Source: Commercialisation of Biotechnologies for Agriculture and Aquaculture: Status and Constraints in India, eds., U.K.Srivastava, S.Chandrasekhar, New Delhi, Oxford & IBH Publishing Co. Pvt. Ltd. Pp 117-126

CHAPTER 14

Biotechnology for Livestock Improvement: Some Issues and Perspectives

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The research allocations for biotechnology have been reasonably liberal in recent years, more due to what it promises than what it has delivered. In fact, this has already created some tension in the scientific community. Conventional breeders and other technologists suspect that too much is being promised by the biotechnologists to attract resources. They also argue that squeezing the conventional research areas of resources may not be very wise. There are others who believe that biotechnology is one field where closing the global gap is far more easier and also where returns can, indeed, be asked in shorter time. Further, biotechnology is not a Stand-alone field of knowledge. Its greater utility will be really appreciated when it is used to improve conventional agricultural and livestock research programmes. In any case, a comprehensive review of the implications of trade-offs in resource allocation within biotechnology is yet to be made.

It is true that the applications of biotechnology have generated far more commercialisable alternatives in the livestock sector than in the crop sector. Within livestock, vaccine development has had a far more generalised welfare and social impact than, say, development of embryo transfer technology. It is natural that in a developing country with limited resources, those responsible for funding research, whether basic or applied, would like to know what are the economic and social returns from these investments are likely to be, and in what time-frame. This paper does not deal with this issue directly, but reviews the recent debate on biotechnology and raises issues which may have implications for our-condition. It is hoped that a discussion on these issues will provide a perspective in which social, economic and ecological returns

from biotechnological applications in agriculture and animal husbandry can be anticipated.

In part one, I deal with the various applications already achieved, or which are on the horizon, relying essentially on the review by Seidel (1991)[2]. In part two, I have reviewed a survey of public feeling in European Community member countries on the perception of biotechnology, associated environmental risks, anticipated potential benefits, etc. In part three, a review of aquaculture has been drawn upon to illustrate the kind of issues which are being raised in a particular livestock sector.

Part One

BIOTECHNOLOGICAL BREAKTHROUGH IN ANIMAL HUSBANDRY

Seidel (1991) has summerised various commercialised biotechnologies before 1980, after 1990 and expected in the early 1990s in Tables 1-6, given as annexures.

Some of the issues arising out of these trends are:

a) Most of the technologies apply to only a minority of the animals in the population, often aimed at special market segments, for instance, the technology of embryo transfer for upgrading pathogen-free swine herd may be a narrowly focused technology in the US, whereas artificial insemination may apply to a much larger population in the West as well as in the developing countries. Likewise, all turkeys in the US are conceived by artificial insemination because excessive breast meat in the males interferes physically with mating.

The issue is what should be the priorities in resource allocation in a developing country. Should embryo transfer in cattle receive so much attention when much larger gains are likely to be achieved through improvement in artificial insemination technologies.

The second list in Table 2 refers to growth promoters which are widely used in the West. The technologies for storing bovine embryos in liquid nitrogen may be relevant for a narrow market segment. The latter technology makes possible the transportation of frozen embryos with far less risk of disease-diffusion compared to transportation of live animals or semen.

Ivermetcin is a drug developed primarily for animals and found very safe and effective. However, it has also unexpectedly found human use in countries affected by parasites such as the one causing river blindness.

The issue here is whether nutrition-oriented technologies vis-a-vis medicinal technologies have wider social impact and significance or not. Thus, should the former receive a higher resource allocation or the latter? If both are important, as they indeed are, how should resources be allocated by a developing country? In the Indian case, poverty reach-down effects are largest.

Alternatively, in what mix should both be supported, given our comparative advantage and strategic needs.

The technologies which are being commercialised provide much more interesting trade-offs. Therefore, we will deal with them in greater detail.

