any concrete conclusion in recent future. Such a situation leads scientists and concerned institutes and policy-makers to shed the controversies and arrive at a concrete picture based on scientific facts. An evaluation of the nutritive value of the feeds derived from the parts of the transgenic crops and the impact of such feeds on the health and productivity of domestic animals whose milk and other products are consumed virtually by entire human populations, therefore, would attempt to unfold the safety issues having implications for human health.

Transgenic crops are caught up in an unending controversy. While a school of thought claims that they are not unsafe to life, the other school attempts to prove that these crops are flawed by potential negative consequences. But one thing is sure: these crops carry enormous risks of environmental disruption. Some important impacts of GMO applications in the environment are pointed in Fig. 1.

GMOs affect human health in three most possible ways by causing toxicity, allergenicity and antibiotic resistance. Transgenic organisms either produce some compounds during metabolic processes which may be lethal for the human or upon consumption, may introduce new protein in the human body which may be left unconsumed and work as allergen. For selection of suitable transgene, antibiotic resistance is used as selectable marker and continuous consumption of these crops may further reduce the effectiveness of antibiotics to fight a disease (Singh *et al.* 2014).

Consuming certain phytotoxins directly through vegetarian food and indirectly through animal products derived from the animals who also consumed the same phytotoxins through feeds will have different impacts on

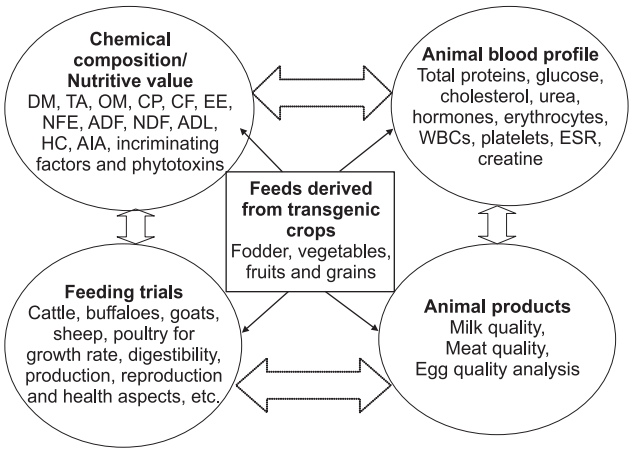

Fig. 1. A modeling approach to evaluate transgenic crop-derived feeds.

human health. The phytotoxin would increase in concentration in animal body due to biological magnification, the phenomenon through which certain pollutants/toxins get accumulated in tissues in increasing concentration along the food chain. Thus, eating meat of the animal feeding on transgenic crop residues will have a more pronounced effect on health than would otherwise be the case. This safety aspect must also be taken into consideration.

Dependence on animals for food in India, particularly for milk and eggs, is so critical that it cannot be avoided. Livestock health and productivity are primarily influenced by the quality of feeds. Incorporation of the feed products to come from the transgenics (e.g., green and dry leaves, shoots, whole plants, fruits, seeds and by-products such as cakes, pellets, flour, offal etc.) need to be safe from the nutrition point of view, i.e., these should be free from any toxic or incriminating contents, or within the safe limits. The impact of transgenic plant-based feeds should be studied in relation to analysis of feeds derivable from transgenic plants, animal blood for different parameters, human foods of animal origin, and impact of the feeds on growth and production of the animals.

Evaluating feeds of transgenic crops

The above aspects of the probable effects of transgenic plants would help the policy makers and governing system to take measures regarding adoption or rejection of the introduction of new transgenic crops in the country.

Based on their intensive studies on animal feeds from various sources, conventional as well non-conventional, Singh *et al*. (2001), Singh and Bohra (2005), Singh and Gaur (2008) and Rai *et al.* (2014) have presented nutritive values of a variety of feeds. However, little care needs to be taken while evaluating transgenic plant based feeds. This must meet the following objectives:

(i) determination of nutritive value, toxic/ incriminating factors (cyanide, tannins, saponins, oxalates) and digestibility of feeds derived from transgenic crops; (ii) analysis of blood parameters as indicators of livestock health

on feeding the feeds of transgenic crops; (iii) determination of the quality of livestock products of human consumption – milk and eggs – produced by livestock kept on rations incorporating feeds from transgenic crops; and (iv) effects of transgenic crop-based diets on growth, health, production and reproduction of livestock.

