Genome editing techniques – Implications for risk assessments

Background

Humans have always influenced the genetic composition of other species, through selective hunting, breeding and cultivation of selected individuals or traits. Through time, we have sophisticated our techniques and become increasingly more efficient in shaping the organisms around us to better serve our needs.

In recent time we have seen how new molecular understanding and technological advances have facilitated the production of genetically modified organisms (GMOs), allowing us to design new genotypes by editing of the genome and thus producing improved versions/genotypes with novel traits. However, until very recently, this type of targeted gene editing was extremely demanding/expensive, unprecise, ineffective, time consuming and technically difficult to perform. A new paradigm started in the early 2000`s with the discovery and understanding of the clustered regularly interspersed short palindromic repeats (CRISPR), and the associated protein (Cas9). CRISPR is an important part of the bacterial immune system against bacteriophages, which stores small amounts of the viral DNA in an operon, the CRISPR-locus, which enable the bacteria to recognize/"remember" previously encountered phages and raise an adequate response.

Since the first successful use in mammalian cells in 2012, the CRISPR/Cas9 technology, and others like it, now represent the current pinnacle of targeted genome editing approaches. These methods combine the high precision DNA-cutting abilities of different enzymes and the intrinsic DNA repair system of all cells to perform tailored RNA-guided alterations in the genome. The significantly reduced time, effort and costs associated with this method has changed genome editing from being a niche technology to a mainstream method used by many life science researchers.

The application of these new technologies and CRISPR/Cas9 in particular, is virtually limitless as this method works most types of organisms of commercial interest. Of special interest in this regard is the genome editing of plants and animals intended for food production. Scientists have already produced genderless salmon, virus resistant pigs, hornless cattle, rice with significantly increased yield, mushrooms and apples that resist browning, mildew resistant wheat and blight resistant potatoes. All of these can potentially promote animal welfare and increase food production. In addition, improved health benefits to humans would be added through genetically edited potatoes that produce fewer cancerous substances when fried and soybeans and rapeseeds with modified fatty acid profiles.

However, the power of this new approach and the ease of which it can be applied to various systems also brings severe concerns. Both in terms of the ethical aspects, and the ecological implications of novel (genetically edited) organisms, researchers are concerned regarding how fast this is progressing without proper assessment of the risks involved. Understanding the risks these pose to local biodiversity and food safety, and evaluating how these can be assessed is thus key to ensure safe food and a modern, yet sustainable, agriculture.

Unlike traditional GMO techniques, the new genome editing technologies often promote phenotypic change without inserting foreign DNA into the organisms' genome, or even without making any changes to the genome at all, through epigenetics. The boundaries between genetically "modified" and "edited" are thus hard to define.

Terms of Reference

Based on the above-mentioned concerns VKM will undertake a project to address the following terms of reference:

1. **Describe the various methods that constitute the genome editing technologies.** Different methods and their technologies, including the variation within these and the genomic alterations they result in should be described.

2. **Describe the use of genome editing technologies today, including future perspectives.** The main applications of new genome editing technologies within plant breeding, animal breeding (including farmed fish) and microorganisms should be described, and examples relevant for Norway should be highlighted.

3. **Discuss implications for risk assessment regarding genome edited organisms.** Potential challenges for risk assessment of genome edited organisms (and products thereof) with the existing EFSA guidance for genetically modified organisms should be investigated and described.

4. **Discuss possible implications for biodiversity in Norway**. Potential effects stemming from the spread and establishment following the use of or production of genome edited organisms should be discussed.