Bovine somatotropin (a growth hormone), also called BST, has been produced with the help of a bacteria through recombinant DNA technologyinjection of BST in cows every two weeks increases milk production by about 20 per cent. It cannot be used during the first quarter of lactation because at that stage the animals need more energy for their own maintenance. Higher milk production creates stress. The hormone works by improving partitioning efficiency, i.e. more nutrition going to milk production rather than carcass fat. Without this hormone, the milk production declines significantly after one-third of the lactation.

Even though scientists consider BST very safe and cost-effective, it has been banned in some European countries. This is partly because of current milk surpluses and partly because of the risks inherent in DNA recombinant technology.

The issue is whether the improvement in milk production-efficiency through better management of nutrition will not be advantageous compared to the improvement through BST implant. The stress on the animal and the consequences for subsequent conception rate, digestibility efficiency, etc., have to be properly weighted.

The programme to produce vaccines to eradicate brucellosis in cattle and for pseudo rabies in swine are obviously quite effective investment choices.

The technology of cryopreservation of embryos makes it possible to make exact copies after looking at the adult performances of the clone. This also makes it possible for "automatic sex selection, faithful reproduction of heterozygous transgenic animals, and reproduction of outstanding cross-breed animals" (Seidel 1991: 102). The sexing of embryos is possible through a Y chromosome-specific DNA probe.

Transgenic animals: The possibility of transferring genetic information from one specie into an animal creating a new genetic resource for the specie has provided one of the most dramatic and exciting applications of biotechnology. Even through commercial application of transgenic animal technology for improving quantity or quality of animal base products has not yet become apparent, concern about social and ethical issues is already being expressed. The possible unintended consequences attached to transgenic animals discussed at a workshop of the National Agricultural Biotechnological Council in 1991 included: (a) The possibility of environmental risk, including impact upon genetic diversity, animals as disease vectors and effects upon wild populations, as well as pollution that may be associated with animal production, (b) issues associated with the well-being of the animals themselves, both in terms of their health and their ability to lead relatively tranquil lives, and (c) the possibility of consequences not readily anticipated.

Among various strategies suggested to provide for these risks the need for strong peer review and greater sharing of information among consumers were considered the key strategies. It was noted that transgenic technology is merely a research and technological tool and should be seen as a part of basic animal genetic research.

The breeding in sheep and goats is season-specific. When days become short and nights long, the penile gland at the base of brain secrets melatonin when it is dark. By feeding melatonine the same effect can be caused as caused by darkness. This helps in animals becoming pregnant any time of the year.

Table 4 provides the technologies on the horizon where technical feasibility and environmental safety are yet to be established.

Tables 5 and 6 provide the future technological goals or needs and the bottlenecks likely to be faced in the application of biotechnology.

The issues which emerge from the review of these technologies are:

(a) The fear of too much of genetic uniformity because of cloning of embryos,

(b) Untoward effects of growth hormones on the health of the consum ers,

(c) Stress on the animals which may eventually show up through higher vulnerability to diseases or other weaknesses,

(d) Possibility of transfer of certain diseases from livestock to humans because of changes in the vectors on account of changes in the animal biology,

(e) Proprietary rights regarding propagation of offsprings from an animal produced through patented biotechnologies, etc.

(f) Relative effect of milk surpluses on the economy of the developing countries where dumping of subsidised exports may depress the prices of the locally-produced milk.

The fear that many socially concerned scientists in developed as well as developing countries have been raising about the applications of biotechnology are essentially based on the fact that a very large proportion of research is done by large multinational companies. It is unlikely that they would like to share their technological investments with developing countries. In most international centres, biotechnology is being used for transfer of genetic characters which are difficult to incorporate through conventional breeding methods. For instance, the International Laboratory for Research on Animal Diseases (ILRAD) is essentially working on developing new diagnostic techniques and vaccines for animal diseases like theileriosis and trypansomiasis (Biotechnology and Development Monitor 1989, No. 1, 16).