Nutritive value and digestibility of transgenic feeds

Determination of nutritive value of different parts of all the transgenic cultivars – whole plant, leaves, roots, fruits, seeds/grains, etc. – should be based on the determination of: (i) dry matter (DM)/moisture, total ash (TA) or minerals/ organic matter (OM), crude protein (CP), crude fibre (CF), ether extracts (EE), nitrogen-free extracts (NFE), acid detergent lignin (ADL), hemicelluloses (HC), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid-insoluble ash (AIA) and toxic factors; and (ii) digestibility coefficients of the nutrients: DM, TA, OM, CP, CF, EE, NFE, ADF, NDF, ADL and HC.

Feeding trials

- Feeding trials should be conducted on growing ruminants and milkers (both bovine and ovine) as well as on poultry birds (growers, broilers, layers).
- In ruminants, control diet can be replaced by transgenic crop-derived feeds (20, 40, 60% or so). In poultry, the experimental diets may have 10, 20, 30, 40 and 50% proportion of the feeds derived from transgenic crops.
- Blood samples of the experimental ruminants should be analyzed before the experiment and then fortnightly. Blood analysis should include determining total protein (g/dl), blood glucose (mg/ dl), blood urea (mg/dl), blood cholesterol, hormones (testosterone/estrogen, T3 and T4), red blood corpuscles (RBCs), white blood corpuscles (WBCs), blood platelets, erythrocyte sedimentation rate (ESR), creatine, etc.
- Growth rate/body weight gain of animals and poultry birds, productivity status, blood profile, etc. are good indicators of animal health. Other morphological indicators can also be taken into account in consultation with animal health experts.

Milk and egg quality analysis

Milk is the most consumable animal product in India as also in most of the Asian countries and the consumers are quite conscious about milk quality. Milk quality should be determined by using standard milk parameters. Egg quality should be determined following common egg quality indicators.

A modeling approach to the evaluation of GM-based feeds for animals is presented in Fig. 1. Comprehensive evaluation can be done adopting four steps, namely, chemical analysis of the feed, feeding trials, blood profile, and animal products' quality.

Indian Research and Development (R&D) system has been very cautious about the introduction of transgenic crops in Indian agricultural scenarios. The lone transgenic, the Bt cotton, introduced so far is the result of our very clear-cut policy system that depends on research back up. However, many more transgenic crops are in the pipeline and could be released in future. Most of the apprehensions regarding the introduction of transgenic cultivars are based on the possible impact of the products derivable from these crops on public health.

Livestock are often the readily susceptible organisms as they are the first to be affected by any sort of a change in the genetic resources in agriculture, as their feeds are derived from these cultivars. Any impact on livestock health amounts to direct effect on human health.

Information available on the nutritive value of feeds of the genetically modified crops and their impact on livestock health and productivity are the valuable indicators for the policy makers to arrive at concrete decision about the release/introduction of the transgenic crops in Indian agriculture.

REFERENCES

G M O Compass. 2013. Genetically modified plants: global cultivation on 174 million hectares. (http://www.gmo-compass.org/eng/agri_biotechnology/gmo. Retrieved March 30, 2016).

Indian Express. 2015. India world's 4th in GM crop acreage, well ahead of China. *Indian Express*, New Delhi, Feb 2, 2015.

Jonas D A, Elmadfa I, Engel K H, Heller K J, Kozianowski A, Muller J F, Narbonne J F, Wackernagel W and Kleiner J. 2001. Safety considerations of DNA in food. *Annals of Nutrition and Metabolism* **45**: 1–20.

Postlethwait J H. 2015. Wrecks of ancient life: genetic variants vetted by natural selection. *Genetics* **200**: 675–78.

Rai S K, Ghosh P K, Kumar S and Singh J B. 2014. Research in agrometeorology on fodder crops in Central India: an overview. *Scientific Research* **4**(1): 78–91.

Singh V and Bohra B. 2005. Livestock feed resources and feeding practices in hill farming systems: a review. *Indian Journal of Animal Sciences* **75**(1): 121–27.

Singh V and Gaur R D. 2008. *Rangeland Ecosystems in the Himalayan Mountains*. Daya Publications, New Delhi.

Singh V, Tulachan P M and Partap T. 2001. Livestock feeding management at smallholder dairy farms in Uttaranchal hills. *Indian Journal of Animal Sciences* **71**(12): 1172–77.

Singh V, Shiva V and Bhatt V K. 2014. *Agroecology: Principles and Operationalisation of Sustainable Mountain Agriculture*. Navdanya, New Delhi.