

# Genetically modified (GM) feed in farm rabbits: scientific, ethical, legal and religious dimensions

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**Abstract.** This paper examines the use of genetically modified (GM) feed in farm rabbits from a multidisciplinary perspective, integrating scientific, ethical, legal, environmental, and religious dimensions. Current evidence indicates that first-generation GM feed ingredients, such as Bt maize, Roundup Ready soybean, and GM cottonseed, are nutritionally equivalent to conventional feeds and generally do not produce clinically significant adverse effects in rabbits or other livestock species. A 180-day feeding study in rabbits confirmed the absence of biologically relevant alterations in key biochemical parameters, while broader livestock reviews support normal health and performance outcomes. However, some rodent-based studies and meta-analyses raise concerns regarding potential long-term and organ-specific effects, highlighting limitations of standard 90-day toxicity assessments and the need for extended and multigenerational studies. For human consumers, available data suggest that GM DNA and proteins are largely degraded during digestion and are not transferred into animal-derived products, supporting the safety of rabbit meat obtained from GM-fed animals. Nevertheless, uncertainties related to long-term exposure and indirect effects justify continued monitoring and transparent labeling practices. Ethical considerations include animal welfare implications, the proportionality of animal testing, and broader socio-economic concerns such as farmer dependency and global food security. Regulatory frameworks differ significantly between regions, with the European Union applying stringent authorization, traceability, and labeling requirements, while other jurisdictions adopt more flexible, product-based approaches. Religious and cultural perspectives remain diverse, often emphasizing naturalness, safety, and the origin of genetic material, contributing to ongoing public skepticism. Overall, while GM feed offers potential benefits such as reduced mycotoxin contamination and improved feed efficiency, a cautious, case-by-case approach remains essential, supported by long-term research, regulatory transparency, and societal dialogue.

**Key Words:** animal nutrition, biotechnology, consumer perception, ethics, food safety, genetically modified feed, GM crops, legislation, livestock health, mycotoxins, rabbits, religion, sustainability.

**Introduction.** Genetically modified (GM) crops are widely used in animal nutrition, and rabbits can receive GM maize, soybean or cottonseed as part of compound feeds. The debate around these feeds involves direct biomedical safety for rabbits and consumers of rabbit meat, together with ethical, legislative and religious aspects.

The aim of this study is to critically evaluate the use of GM feed in farm rabbits by integrating scientific evidence on animal and human health with ethical, legal, environmental, and religious considerations, in order to provide a comprehensive and balanced assessment of its benefits, risks, and societal implications.

**Biomedical effects on rabbit health.** A controlled 180-day feeding study in albino rabbits evaluated diets containing 20-40% GM cottonseed expressing Bt (Cry1Ac/Cry2A) and Cp4EPSPS proteins. Serum enzymes, glucose, proteins, cholesterol and electrolytes were measured at multiple time points. Most parameters showed no significant dose-dependent changes, and those that differed statistically remained within normal physiological ranges, leading to the conclusion that this GM cottonseed meal was as safe as conventional ingredients for rabbits (Salisu et al 2018).

Large reviews of livestock studies (ruminants, pigs, poultry) fed Bt maize and Roundup Ready soybean similarly report no clear evidence of adverse health effects. Significant differences in organ weight, haematology, serum biochemistry or immune parameters were usually small, within normal biological ranges, and not indicative of

toxicological concern (Snell et al 2012; De Vos & Swanenburg 2018; Akram et al 2019). These reviews conclude that first-generation GM feeds are nutritionally equivalent to their non-GM counterparts and can be safely used in animal diets (Snell et al 2012; De Vos & Swanenburg 2018; Akram et al 2019).

At the same time, critical analyses highlight limitations of the standard 90-day rodent tests used in regulatory assessment. Meta-analysis of 19 rat studies with GM maize and soybean reported convergent alterations in kidney and liver endpoints, with kidneys in males and livers in females showing the highest proportion of disrupted parameters. The authors argue that 90-day studies may be too short to detect chronic toxicity and call for longer, multigenerational and reproductive studies (Séralini et al 2011). A broader systematic review of 204 animal and human studies identified 21 GM-related serious adverse events (mortality, tumors, low fertility, neurobehavioral changes, organ abnormalities) linked to specific GM events such as NK603 × MON810 maize, MON863 maize and GTS 40-3-2 soybean, although overall study quality and risk of bias were frequently poor (Shen et al 2022).

