Agricultural Biotechnology Council of Australia

Biotechnology and animal production

This fact sheet explores the use of gene technology and biotechnology in animal production in agriculture. Globally, there is much research underway in this area.

To-date, no GM livestock or GM feed specifically developed for livestock health or nutrition have been commercialised. The biotechnology applications available in the marketplace relate to research outcomes from applications such as molecular markers and genomics which do not result in a GM end-product.

According to the Council for Agricultural Science and Technology (CAST), genetically modified animals can be divided into six broad classes based on the intended purpose of the genetic modification:

1. to enhance production attributes or food quality traits (for example faster growth)
2. to improve animal health (for example disease resistance)
3. to produce products intended for human health/therapeutic use
4. to enrich or enhance the animals' interactions with humans (for example new color varieties of pet fish)
5. to develop animal models for research purposes (for example pigs as models for cardiovascular diseases)
6. to produce industrial or consumer products (such as fibres for multiple uses).

In Australia, the majority of the focus in animal biotechnology research centres round increasing the nutrition levels of animal feed; disease diagnosis, treatment and prevention; mapping the genetic profile of animal species to understand gene function; and, controlling pest animal species. In the past, research to develop GM livestock to be more productive, for example in dairy cows and sheep has been undertaken, however this has now concluded.

GM animal feed

Researchers in Victoria are using gene technology to improve the forage qualities of perennial ryegrass and tall fescue grass. The modified pasture grasses are expected to be more nutritious with changed carbohydrate levels and improved digestibility. For example, lignin is the part of the plant cell wall that gives it strength and rigidity, and as a result, high lignin results in a stiffer and less palatable grass to livestock. By altering lignin production, the aim is to create ryegrass with higher digestibility.

Researchers have also identified the genes involved in fructan metabolism, and are working to produce grasses with high fructan content for the dairy industry. Fructan is a naturally occurring sugar in pasture grasses and is an excellent energy source. Increasing fructan content and creating a high-energy ryegrass, will translate into an increase in live weight, milk production and possibly fertility.

Improving animal health

Researchers from CSIRO, and animal health company, Imugene Limited, have developed a vaccine for the deadly strain of the **avian influenza** which affected poultry throughout Asia. Researchers now aim to modify the vaccine to address other bird flu strains.

Another research relationship between CSIRO and Imugene looked at **alternatives to antibiotics** for pig and poultry production. Antibiotics are added to animal feed when raising animals to control bacterial and parasitic infections and improve the animal's feed-conversion efficiency. However, concern about antibiotic-resistant organisms in livestock and passing this resistance to humans through food has arisen in many countries.

CSIRO research looked at the use of molecules called cytokines as treatments. Cytokines are proteins naturally produced by the body's immune system following infection by bacteria or viruses. Treatment with cytokines enhances protection against disease. It also reduces harmful responses to disease, such as inflammation. Some cytokines promote growth in livestock and improve the effectiveness of vaccination.

In trials, treating chickens with one particular cytokine, gamma interferon, led to improved animal health, weight gain of up to 10 per cent and increased disease protection. CSIRO has now licensed this technology to Imugene Ltd for commercial development. Similar results have been seen in pigs.

Using biotechnology, Imugene has developed 'adenoviral vector (AV) vaccines', special viruses that are taken up by pig or poultry tissue, but do not cause disease. The viruses are engineered to contain genes for proteins that stimulate the animal's immune system. When cells take up the virus, they make the protein of interest, which in turn stimulates the immune response that provides protection against disease if the animal is later infected with the disease virus.

CSIRO researchers are set to commercialise a new **parasite DNA test** which will improve the diagnosis of three major disease-causing gastro-intestinal worms in sheep. Sheep graziers lose hundreds of millions of dollars annually because of worm infections. The worms are a major cause of lost meat and wool production for Australian graziers, and are becoming increasingly resistant to chemical treatments. The new DNA-based diagnostic tests are rapid, detailed and accurate, and could help reduce this worm problem by assisting producers in applying the most effective treatment during the crucial, early stage of infection.

CSIRO is also working to breed production animals that are better adapted to a range of production environments. Examples of this research include:

- developing DNA tests to identify cattle and sheep that are naturally resistant to parasites and flystrike
- identifying drug resistance genes in parasites, using modern DNA sequencing technology
- developing a cell-based test system for generating improved anti-parasite vaccines
- developing high-throughput tests that identify and characterise new classes of anti-parasite drugs.

In Australia, genetic research aimed at improving beef production has largely been led by the Cooperative Research Centre for Beef Genetic Technologies which has now concluded its funding period. The CRC utilised genomics and genetic markers for outcomes such as:

- improved feed efficiency, carcase and beef quality
- marker tests to allow breeders to select polled cattle (no horns)
- allowing seedstock breeders to cull carriers of certain genetic conditions
- improving reproduction outcomes.

Overseas, an example of biotechnology used to improve animal and human health is being undertaken in Scotland where researchers have successfully developed **GM chickens** that do not transmit the avian influenza virus to other chickens. This genetic modification has the potential to stop bird flu outbreaks spreading within poultry flocks — not only protecting the poultry industry but also reducing the risk of bird flu epidemics leading to new flu virus epidemics in the human population. The longer-term aim of the research is to develop GM chickens fully resistant to avian influenza infection rather than just blocking bird-to-bird transmission.

Mapping genes

An international project to map the genetic profile of **cattle** was launched in 2003, and in 2006 researchers released the most complete sequence of the cow genome ever assembled. The US$53 million project involved researchers from Australia, the USA, Canada and New Zealand. Expected benefits of the project include the ability to identify the genes that control growth efficiency, lactation, muscle development, reproduction and milk composition; and, the ability to breed disease resistant cattle.

