II. Innovation related to the production of animal-derived agricultural raw materials

Innovation related to the production of animal-derived raw materials has been largely influenced by the application of biotechnology. The traits addressed by animal biotechnology involve nutrition, breeding and health. With respect to animal nutrition, genetically modified bacteria improve animals' health and the efficiency of their feed-to-weight conversion.[310]

Traditional breeding methods supplemented by molecular breeding, e.g. marker assisted selection, have accelerated the breeding process. Reproductive biotechnology, including artificial insemination and embryo transfer, accelerates it further.[311]

Which genes should be genetically modified to improve animal productivity or health is still difficult to predict. This is due to complex interactions of genes with each other and with the environment. Changes such as the introduction of genes that are involved in the expression of growth hormones have been successful.[312]

Animal biotechnology with regard to genetically modified animals has not yet been implemented to the same extent as plant biotechnology.[313] Genetic modification of animals is still in its infancy. Consequently, genetically modified animals for the production of agricultural raw materials have yet not been marketed in the EU. Rapid advances in molecular biology and developments in reproductive biology provide new tools for further innovation. Table 10 shows fields of biotechnological research related to the production of agricultural raw materials involving animals.

310 *Madden,* Food Biotechnology - An Introduction, ILSI 1995, 23, available at www.ilsi.org/publications/ilsifobi.pdf.

311 FAO, Electronic Forum on Biotechnology in Food and Agriculture, Conference 3: The Appropriateness, Significance and Application of Biotechnology Options in the Animal Agriculture of Developing Countries, June 12–August 25, 2000, available at www.fao.org/biotech/C3doc.htm.

312 *Madden,* Food Biotechnology - An Introduction, ILSI 1995, 24, available at www.ilsi.org/publications/ilsifobi.pdf.

313 "Production of transgenic agricultural mammals is challenging and expensive, especially because of their low reproductive rate and internal fertilization and development." AO/World Health Organisation, Expert Consultation on the Safety Assessment of Foods Derived from Genetically Modified Animals, including Fish, Rom 2003, 5, available at www.who.int/foodsafety/biotech/ meetings/en/gmanimal_reportnov03_en.pdf.

Table 10:
Fields of biotechnological research related to the production of animal-derived agricultural raw materials.[314]

Field of research	Example of biotechnology
Animal nutrition	- Genetically modified probiotics to improve the health and efficiency of feed-to-weight conversion of farm animals
	- Genetically modified rumen bacteria to enable animals to make better use of a wider range of food plants
	- Genetically modified bacteria to enhance the nutritional value of silage
	- Genetically modified bovine growth hormone to enhance milk yield, growth rate and protein-to-fat ratio in meat
Animal breeding and health	- Classical breeding methods supplemented by modern genetic analysis, e.g. marker technology, genetic mapping
	- Reproductive biotechnology including artificial insemination and embryo transfer
	- Genetically modified pigs with growth hormone to enhance growth
	- Cloned sheep to disentangle the role of genes and the environment in an effort to improve the quality of the livestock
	- Genetically modified chickens with genes for viral proteins to give chickens immunity to fatal viruses
	- Transgenic fish with disease resistance and stimulation of growth[315]

314 *Madden,* Food Biotechnology - An Introduction, ILSI 1995, 23, available at www.ilsi.org/publications/ilsifobi.pdf. For a risk assessment of the different technologies used in the production of transgenic animals see FAO/World Health Organisation, Expert Consultation on the Safety Assessment of Foods Derived from Genetically Modified Animals, including Fish, Rom 2003, 6, available at http://www.who.int/foodsafety/biotech/meetings/en/gmanimal_reportnov03_en.pdf. Table 1 of that analysis shows further examples of applications of gene transfer into animals. See also National Research Council, Animal Biotechnology: Science-Based Concerns, Washington, 2002. The website animal biotechnology provided by the Federation of Animal Science Societies provides current topics on the subject animal biotechnology, available at /www.animalbiotechnology.org/.

315 For developmental status and economic impact of transgenic fish see Pew Initiative on Food and Biotechnology, Future fish: issues in science and regulation of transgenic fish, Washington 2003, 1 ss., available at www.pewagbiotech.org.

B. Innovation related to the production of processed food

Innovation related to the production of processed food has also been influenced to a large extent by biotechnology. Biotechnology related to the production of processed food comprises the use of microorganisms, cell cultures and genetic modification. The food sector's ability to develop new processed food products is widened by biotechnology.[316] First, the use of microorganisms in the production of processed food is described. Next, the completely new fields of functional food and nutraceuticals are explained.[317]

I. Use of microorganisms in the production of processed food

The most important field of innovation in the production of processed food with regard to biotechnology is the use of microorganisms.[318] Improved genetically modified microorganisms, especially bacteria and yeasts, are used for conventional fermentation. Genetically modified microorganisms are applied in processing bread, wine, beer, yoghurt and cheese. Additionally, new fermentation products for food or feed additives have been developed using genetically modified organisms. Such fermentation products contain enzymes, vitamins, amino acids and flavoring agents.[319] The evolving concept of functional food, nutraceuticals and dietetic food raises exciting prospects for future implementation of biotechnology in the field of processed food production.[320]

A wide range of food additives, supplements and processing aids are obtained from microorganisms. These include amino acids, citric acid, vitamins, natural colorings and gums, as well as enzymes.

316 *Gardner*, The Development of the Functional Food Business in the United States and Europe, in: *Goldberg* (ed.), Functional Foods, Designer Foods, Pharmafoods, Nutraceuticals, London 1994, 468, 476.

317 For a detailed overview of biotechnology in food production and processing see *Reed&Ngodavithana* (eds.), Biotechnology, 2, ed., volume 9: Enzymes, Biomass, Food and Feed, Weinheim 1995. A recent overview is provided in World Health Organisation, Modern Food Biotechnology, Human Health and Development: An Evidence-Based Study, Geneva 2006, 9 s.

318 For an overview see GMO Compass, Additives, Vitamins, Amino Acids, Enzymes - GM Microorganisms Taking the Place of Chemical Factories (2006), available at http://www.gmo-compass.org/eng/grocery_shopping/ingredients_additives/36.gm_microorganisms_taking_place_chemical_factories.html.

319 FAO, Electronic Forum on Biotechnology in Food and Agriculture, Conference 11: Biotechnology Applications in food production: Can Developing Countries Benefit?, June 14–July 15, 2004, available at www.fao.org/biotech/C11doc.htm.

320 *Hardy*, Nutraceuticals and Functional Foods: Introduction and Meaning, 16 Nutrition 688, 689 (2000).