SAFETY AND FEEDING VALUE FOR FARM ANIMALS AND THE FOOD CHAIN OF GENETICALLY ENHANCED PLANTS.

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In a controversial world with the quick adoption of genetically modified GM crops covering nowadays 67.7 million hectares, the question for the scientists responsible for health and consumer protection is not to be in favour or against the products issued from new technology. Users and consumers must be objectively informed on the safety of the genetic constructs, of expressed proteins and finally of new feeds/foods. New recombinant genes as rDNA representing 1 10^{-4} % of the total nucleus DNA mainly code for functional proteins conferring tolerance to herbicides or insect resistance or both traits for a few. From the consumer point of view, the safety, concerned by the presence of the rDNA, the new proteins and eventually of other substances not intended and synthesised in the plant. Scientific authorities or agencies only authorised their dissemination on the basis of results on risk assessment derived from appropriate tests. Examples on the compositional analysis, substantial and nutritional equivalence, long term safety tests are summarised and discussed in the present review. Results on the quality and the safety of animal products, milk and meat issued from animals fed GM plants have been also interpreted .

1. Typical genes, expressed proteins and substantial equivalence

New proteins such as Bt CryIA(b,c), Pat and Cp4epsps are generally expressed in low amounts (0.1 to 10 µg/g fresh weight in leaves) representing 0.00005 to 0.0005 % of total proteins (agbios.com 2003). Acute toxicity tests in mice revealed a high safety factor for expressed proteins which are easily degradable in vitro at low pH in simulated gastric or intestinal fluid. Similarly, because of the presence of low levels of rDNA in genetically modified plants and its massive destruction into small nucleotides during fermentative processes, functional rDNA (> 2000bp) is low or absent from the silage and from the small intestine of ruminants. No significant modification of the chemical composition of plants in macro and micro-nutrients and toxicants have been observed between GM plants and their near isogenic parents. This is valid for the protein and amino acid content, the carbohydrate or fibrous content, the fat and fatty acid in their leaves, the whole plants, beans and kernels. It has been almost always concluded that new GM plants are substantially equivalent to their near isogenic parents. However, the concept of substantial equivalence identifying known nutrients and toxicants is neither a safety assessment *per se* but that characteristics and composition of the novel food as equivalent to the conventional food with a history of safe consumption.

The resistance of maize to the damage of the corn borer, prevents the plant in the development of mould contamination before and after harvesting. A typical unexpected and unintentional bonus in favour of the insect protected maize leads in its substantially lower level in several mycotoxins.

2. Safety and nutritional equivalence of GM plants and feeds.

Results of long term experiments corresponding to toxicological studies systematically run on high producing animals such as the dairy cow for forages and silage , the fattening steer, the growing chicken and the growing-fattening pig for maize kernels, oilseeds and oilmeals are available in the referred literature. None of the comparative performance of the dairy cows including average daily dry matter intake, fat corrected milk and milk composition are modified by the use of Bt or herbicide resistant maize silage. GM cotton seeds bearing various rDNA and fed as raw seeds at the level of 2.3 kg/ cow/day did not affect either milk production or milk composition. Moreover, nitrogen and rumen metabolism have not been modified in cows fed raw soybean resistant to glyphosate. No physiological and hormonal disturbance have been associated with feeding GM beets to dairy cows. The content of milk in total protein, but also the proportion of casein, non protein nitrogen, α-lactalbumin and β-lactoglobulin are not modified, leading to the absence of effect on the physicochemical characteristics of the curd and of the cheese made with milk issued from cows fed GM maize.

Additional digestibility trials in adult rams confirmed the nutritional equivalence of GM maize forage and sugar or fodder beets to their near isogenic parental plants. Similarly, across 8 long term studies lasting from 101 to 234 days and undertaken on fattening steers fed up to 96 % of their dietary dry matter intake with GM maize silage or grain, no deleterious effect on performance, health, frequency of liver abscess have been found in hundreds of experimental animals. As a consequence, the nutritional equivalence, carcass performance, dressing percentage, the 12^{th} rib fat thickness and ribeye area have not been modified by the ingestion of insect and glyphosate resistant maize. The chemical composition of the *Longissimus dorsi* muscle in steers as in pigs fed glyphosate tolerant maize or soybean, respectively are also not modified by feeding GM grains.

3. Safety of animal food.

Animal food produced by animals fed GM plants has been suspected to be of lower quality, on the basis of the transient presence of foreign plant DNA fragments (140bp) in organs (liver, spleen, ovary) and tissues (muscle, blood). The first observation in mice species has been confirmed in farm animals without an explanation on their physiological significance. Opposed to that, all samples of milk, muscle and eggs (yolk and albumen) of animals fed Bt maize silage, Bt cotton or soybean resistant to glyphosate were negative of the presence of transgenic DNA for either traits or fragment thereof and the protein encoded in the GM plants.

Because GM plants have only been grown recently (www.isaaa.org), few toxicological data are available on the long term effect on reproductive performance of

animals. However, recent data demonstrated the absence of effect of feeding Bt maize grain to the quail over 4 generations.

4. Conclusion and the near future.

Nowadays, maize (26% of requests sent to the EFSA panel), oilseed rape (21%), sugar beets (16%), potatoes and even wheat are concerned by genetic modification. Major modifications in the proportion and in the balance of nutrients could be particularly concerned (18 % of the new requests) as abiotic stress yield (13%) or resistance to pathogens which are still in the laboratory phase. Further experimental tests and experimental approaches concerning the safety and even more importantly the nutritional value of the new plants will be required. The safety and the nutritional value for animals must be tested and the results published. The quality and the safety of animal food must also be considered for health and consumer protection. Methods for testing and guidance documents on the information need for the risk assessment of GM plants and derived food and feeds are now fully available.

References

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