These findings indicate that in rabbits, available data for GM cottonseed suggest absence of clinically relevant harm over 180 days (Salisu et al 2018), and that in other livestock species GM feeds generally support normal health and performance (Snell et al 2012; De Vos & Swanenburg 2018; Akram et al 2019). However, concerns from rodent datasets and limited long-term species-specific work justify continued surveillance and targeted long-duration studies (Séralini et al 2011; Shen et al 2022).

**Implications for human consumers of rabbit meat.** GM crops used in feed are primarily assessed for compositional equivalence and for toxicological and allergenicity risks of the newly expressed proteins. Reviews of livestock feeding trials report that recombinant DNA and transgenic proteins are largely degraded in the digestive tract and are not detected in tissues, milk or eggs, suggesting minimal direct transfer to products consumed by humans (De Santis et al 2018; De Vos & Swanenburg 2018; Akram et al 2019; Giraldo et al 2019). Under these conditions, meat from rabbits fed GM maize, soybean or cottonseed is expected to be compositionally similar to meat from animals on non-GM diets, with no evidence of additional allergenicity or acute toxicity (Snell et al 2012; De Vos & Swanenburg 2018; Giraldo et al 2019).

Nevertheless, safety concerns focus on indirect and long-term aspects. Insect-resistant Bt maize often has reduced fumonisin contamination, which is beneficial for both animal and human health, since fumonisins are important mycotoxins in maize-based feeds (Tsatsakis et al 2017; De Santis et al 2018). Conversely, serious adverse events noted in some animal studies raise questions about possible subtle organ changes or reproductive effects that could, in theory, have human analogues if similar mechanisms apply (Séralini et al 2011; Shen et al 2022). The systematic review of GM-food adverse events therefore recommends labelling GM foods to allow consumer choice and to support epidemiological monitoring (Shen et al 2022).

**Ethical and animal-welfare considerations.** The breeding of GM animals, although discussed in the literature as a solution for human medicine, is still far from being accepted as a viable solution for animal husbandry (Petrescu-Mag & Safirescu 2021; Petrescu-Mag 2023a, b).

From an animal-welfare perspective, GM feed can have both positive and negative potential. When GM crops decrease reliance on chemical insecticides and reduce mycotoxin loads, they may improve animal health and welfare by lowering disease risk and subclinical toxin exposure (Tsatsakis et al 2017; De Santis et al 2018; De Vos & Swanenburg 2018; Akram et al 2019). For rabbits, use of Bt maize or cottonseed that is less contaminated with fumonisins could be advantageous compared with highly contaminated conventional feed (Tsatsakis et al 2017; De Santis et al 2018).

On the other hand, the very process of testing GM feeds relies heavily on rodent and, more rarely, target-species feeding trials. Reviews of GM feed safety note that many trials are 90-day subchronic tests, with calls for longer and multigenerational studies particularly for crops with modified nutritional traits (Séralini et al 2011; Snell et al 2012;

Giraldo et al 2019). This raises ethical questions about the proportionality of animal use versus the incremental information gained, especially when substantial equivalence has already been established (Giraldo et al 2019). Some authors propose prioritizing animal testing efforts for “second-generation” nutritionally modified GM crops (e.g., altered fatty acid or amino-acid profiles) where physiological uncertainty is greater, and simplifying testing for classic herbicide-tolerant and insect-resistant events that are compositionally close to conventional lines (Akram et al 2019; Giraldo et al 2019).

Ethical debates also encompass distributive justice and global food security. Reviews emphasize that GM crops can increase yields, improve pest resistance, and stabilize production, supporting more affordable animal feed and protein sources in regions facing food insecurity (Giraldo et al 2019; Rodríguez et al 2022; Dolapo et al 2025). Critics counter that benefits are unevenly distributed, may increase dependency of small farmers on a few multinational seed companies, and can exacerbate socio-economic inequalities (Tsatsakis et al 2017; Abushal et al 2021; Rodríguez et al 2022). For small rabbit producers, access to cheaper, more stable GM-based feed may improve livelihoods, but can also tie them to global GM commodity chains.

