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Heritable Genetic Modifications in Food Animals

Report Release Webinar



APRIL 22-23, 2025

Heritable Genetic Modification in Food Animals

Current Situation:

- Global demand for animal-derived foods (e.g., meat, eggs, and milk) is increasing as worldwide arable land declines.
- US food-animal researchers and producers are using genomics and biotechnology to make heritable genetic changes that speed up genetic improvement in livestock.
 - Targeted changes in DNA
 - ***Heritable Genetic Modifications (HGMs)***



Assessing health risks associated with HGM food animals.

- In the US, FDA approval is required for HGM food animals.
- This regulation protects animal welfare and ensures food safety for consumers.
- In 2023, Congress asked the National Academies to assess health risks linked to HGM regulation in food animals.



Study Statement of Task

- A NASEM committee will evaluate the current science behind developing food animals with heritable genetic modifications (HGMs) and associated health risks.
- It will identify gaps in knowledge needed to assess those risks and suggest ways to address them.
- The committee will produce a report outlining current understanding, potential hazards, and research needs.
- The report will recommend research priorities for the next 3–10 years to support regulatory science, targeting agencies like NIH and HHS.



Consensus Study Committee

Eric M. Hallerman, *Chair*, Virginia Polytechnic Institute and State University, Blacksburg

Bernadette M. Dunham, George Washington University, Washington

Lyda G. Garcia, The Ohio State University, Columbus

Fred Gould, North Carolina State University, Raleigh

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Elizabeth A. Maga, University of California, Davis

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Mike J. McGrew, University of Edinburgh, Edinburgh

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James D. Murray, University of California, Davis

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Penny K. Riggs, Texas A&M University, College Station

Thomas E. Spencer, University of Missouri, Columbia

Virginia Stallings, Children's Hospital of Philadelphia, Philadelphia

Aspen M. Workman, U.S. Dept. Agriculture - Agricultural Research Service, Nebraska

Organization of the Report

Chapter 1: Introduction

Chapter 2: Heritable genetic modification of food animals

Chapter 3: Potential benefits and hazards to animals and consumers

Chapter 4: Likelihood of heritable genetic modifications presenting harms to food animals or humans

Chapter 5: Experimental strategies for address risk issues

Chapter 6: Scientific questions to be addressed



Heritable Genetic Modification in Food Animals

Technical Background

Purpose: Generate Beneficial Phenotypes (Traits)

Selective Breeding – ancient and modern-day practice

- Basis for trait improvement of food animals

Reproductive Technologies – essential element for application of animal biotechnology

- Artificial insemination, in vitro fertilization, embryo transfer, and somatic cell nuclear transfer

Gene Transfer – introduction of new DNA sequence into a host genome

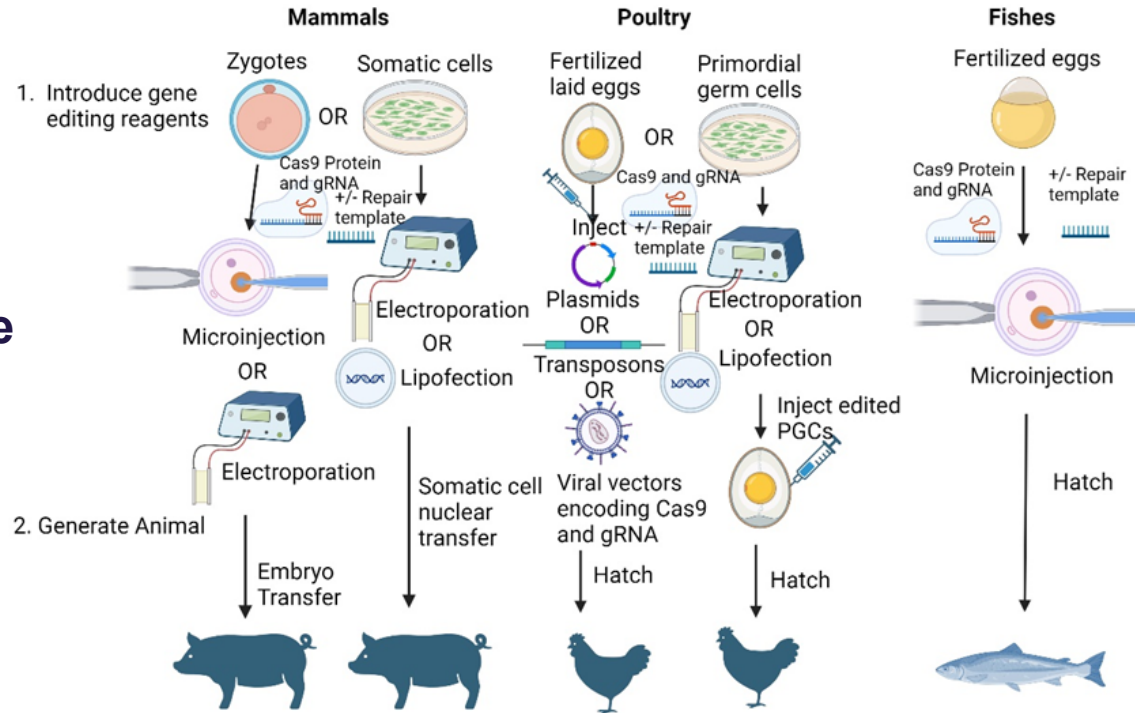
- Limitations: inefficient, no control over site of integration, often has unexpected alterations