The same enterprise, say sheep, is managed by very large farmers in one European country, for example Britain, and by very small farmers in another country, in this case France. The implications for technological change have to be worked out for the respective farming system and the consequent economies of the region. It is true that one cannot expect technology to resolve problems emerging essentially due to political differences. At the same time, the technological change particularly involving biotechnology is likely to generate more and more political questions.

Because of increasing consumer pressure, some of the private companies in the West have voluntarily set up ethics committees which advise the top management on biosafety, consumer interests, and environmental risks in any given research programme. Thus, before approving a research programme, an ethics committee would evaluate the likely consequences to ensure that reasonable care had been taken. In the Netherlands, the Government has made it obligatory that an ethical test be applied about biotechnological handling of animals (B.D. Monitor, December 1991). Three areas which have been identified requiring experiments from the ethical point of view are: (i) transgenic experiments, (ii) embryo transplantations, (iii) substances derived from RNA or DNA techniques and genetically modified macro-organisms. The Dutch Agriculture Minister while announcing the ethical tests, did not incorporate other issues concerning environment, socio-economic consequences or animal testing for research into human diseases (European Biotechnology Information Service, Newsletter, 2 (1) 1992: 20). In 1985, UNIDO, WHO and UNEP set up a working group for assessing actual and conjectural hazards in dealing with biotechnology. The UNCED 1992 Preparatory Committee is also looking forward to incorporating the results of the working group deliberations on bio-safety.

Pan Two

PUBLIC PERCEPTION OF BIOTECHNOLOGY

Recently a public opinion poll on biotechnology was conducted involving a multitude across the European Community. The findings were:

(1) The majority thought that new technologies would improve their life but a significant number (11 per cent) feared that biotechnology might make things worse. There was a greater fear of genetic engineering than of biotechnology.

(2) The awareness of biotechnological applications was higher in Northern Europe and less in Southern Europe where poverty is much more.

(3) Most biotechnological applications were considered worthwhile to be encouraged, ranging from 58 per cent for food processing to 89 per cent for drug and vaccine developments, except in the case of animal biotech nology, where 42 per cent were in favour and 49 per cent against. A large majority favoured adequate *government control* of research.

(4) There were significant country-specific differences with regard to perception of risks, and Denmark had the highest concern in this regard. It

appeared that the more people knew about biotechnology the less they liked it.

(5) A majority of the people learnt about biotechnology from television, followed by newsletters, radio, magazines, etc.

(6) It was most interesting to note that among various sources of information considered trustworthy, the environmental organisations and consumer organisations ranked at the top followed by schools or universities, animal welfare groups, public political organizations (EBIS, July 1991, No. 4, 15-19).

SEVERAL ISSUES EMERGE FROM THE SURVEY

Let us *chronide* these:

(a) A strong distrust of industrial and political organisations implies that the voluntary organisations and consumer organisations would have to take up major responsibility for disseminating information in a manner that people believe it. How public institutions share the potential as well as the actual risks involved in biotechnology would also influence the future reliability of the particular channel of information. Needless to say we need to undertake a similar survey in our country too.

(b) If in developed countries more information implies less liking for biotechnology, the pattern in developing countries would be worth considering. There is a need that scientists in their enthusiasm do not underplay the likely adverse consequences and thus put ignorant people to greater risks.

(c) In a country where policy-making does not generally involve broad-based expert opinion, secrecy and lack of public accountability can play havoc. It will be necessary, therefore, that research programmes and their implica tions, whether for animal biotechnologies or otherwise, are widely shared.

(d) The demand for greater control by the Government even in developed western societies only confirms the distrust against large industries. This has been confirmed in the survey. It is important for Indian biotech-nological companies to decide whether they would like to generate a similar reputation. They have also to decide whether they can evolve innovative mechanisms of partnership with public institutions so that we deal with the problem in our own but a more consumer-friendly way.

