FOCUS ON BIOTECHNOLOGY

Biotechnology in Animal Husbandry

Edited by

R. Renaville and A. Burny

Series Editors: Marcel Hofman and Jozef Anné

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COLOPHON

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PREFACE

RENAVILLE R. AND BURNY A.

In the past decade, many impressive advances were made in a number of scientific disciplines that have led to the discovery and development of exciting new biotechnologies that offer the potential to improve the production efficiency of animal agriculture. Nevertheless, while recent progress seems extremely rapid, it is impressive to recall the first attempts to culture (1880) and transfer embryos (1891) took place in the late 1800s.

The application of biotechnologies to farm animals has been the subject of numerous, and often heated, debates. Most of this controversy and bad public perception result from animal cloning, nuclear transfer (Dolly) and other genetic manipulations which could be applied to humans. But, reducing animal biotechnology to these sole applications is extremely restrictive. Indeed, biotechnology, of fundamental importance to the food industry, could be defined as any technology that exploits the biochemical activities of living organisms or their products to create industrial products and processes.

Biotechnology is perceived by many as a collection of very recent procedures but they forget that biotechnology has been around almost throughout human history. Animal breeding, applied to farm livestock such as dairy or beef cattle, or to companion animals such as the many different breeds of dogs, is a type of biotechnology that has been going on for many centuries. Breeders have selected animals that show particular characteristics or traits and used them in breeding programmes to ensure that these traits are retained.

Identification of restriction enzymes that cut DNA chains at specific sites (1970), methods for replicating genes (1973) and nucleic acid sequencing (1977) provided tools for a "new" biotechnology involved with gene identification, gene manipulation and transfer between species. With these techniques, it is now possible to identify how different genes control different characteristics. Scientists are "mapping" the genes on the chromosomes, so that they can see where genes are located and the extent to which they tend to be co-inherited. This will help identify which combinations give the traits that are desired. We now know that this type of conventional breeding of animals involves swapping hundreds of genes, most of which are unidentified. Some traits are determined by a single gene (associated with disease when mutations occur) and these are relatively easy to study. But others, including commercially important traits (ETL/QTL) such as lactation, growth rate and feed conversion efficiency, are controlled by many genes working together. Also, accelerated progress in animal breeding should be possible once the proper genes will be identified, appropriate markers will be found. However, identification of associations between QTL/ETL or candidate gene markers with animal productions or diseases require development of new quantitative genetic strategies. Moreover, embryo transfer, semen sexing, gene transfer, cloning, ... could affect the selection scheme in the near future and require adaptive strategy.

The successful transfer of the growth hormone gene from rats to mice (Palmiter *et al.*, 1982, Nature, Lond., 300:612-615) stimulated considerable interest and substantial research into development of new applications involving manipulation of subcellular components rather than complete organisms. To date, although an impressive body of new knowledge has been acquired and laboratory successes are numerous, biotechnology is still somewhat long on promises but short on performances that contribute to substantial improvements in commercial livestock farming. As the methodology for molecular genetics is refined, expression of introduced genes can be regulated in recipients. Another approach involves identifying and isolating the genes coding for specific proteins that are deficient in certain human diseases. The ideal techniques allow regulating expression of the "foreign" gene or genes so they are only active in mammary tissue; for example, ewes, does or cows that successfully express the introduced trait should secrete the human protein in their milk, providing opportunity for isolation of the compound for therapeutic use. Similarly, immunoglobulin genes or even genes from other species can be introduced into chickens. The antibodies or pharmaceutical proteins resulting from such treatments are concentrated in the egg yolk and can be harvested for use in humans or other animals.

Introduction of foreign genes into bacteria or hybridoma lines so that these altered cells will produce new compounds for harvest is another aspect of biotechnology. Many companies initiated programs to examine application of biotechnology to the somatotropic axis. One of the most extensively investigated technology in animal husbandry is recombinant porcine (pST) and bovine (bST) somatotropin. It is clear that the approach of elevating somatotropin concentration in blood results in a remarkable change in growth and lactation. However, application of these first biotechnology products in agriculture generated a heated debate between USA where bST is accepted and Europe where consumer associations are opposed to use of bST.

One possible 'friendly consumer' alternative method to promote growth or lactation is not to administer but rather to modulate the producing cells. The advent of technology allowing the generation of specifically targeted and engineered antibodies may make such regulation possible and can be considered as an alternative strategy with the potential to make important impact in animal science. Immunomodulatory approaches are attractive for at least three reasons. Firstly, the concept of vaccination is still perceived as 'acceptable' by the consumer when compared with the use of hormones or transgenic animals. With vaccine technology, it is easy to certificate the origin of the products (detection of induced antibodies). Secondly, the approach is economically cheaper than hormonal treatment (the technique involves an amplified response in vivo to small amounts of immunogen) and one of a long duration (weeks to months)). And thirdly, with epitope mapping and peptide synthesis, stimulation of the immune system can now be obtained by using very small molecules without any 'direct hormonal activities'.

Another biotechnological approach consists in manipulating the genome of micro-organisms to reduce pathogenicity (the ability to cause disease) while enhancing antigenicity (the ability to stimulate immunity), providing a methodology to create more effective vaccines. Perhaps even more futuristic and exciting is the prospect for genetic engineering of rumen micro-organisms to enhance their ability to degrade cellulose. Other strains could possibly be developed to break down highly ligninized materials *in vitro* to liberate cellulose or even convert the basic material in to starch. Cereal grain and sugar cane production generate several billion tons of crop residue every year which, if treated to improve digestibility, would alleviate much of the livestock malnutrition commonly encountered in lesser developed regions. Recombinant DNA technology might also be used to produce relatively inexpensive phytases which could be incorporated into animal diets to make phosphorus, which is usually tightly bound into the plant tissue, more readily available for digestion.

Finally, biotechnology must be cost-effective. This should translate into fewer mature breeding animals generating lower quantities of manure with less potential for pollution. The use of biotechnological processes, particularly genetic modification, is extremely important in devising new ways to increase food production, improve nutrient content, and provide better processing or storage characteristics. It follows that when new foods or food components are developed using biotechnology, there are both national legal requirements and consumer expectations for effective systems and procedures to assess the safety of food components for consumption.

As editors, we wish to thank those authors who contributed to this book and helped us to bring this endeavour to fruition.