Genome Editing – e.g. CRISPR-Cas, site-specific alterations of DNA sequence

- Relatively efficient and precise
- Leads to removal, writing, or rewriting of sequence

Strategies to Generate Food Animals with HGMs

**Genetic Modification
Must be in the Germ Line
to be Inherited**



Examples of HGM Applications

Mammals:

- PRRS-resistant pigs
- *Polled* allele hornless cattle
- “SLICK” allele thermotolerant cattle
- Germline-ablated cattle, pigs, and goats



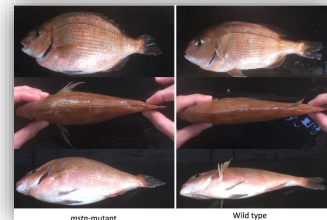
Poultry:

- Avian influenza-resilient chickens
- *Ovalbumin*-knockout chickens
- Sex-marked layer chickens



Fishes:

- *GH*-transgenic Atlantic salmon and other species
- *Myostatin*-knockout red sea bream and other species
- Reproductively (reversibly) sterile salmon and other species



Committee Conclusions

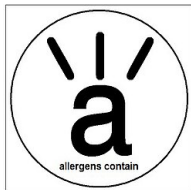
Food from Genome-Edited Animals is Generally Safe to Eat

- Genome editing can improve food production by making livestock more efficient and healthier.
- Genome editing tools complement traditional breeding approaches.
- This technology can speed up the process of adding useful traits to animals.
- Impacts include more sustainable and resilient livestock production, leading to greater global competitiveness for U.S. agriculture.

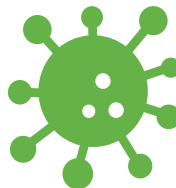
Assessing Risk to Human Health.



1. Risks associated with altered food composition.



2. Possible expression allergenic or toxic compounds.



3. Potential for incomplete disease resistance to drive pathogen evolution.



Recommendation

Updated testing methods for allergenic & toxic compounds are required.



- ✓ Food allergens are well characterized and labelled.
 - ✓
 - Well-defined and have not changed.
 - ✓ Food intolerances or sensitivities tend not to be life-threatening.
 - Poorly understood and complicated by consumer preferences.
- ➔ **Need models for understanding the long-term effects of food sensitivities.**

Knowledge Gap

Research is required to investigate the risk of incomplete disease resistance contributing to pathogen virulence.



- Disease-resistant and disease-resilient animals are being developed.
 - current focus on human disease
- It is ***not known*** if disease resilient HGM animals could drive evolution of a pathogen.

Recommendations

- HGM animals need continued testing to ensure resistance/resilience.
 - new field isolates of pathogens
- Surveillance of HGM animals for signs of disease.
- Targeting multiple pathogen genes may limit risk.
 - “Stacking” to target multiple pathogen genes is limited by current knowledge



Summary of Findings - 1

1. **More accurate and reliable genome-editing tools** are needed, along with more research into how genetic changes influence phenotypes.
2. **Improved ways to distinguish natural mutations from unintentional genetic changes** will help us understand the effects of heritable genetic modification and improve safety assessments.
3. **Assessment of the safety of HGM-derived foods** must be *hypothesis-based* and consider the compositional variation that *normally* exists.

Summary of Findings - 2

4. **Determine if incomplete disease resistance contributes to increased pathogen virulence** along with identifying multiple mechanisms of disease-resistance to target pathogens.
5. **Collaboration with scientists, producers, and consumers** is key to defining animal welfare standards and identifying which HGM traits are truly beneficial to animals.
6. **Consumer engagement to understand public attitudes**, which will shape the use of HGM animals.
7. **Continued access to international markets** via alignment or harmonization of regulatory policies among countries.



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