CSIRO researchers also released the DNA map of more than 98 per cent of the **sheep** genome in 2006. This new sheep genetic data will allow fast-tracking of the genes responsible for sheep health and productivity, as well as for wool and meat quality. Tests that allow sheep breeders to identify and select animals with superior muscle quality and quantity, parasite resistance and wool quality, are also in the pipeline.

Managing pests

Introduced pests cause a myriad of problems for the Australian environment, such as erosion, and loss of native vegetation and wildlife. They can also have a major economic impact on agricultural systems. Researchers are investigating control options for some of these pests using gene technology. For example, control of carp using gene technology is being investigated because carp can cause significant damage to waterways and they are becoming increasingly dominant over native fish species.

Researchers in New Zealand are investigating the use of gene technology to control **possums**.

Animals modified to be more productive

AquaAdvantage, a **fast-growing salmon**, is the GM animal most developed in the regulatory pipeline globally. Developed by researchers in North America, the salmon contains an additional salmon growth hormone gene, and an antifreeze gene from an ocean pout fish which allow it to produce growth hormone all year-round, rather than just producing growth hormone in the warm months like conventional salmon. The GM salmon is still awaiting final regulatory approvals from US and Canadian regulatory agencies, before it can be used in commercial fish farms.

Following regulatory and scientific hurdles, the salmon now faces Government hurdles to achieve final commercial approval.

Using the GM salmon as a case study, the Council for Agricultural Science and Technology (CAST) has released a report looking at GM animal food products and the regulatory process for such products in the USA. After looking at various sides of the issue, CAST researchers concluded, 'The current regulatory approach, coupled with the prolonged and unpredictable time frame, has resulted in an inhibitory effect on commercial investment in the development of GM animals for agricultural applications with ramifications for US agriculture and food security.'

Consumer focused research

Consumers may be guaranteed tender, juicy steaks in the future because of tests developed by CSIRO scientists. One DNA test identifies cattle carrying a 'tenderness' gene and can be performed at any stage on the live animal. The other DNA test identifies animals with the desirable trait of fat distributed through the muscle, known as 'marbling'.

Researchers in the USA have bred GM laboratory mice whose tissues contain high levels of the healthy properties of fish oil. The research may one day be applied to beef cattle or dairy cattle to produce meat and/or milk with high levels of Omega-3. Omega-3, which is found in abundance in fish oil, and is known to prevent heart disease and reduce blocked arteries.

In 2003, the first GM 'pet' became commercially available. The GloFish, a fluorescent red zebrafish, which contains a gene from a sea anenome was approved by the USA's Food And Drug Administration (FDA) which has jurisdiction over GM animals. The fish are now available to consumers in five bright colours in the USA.

The environmental focus

A pig which utilises phosphorous more efficiently has been developed by researchers in Canada. The so-called **'Enviropig'** is able to breakdown and absorb phosphate in its diet, and therefore expel as much as 60 per cent less phosphorous in its manure. Conventional pigs are unable to use an indigestible form of phosphorus called phytate present in their cereal diets, so producers have to add a phosphate supplement, which in turn means the resulting manure contains concentrated phosphorous.

Application rates of manure to land in areas of intensive pork production can result in pollution of local surface water and ground water. High phosphorous levels in watercourses can result in plant and algal growth, tainting the water and robbing it of oxygen, leading to the death of fish and other beneficial aquatic organisms.

Non-agricultural applications

The production of materials for **pharmaceutical** or medical purposes from animals is another aspect of gene technology science, including the use of animal organs, particularly those from **pigs**, for human transplants. Researchers are genetically modifying pigs to try and overcome issues associated with organ rejection. Up to 700 people die each year in Australia awaiting transplants of organs such as hearts, kidneys and livers.

Cloning

Cloning is another biotechnology research tool. It can be defined as 'the propagation of genetically exact duplicates (clones) of an organism by means other than sexual reproduction.'

Globally, all the major livestock species have now been cloned, including cattle, pigs, goats and sheep. The uses of cloning in animals have been categorised as:

1. Experimental animals used in procedural development studies or to produce unmodified or modified cell lines and clones to be used in other applied or basic studies.
2. Unmodified breed-stock or production animals of high genetic merit as regards production efficiency or product quality or other performance or show measures.
3. Genetically modified animals such as dairy cattle producing milk, with enhanced food or production values, or containing high-value biopharmaceutical products, or pigs modified to be a source of xenogenic organs, tissues or serum.
4. Rare or endangered animals.

Some of the commercial outcomes to-date include:

- cattle and goats that produce high value biopharmaceutical products in their milk or serum
- pigs that can serve as organ, cell and tissue donors for humans.

Agricultural applications have been investigated with cloning techniques, for example, to generate livestock with natural or GM enhanced growth rates and food-conversion efficiencies, or superior and or altered qualities in milk, food or fibre production.

One report, commissioned by FSANZ, states that economic analysis indicates:

- **bovine** cloning in particular holds great promise for eventual wide-scale application in both the beef and dairy industry once the problems of pregnancy maintenance and calf viability can be overcome.
- Wide-scale application in the less intensive **sheep** industry is less certain, but cloning is already being used to propagate individual animals with superior traits, such as ultra-fine wool, for use in stud-breeding programs and intensive production enterprises, and in the generation and propagation of GM stock; applications to the production of wool with new or enhanced qualities is anticipated.
- In the **pig** industry, short-term applications of cloning technology will probably remain restricted to use in generating high value animals for medical use.

Research regulation in Australia

Australian research involving gene technology and animals is regulated by the Office of the Gene Technology Regulator. In addition, GM and cloned animals are subject to state and territory government animal welfare legislation applicable to animals used for scientific purposes, in addition to the Australian code of practice for the care and use of animals for scientific purposes.

Further information

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