Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Breeding genetically modified animals for food production – symposium summary

On June 24, 2014 a one-day symposium "Breeding genetically modified animals for food production" was organised within the frame of Mistra Biotech. The initiative was based on discussions on genetically modified (GM) animals and the realisation that there are differences between GM plants and GM animals produced for food production that should be explored and discussed. These differences are related not only to their reproduction, breeding or genetics, but also to animals being sentient beings. Furthermore is one main criticism of GM plants, their possibly difficult to controllable spread, not necessarily applicable to animals. GM animals are very common in medical research and GM farm animals are already used for the production of pharmaceuticals but up to date, the only GM animal close to market is a GM salmon. This symposium provided an opportunity to learn more about the breeding of GM farm animals, both about methodologies as well as ethical issues, and to discuss pros and cons.

All Power Point presentations are available at:
http://www.slu.se/mistrabiotech/GManimalSymposium

Helen Sang and Bruce Whitelaw (The Roslin Institute, University of Edinburgh) gave an overview on GM techniques that are applicable for poultry and mammals and illustrated these with some actual examples. The technologies have advanced significantly over time and today not only traditional GM technologies such as gene transfer (e.g. via lentiviruses) are used to introduce changes in the genome, but also genome editing tools offer new opportunities. Further development of new tools such as DNA-nucleases, zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALEN), clustered regulatory interspaced short palindromic repeats (CRISPR/Cas9), transposons (SB, PiggyBac, Tol 2), and pluripotent reprogrammed cells is ongoing. Another application of new techniques allows cryopreservation of whole genotypes by culturing primordial germ cells (cells that give rise to gametes) in birds. Previously only sperms could be cryopreserved in birds.

With genome editing technologies a specific DNA sequence is identified and modified, in contrast to more traditional GM techniques where the aim is to insert new DNA fragments into an organism. Theoretical and experimental studies are currently investigating the usefulness of the novel genome editing approaches for emerging infectious diseases such as bird flu and African Swine fever, but also to finally be able to control diseases which already have a significant impact on animal production, such as trypanosomosis in cattle and the porcine reproductive and respiratory syndrome virus (PRRS) in pigs. This technology is based on information on natural occurring resistances or other traits of interest, to modify a defined sequence. Thus, changes are similar to those aimed for by traditional breeding, but improvements can hopefully be reached faster and without the possible loss of other positive characteristics in the population.

Stephan Teglund (researcher at Karolinska Center for Transgene Technologies, Stockholm) explained how GM mice for research are produced routinely today. Around 40 new strains are produced yearly. Some of them are transgenic, some are knock out strains (a DNA sequence is deleted) and some are knock in strains (a DNA sequence is inserted). Animals no longer used for experiments can be conserved by cryopreservation of embryos. Experiences from mice show that different strains (i.e. mice with different genetic background) respond differently on genetic modification; i.e. the effect of a gene knock-out can differ between mouse strains. This may be crucial for livestock where we have many different breeds. Furthermore, knock-out experiments show that gene redundancy can result in unexpected phenotypes. Derivation and characterisation of embryonic stem cell lines is an important task. But, as Whitelaw pointed out, there are no embryonic stem cells for mammalian livestock species. This means that such GM approaches, routinely applied in mice, are not applicable to livestock. Thus, GM mice experiments are, besides the basic research goals, adding important knowledge for possible applications in livestock, and experiences will contribute to reduced welfare issues.

Jesper Lassen (sociologist at University of Copenhagen) talked about the perception of GM animals among the general public in Europe. Studies on consumer perception through the Eurobarometer show that the correlation between the level of scientific knowledge and acceptance of GM techniques is complex: With more knowledge, the number of opponents as well as proponents increases at the expense of the number of undecided. Moreover, qualitative studies show that increased level of knowledge has the impact that opponents as well as proponents become more convinced about their opinion. GM animals are perceived as by far more problematic than GM crops. Perceived risks, views on naturalness, usefulness, and concern for the own health, or of close friends' or relatives' health, play a role for the public perception of genetic technologies. It was shown that moral perspectives have a high influence on acceptance of GM techniques. This goes also for the question of naturalness, an important part of the discussion of GM in farm animals. According to Lassen, moral concern is a more important single factor for predicting the overall attitude towards GM than calculations of risks and usefulness, and may have a veto-like status in the assessment of GM.

Heiner Niemann (Institute of Farm Animal Genetics of the Friedrich Loeffler Institut, Mariensee) talked about the possible role of GM farm animals for the future food production. Food production needs to be significantly increased without detrimental side effects to cope with the ever growing human population and environmental challenges. Will GM facilitate a sustainable intensification? New techniques such as zinc-finger nucleases, TALEN or CRISPR/Cas allow very specific genetic changes to be made without. There are many examples of GM farm animals with changed production traits (growth rate, leanness, fleece weight, milk and fat composition etc.) Farm animals' disease resistance can be modified either to improve the general immunological defence or more specifically, e.g. increasing antimicrobial ingredients in milk. GM could also be used for products with an added value related to human health. Genome editing could for example be useful to develop hypo-allergenic milk. Both development and application of new technologies depend on public acceptance and regulation. Niemann was, however, convinced that diversified milk production using GM will happen in the relatively near future (possibly not in Europe but in other parts of the world). He predicted that qualitative changes in animal products will break down public resistance and open the market for GM food.

Mickey Gjerris (ethicist at the University of Copenhagen) gave an overview of ethical aspects on breeding of GM farm animals, and stated two rules for all ethical argumentation: *Be consistent* and *be nice*. Few of us actually live up to the *be nice*-rule and thereby we break also the *Be consistent*-rule. Researchers, frustrated by the obstacles to develop GM organisms, should remember this, and they should also realise that another basic perspective can result in other values. When discussing GM animals, animals' integrity, and socio-economic issues such as international trade and small scale versus large scale are relevant issues where a range of different views are possible and ethically valid. However, whether GM is considered 'natural' or 'unnatural' is still relevant to ask in relation to the ethical justification of GM-procedures. Further we need to discuss the aim of the genetic modification and who is the winner, and according to what criteria a decision is made. Is GM animals the right strategy to decrease the climate effect of our consumption, or is it better to change our dietary habits? Gjerris also proposed that discussions on the ethics of GM farm animals may lead to critical questions about existing practices in animal production.

Funding for GM livestock research is limited and any applications in animal production are far off. Elisabeth Jonas (geneticist at Mistra Biotech, Swedish university of agricultural sciences) sketched an outline of a breeding programme for GM animals. There are both opportunities and difficulties for an integration of GM animals into existing breeding schemes and Jonas raised questions concerning the number of animals in different generations, inbreeding rate, unfavourable correlations between traits, costs of producing GM animals, as well as social and ethical issues. From a practical point of view, genome editing seems easier and quicker than transgenic modification. That does, however, not necessarily mean that genome editing is ethically neutral or will be easily accepted by consumers.

Finally philosopher Sven Ove Hansson (Mistra Biotech, SLU and KTH) shared his reflections from this day. GM plants that are good for human health are easiest to accept, whereas regarding animals, improvement of animal welfare seems easiest to accept. Given it is possible to improve animal welfare and human health it is unwise not to use possible technology. BUT to do this without thorough ethical consideration is a step backwards, in GM ethics is unusually needed. A general neutral mind set has been considered as an important starting point for discussions. The inclusion of technologies using genetic modification should be kept in mind in the future, especially since methods are being further developed, however relevant discussions also on social and ethical considerations need to be ongoing.

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