German Federal Institute for Risk Assessment

FAQ

31 March 2025

Questions and answers on genome editing and CRISPR/Cas9

→ Changes compared to the version of 27 October 2022: Update on the new EU regulation on the use of NGT in plants, question on the market situation in the EU

Genome editing is a collective term for new methods that make it possible to carry out targeted interventions in the genetic material (genome) of a cell. The potential applications of CRISPR/Cas9 in particular have already been described in a large number of publications. The German Federal Institute for Risk Assessment (BfR) is scientifically monitoring this development in the interests of consumer health protection. In the following, the BfR has answered the most important questions on the subject of genome editing and in particular on the CRISPR/Cas9 method.

In April 2017, a group of scientific experts from the European Commission published an assessment of new technologies in agricultural biotechnology.

http://ec.europa.eu/research/sam/pdf/topics/explanatory_note_new_techniques_agricultural_biotechnology.pdf

The European Court of Justice (ECJ) made a legal assessment that genome editing is part of genetic engineering in a judgement in July 2018:

http://curia.europa.eu/juris/liste.jsf?language=de&td=ALL&num=C-528/16

The possibilities of detection of food and feed produced using new mutagenesis methods were analysed by the European Network of GMO Laboratories (ENGL).

On 14 March 2025, the Polish proposal (ST-6426/25) for a new regulation for applications of new genomic techniques (NGT) in plants was adopted by the Council of the EU by qualified majority. This means that the trilogue procedure between the Commission, the EU Parliament and the Council can begin with the aim of establishing a new EU regulation for NGT applications in the future.

What is genome editing?

"Genome editing" means "editing genetic information". This term covers various new molecular biological methods that can be used to specifically modify genetic information.

Genome editing methods can be used to introduce targeted changes in the genome of the target organism. This requires two components: a protein (nuclease) that cuts the DNA of the target organism and a "pilot" that guides this nuclease to the desired location in the DNA. The "pilot" (a piece of DNA, an RNA or a protein, depending on the technique) is produced in such a way that it "recognises" the desired site in the genome of the target organism. The nuclease can either be introduced into the cell from the outside (these techniques are called CRISPR/Cas9, TALEN, zinc finger nuclease) or be naturally present in the cell (OGM).

A point mutation (exchange of a single DNA building block, the so-called nucleotides) or a deletion (omission of one or more nucleotides) can be formed. However, one or more nucleotides can also be added (insertion). It is also possible to introduce a larger piece of synthetic or foreign DNA into the cell, which is then incorporated into the genome during DNA repair.

What are the differences and similarities between genome editing and conventional plant breeding methods?

In conventional plant breeding (non-genetic engineering methods), in addition to the natural crossing of plants, spontaneous or chemical or irradiation-induced changes are also generated in the plant genome, which lead to changes at various random locations in the genome. Therefore, in a subsequent selection process, those treated cells or plant clones that contain the desired change(s) must be identified and selected from a large number. For example, certain barley varieties were produced with the help of gamma rays.

In genome editing, on the other hand, genes can be precisely modified. The nature of the change at this defined point depends on how the tools are used in genome editing (see above). In some cases, it is not possible to tell from the result (DNA sequence) whether a mutation has formed naturally or through a new technique. However, genome editing can also be used to create genetic variants that do not form naturally (introduction of foreign DNA).

Do changes to genetic information automatically mean a health risk?

In principle, the genome of all living organisms is changeable and the form of mutations is a regularly occurring process. Each time a cell divides, the DNA must be copied (replication) so that all daughter cells also have the complete genetic information. Small errors occur again and again during this process. Individual nucleotides can be altered and short or long sections can be lost. In humans, the number of uncorrected replication errors is estimated at 1 per $10^9$to 10^{11}replicated ("copied") nucleotides, in other organisms sometimes significantly higher. Only in the fewest cases do these lead to visible changes in the organism (phenotype). Therefore, a change in the DNA sequence does not automatically mean a health risk. However, as part of the risk assessment, it is examined whether the change

made with the help of genome editing alters a gene sequence in such a way that it results in new properties of the organism.

Established procedures and guidelines exist in the EU for the assessment of possible health risks (risk assessment), which, in accordance with the applicable legal provisions, allow an examination based on the available scientific information and data.

What does the abbreviation CRISPR/Cas9 stand for?

CRISPR is the abbreviation for Clustered Regularly Interspaced Short Palindromic Repeats. These are repetitive DNA sequences that occur in the genome of many bacteria and play an important role in the bacteria's defence system. If a virus invades a bacterium, the bacterial cell incorporates parts of the virus DNA into its own CRISPR structure. If another virus with this DNA enters the bacterium, it is recognised with the help of the CRISPR segments. Cas9 is the abbreviation for *CRISPR-associated protein **9***. The Cas9 enzyme docks onto a recognised DNA section and cuts viral DNA (nuclease function). This inactivates the virus.

How does CRISPR/Cas9 work?

CRISPR and Cas9 were originally discovered as part of a system that protects bacteria against the invasion of foreign genomes by viruses or so-called non-compatible plasmids (extrachromosomal DNA). CRISPR/Cas9 has been used and further developed for a special genome editing process for a few years now:

A so-called "pilot" RNA is attached to the Cas9 enzyme ("pilot" function) - it takes over the role of the viral DNA, i.e. it recognises it. If Cas9 finds the matching piece of genomic DNA, it cuts the genetic strand. This DNA break can then be repaired in various ways by the cell's own processes, whereby mutations can form (see above).

What are the areas of application for genome editing?