**Legislative and regulatory frameworks for GM feed.** Safety assessment of GM crops used in rabbit feed depends strongly on jurisdiction. In the European Union, GM food and feed are regulated under Regulation (EC) No 1829/2003 and implementing rules, which require detailed molecular characterization, compositional analysis, toxicological and allergenicity testing, nutritional assessment and environmental risk assessment before authorization (Kleter et al 2018; Giraldo et al 2019). Regulation (EU) No 503/2013 further specifies requirements for GM food and feed applications, including 90-day rodent feeding studies when triggered by hazard indications, and case-by-case long-term or multigenerational studies (Kleter et al 2018). GM feed materials must be traceable along the supply chain and labelled when GM content exceeds 0.9% in the EU (Kleter et al 2018).

In many non-EU countries, including the United States and several African states adopting GM crops, regulation tends to be more product-focused and sometimes less restrictive. Reviews highlight that these systems often rely on substantial equivalence, targeted toxicology and exposure assessments, and may not systematically require animal feeding trials if compositional data reveal no new hazards (Giraldo et al 2019; Rodríguez et al 2022; Dolapo et al 2025). Despite such differences, there is broad agreement that 70-90% of GM crop biomass globally is used as animal feed, making robust feed-oriented assessment and traceability crucial (Giraldo et al 2019).

For rabbit producers, the practical implication is that the legality of using GM maize, soybean or cottonseed, and whether rabbit meat must be labelled as “from animals fed GM feed”, depends on national and regional legislation. In the EU, feed compounders must respect labelling and traceability rules for GM materials, while in other regions GM use in feed may be more permissive and labelling of derived animal products less stringent (Kleter et al 2018; Giraldo et al 2019).

**Religious and socio-cultural perspectives.** Religious and cultural responses to GM foods and feeds are heterogeneous but tend to revolve around several common themes (Oroian et al 2025). Ethical reviews on agricultural biotechnology point out that many critics perceive GM technology, especially transgenic modifications crossing species barriers, as “tampering with nature” or with the divine order, raising concerns even in the absence of demonstrated health risks (Tsatsakis et al 2017; Gatew & Mengistu 2019; Abushal et al 2021). These concerns can be particularly strong when genes from prohibited animals (such as pigs in some interpretations of Islam or Judaism) are hypothetically introduced into plants or other animals, though in practice most commercial GM feed crops use plant or microbial genes (Tsatsakis et al 2017; Abushal et al 2021).

With respect to dietary laws such as halal and kosher, most discussions focus on the status of the final food rather than what the animals were fed. Reviews of GM foods and religious issues argue that, where the GM modification does not introduce forbidden species components into the final edible product, GM crops and animals may be regarded as permissible, provided that safety is adequately assessed and transparency is maintained

(Gatew & Mengistu 2019; Abushal et al 2021). However, the literature also notes that there is no universal consensus and that positions vary among religious scholars and communities, reinforcing the need for clear labelling and informed consumer choice (Gatew & Mengistu 2019; Abushal et al 2021; Dolapo et al 2025).

Public perception studies cited in reviews show widespread scepticism about GM foods. For example, a survey reported that nearly half of respondents believed GM foods are harmful, while only a minority thought they are safe and a substantial proportion felt they lacked sufficient knowledge to judge (Blagoevska et al 2021). Consumer distrust is fuelled by uncertainty about long-term health and environmental effects, perceived corporate control and ethical objections, which also influence acceptance of GM feeds in livestock and rabbits (Blagoevska et al 2021; Rodríguez et al 2022; Dolapo et al 2025).

**Environmental aspects relevant to rabbit feed crops.** Even when viewed through the lens of rabbit production, environmental impacts of GM crop cultivation remain relevant. Reviews of GM crops in food and feed emphasize that insect-resistant and herbicide-tolerant varieties have often reduced broad-spectrum insecticide applications and facilitated conservation tillage, bringing certain environmental benefits (Tsatsakis et al 2017; Giraldo et al 2019; Rodríguez et al 2022). However, they also document risks such as evolution of herbicide-resistant weeds, potential effects on non-target organisms, and uncertain consequences of gene flow to wild relatives, with impacts on biodiversity still debated (Tsatsakis et al 2017; Giraldo et al 2019).