Genome editing is comparatively easy to carry out in the laboratory and is faster and, above all, more targeted than previous methods (including classic genetic engineering methods). Scientists therefore hope that genome editing will help to form higher-yielding or disease-resistant varieties and breeds in plant and animal breeding, such as mildew-resistant wheat or potatoes that can be stored in cool conditions. In the field of medicine, research is being conducted into the impetus that genome editing can provide for the development of new therapeutic methods for various diseases.

How can genome editing be detected?

An organism into which larger elements of foreign DNA have been introduced can usually be easily detected as a genetically modified organism (GMO) within the meaning of the GMO Directive. Numerous detection methods for various GMOs have already been developed and are available to the food and feed inspection authorities for monitoring purposes. However, there is still a hazard of overlooking something unknown.

Important: The detection of modified DNA is not necessarily the same as the detection of a specific method, as long as the same result could have been achieved in different ways (natural, classical mutagenesis methods; see question "What are the differences and similarities between genome editing and conventional plant breeding methods?").

It is currently impossible to detect that, for example, a point mutation (see question "What is genome editing?") is the result of genome editing, as such changes could also have been formed by other means (natural mutation, classical mutagenesis methods).

How can potential health risks for consumers from genome editing in the area of food and feed safety be assessed at present?

In the EU, the principle applies that food and feed that is not safe may not be placed on the market.

In the view of the EU Commission's expert group, a case-by-case assessment is currently required to assess the risk of organisms created using new techniques (genome editing).

In principle, the established procedures for the health risk assessment of food and feed from genetically modified plants can also be applied to the risk assessment of plants generated with the help of genome editing.

The starting point for the risk assessment of GMOs under current legislation is a comparison with a suitable reference organism (in the case of a genetically modified maize line, the unmodified maize parent line) with regard to molecular structures, important ingredients, toxicological and nutritional properties and environmental compatibility. The differences identified in the process are examined and assessed for possible risks in each individual case using internationally established guidelines. This principle of "substantial equivalence" can also be applied to organisms created with the help of genome editing.

How is genome editing to be assessed legally?

As a scientific institution, the BfR does not decide on the legal classification of genome editing. On 25 July 2018, the European Court of Justice (ECJ) ruled that organisms produced by means of genome editing are to be considered genetically modified organisms (GMOs) within the meaning of the GMO Directive of the European Parliament and of the European Council and are therefore subject to genetic engineering regulation.

Products manufactured in this way are therefore subject to GMO labelling requirements and must be labelled accordingly.

What is the BfR working on in the field of genome editing?

Human health protection is at the centre of the Institute's work. Through its independent scientific assessment, research and transparent communication of health risks, the BfR contributes impartially to the safety of food, feed, products and chemicals. Against this background, the BfR deals with genome editing from a scientific point of view and is in regular dialogue with national, European and other international institutions.

As a scientific institution, the BfR does not decide on the legal classification of genome editing. In accordance with its legal mandate, the BfR, together with other authorities, does not assess the genome editing process itself, but rather the food, feed and products that have been modified using it. The risk assessment is based on the process used in production. Applicants must also provide information on the genetic modifications introduced by the method used.

With the symposium "New technologies for modifying the genome" on 6 December 2016, the BfR provided information on the current state of knowledge and offered a platform for discussing the various aspects. With this kick-off event, the BfR is fulfilling its legal mandate to communicate possible, identified and assessed risks in a balanced and scientifically sound manner.

In autumn 2019, the BfR organised a consumer conference on genome editing. This conference produced a differentiated opinion of informed consumers on the use of genome editing in the form of a consumer vote. This vote was presented to representatives from the fields of politics, science, business and civil society at the final conference.

In March 2023, the BfR, together with the Julius Kühn Institute (JKI), the Federal Office of Consumer Protection and Food Safety (BVL) and the Joint Research Centre of the European Commission (EC-JRC), organised a conference entitled "International Conference on GMO Analysis and New Genomic Techniques". In addition to the fundamental topics of GMO detection, a special focus was placed on genome editing and its detection. The recordings of numerous presentations from the event can be viewed here. The results of the conference have also been incorporated into a scientific publication (https://doi.org/10.1007/s00003-025-01542-y).

What role does the BfR Commission for Genetically Modified Food and Feed play?

The Commission for Genetically Modified Food and Feed advises the BfR as an honorary and independent body of experts on issues relating to the food and feed safety of products made from genetically modified organisms. As an instrument of external quality assurance, the Commission increases the scientific quality of the BfR's opinions and can support the Institute in an advisory capacity as a network of experts in the event of a crisis. The Commission consists of eleven members, who were appointed for a four-year term via an open call for applications procedure and are characterised by scientific expertise in their respective fields. The members of the commission are obliged to maintain confidentiality towards third parties and to fulfil their duties impartially. Any conflicts of interest relating to individual agenda items discussed at the meeting are transparently enquired about and disclosed. The scientific opinion of the BfR Commission can be seen from the minutes of the meeting. The Commission's recommendations are purely advisory in nature. The Commission itself does not issue any orders or expert opinions and is not authorised to issue instructions to the BfR (and vice versa) or involved in its risk assessments. Further information on the BfR Commission can be found here.

Are genome-edited food products already authorised for sale in the EU?

There are currently no plants or animals in the EU that are obtained exclusively using new genome methods and are authorised for sale as food or feed. Further information is also available from the European Food Safety Authority (EFSA) and the EU Commission.

About the BfR

The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the Federal Ministry of Food and Agriculture (BMEL) in Germany. The BfR advises the Federal Government and the States ('Laender') on questions of food, chemicals and product safety. The BfR conducts independent research on topics that are closely linked to its assessment tasks.

This text version is a translation of the original German text which is the only legally binding version.

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