A particularly important link between environment and health is mycotoxin contamination. Insect-damaged maize is more susceptible to *Fusarium* infection and fumonisin production. Studies within the MARLON project and related reviews indicate that Bt maize tends to have lower fumonisin levels, which is beneficial for animal health and can indirectly protect human consumers of animal products derived from such feeds (Tsatsakis et al 2017; De Santis et al 2018). This environmental-health interaction is directly relevant for rabbits, which are sensitive to some mycotoxins and often rely on maize-containing compound feeds.

**Comparative synthesis of pros and cons.** The major scientifically documented advantages and remaining concerns regarding GM feeds for farm rabbits and other livestock can be summarized as follows in Table 1.

Table 1  
Main advantages and concerns of GM feed use in rabbits and livestock

<i>Aspect</i>	<i>Main points (pros and cons together)</i>	<i>Citations</i>
Animal health and performance	Most feeding trials in livestock show that first-generation GM maize and soybean support normal growth, reproduction and health; a rabbit study with up to 40% GM cottonseed over 180 days found no biologically relevant serum biochemical changes. Some rodent meta-analyses report liver and kidney alterations and argue that 90-day tests may not reveal chronic toxicity, calling for longer and multigenerational studies.	Séralini et al (2011); Snell et al (2012); De Vos & Swanenburg (2018); Salisu et al (2018); Akram et al (2019); Shen et al (2022)
Human consumer safety	GM DNA and proteins are largely degraded in the digestive tract; compositional studies and feeding trials support nutritional equivalence and do not demonstrate added allergenicity or acute toxicity in animal products. Yet, identification of serious adverse events with certain GM events in animal studies and limited long-term human data underpin calls for precaution and mandatory labelling.	Snell et al (2012); De Santis et al (2018); De Vos & Swanenburg (2018); Akram et al (2019); Giraldo et al (2019); Shen et al (2022)

Mycotoxins and indirect health effects	Insect-resistant Bt maize often shows reduced fumonisin contamination, improving feed safety for animals and indirectly for humans. For some other mycotoxins, results are inconclusive and context-dependent, so ongoing monitoring is recommended.	Tsatsakis et al (2017); De Santis et al (2018); Akram et al (2019)
Environmental impact	GM crops can reduce insecticide use and support conservation agriculture, but also contribute to herbicide-resistant weeds, possible non-target effects and uncertain biodiversity impacts. These environmental changes indirectly affect feed safety and sustainability for rabbit production.	Tsatsakis et al (2017); Giraldo et al (2019); Rodríguez et al (2022)
Ethical and welfare issues	Potential welfare benefits arise from lower pesticide exposure and mycotoxin burdens, while heavy reliance on animal testing and concerns over corporate control and smallholder dependency raise ethical questions. Many argue for risk-benefit frameworks that weigh health, welfare and food-security benefits against uncertainties and social impacts.	Séralini et al (2011); Akram et al (2019); Gatew & Mengistu (2019); Giraldo et al (2019); Abushal et al (2021); Rodríguez et al (2022); Dolapo et al (2025)
Legal and regulatory context	The EU applies stringent pre-market authorization, traceability and labelling for GM feed and food, including feeds for rabbits; other regions use more flexible, product-based assessment with less emphasis on animal feeding trials. Divergent regulations affect trade, availability of GM feed ingredients and labelling of rabbit meat from animals fed GM diets.	Kleter et al (2018); Akram et al (2019); Giraldo et al (2019); Rodríguez et al (2022)
Religious and consumer acceptance	Religious analyses generally focus on safety, species origin of transgenes and stewardship; positions vary, but many authorities accept GM foods if no forbidden components are introduced and safety is demonstrated. Public perception remains cautious; many consumers express concern or uncertainty and demand transparent labelling and more independent research.	Gatew & Mengistu (2019); Abushal et al (2021); Blagoevska et al (2021); Rodríguez et al (2022); Dolapo et al (2025)

**Conclusions.** For farm rabbits, available evidence indicates that typical first-generation GM feed ingredients such as Bt maize, Roundup Ready soybean and GM cottonseed can be nutritionally equivalent to conventional feeds and, in controlled studies, do not produce clinically significant adverse effects, while offering potential benefits such as reduced mycotoxin exposure and improved feed security. At the same time, limitations in study duration, mixed results from some rodent experiments, and broader ethical, legal, environmental and religious concerns mean that a cautious, transparent, and case-by-case approach remains essential, together with ongoing development of long-term, species-relevant safety assessments.

**Conflict of interest.** The authors declare that there is no conflict of interest.

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