(e) It seemed that the perception of risk in animal biotechnologies weighed higher in the opinion survey. The issue is whether society is less likely to trust scientists engaged in animal biotechnological research. And if so, should such scientists adopt different ways of communicating their research programmes and the attendant risks more widely. It has also to be established whether the risks, indeed, are higher in animal biotechnologies than in plant-based biotechnologies.

Part Three THE CASE OF FISH BIOTECHNOLOGY[3]

Even though no fish has, perhaps, yet been patented, in 1987 the US Patent and Trade Mark Office decided that polyploid oysters were patentable. This decision, resulted in a patent for the Harvard mouse. Subsequently, oysters were never granted a patent because they did not meet the patent requirement for non-obviousness. However, if fish genes were considered part of inventions, there is a fear that fish genes as well as fish varieties might become patentable (B&D Monitor, 1991).

Much of the current biotechnological results, studies have shown, seems to be directed at high-input aquaculture (i.e. well-trained staff, pumps, tubewells, and formulated feeds). To justify these costs, the farmers would have to produce value-added products aimed at export markets. Several technologies have, on the other hand, improved fish production on a large scale. For instance, human chorionic gonadotropin (HCG), prepared from urine of pregnant women, has been injected into mature fish for the induction of spawning. The technique first developed in 1934 has boosted Chinese and Indian carp seed production. The sex determination and control, whether through hormonal or genetic means, is a priority in the above culture. Temperature shock has been found to be an important method of generating a monosex population. Sterile fish are known to grow faster because more energy goes into additional muscle development rather than development of reproductive organs.

The polyploidy in fish or molluscs has become commercially very attractive. The growth hormones have been synthesised by using recombinant DNA technology for subsequent injection to increase the fish weight. Transgenic fish requiring insertion of a DNA sequence controlling growth hormone production has become one of the frontier areas of biotechnological application. So far, the introduction of genes into the chromosomal DNA has been successfully done but transmission of the gene producing growth hormone to the subsequent offspring has not been achieved so far.

Biotechnology has also been used to improve feed-conversion efficiency in the fish. The environmental impact can be quite serious, particularly in the agricultural-aquaeulature system. The toxic substances, being part of livestock fields such as heavy metals, pesticides or antibiotics, may accumulate in the pond sediments and the fish.

Some of the issues are:

(a) Apart from following the precautions applicable to animal biotechnology in general, several specific precautions have to be exercised in aquaculture. Given the choice between technologies affecting high-input intensive aquaculture vis-a-vis low-input intensive enterprise, what should be our priorities?

(b) Since fish can accumulate various toxic substances, the biotechnological changes will have to be evaluated to see whether the modified fish breed accumulated more toxins or the same toxin at a faster rate.

(c) The genetic diversity and consequent prevention of large-scale calamity through diffusion of diseases or pests also needs attention.

SUMMING UP

The issues raised in this note are derived from a review of western scientific debates but with implications for developing countries. Biotechnology is one of those scientific fields where the consequences in developed and developing countries are unlikely to vary in *direction* though certainly in *scale.* Further, consumer awareness being much less in developing countries, scientists and the corporate managers have to shoulder a much greater responsibility. While considering various alternatives for comercialising biotechnologies, we might like to consider the development of processes of peer review which would ensure that social, environmental, ethical, economic and IPR-related issues have been carefully considered. We have also to ensure that the technologies banned in developed countries on any of these criteria do not sneak into our country through misinformation. The fact that many banned pesticides and human drugs are still sold in India should make us take up this responsibility with greater care. There is an added reason for greater caution in the present case. This is the public funding of much of research and development in India. Even in cases where the private sector has invested resources raised within the country or from abroad, regulation will have to be provided by public bodies. Let it be clearly understood that by "public" one does not mean necessarily Government-controlled bodies. The regulatory body should be one which can appraise various implications. It should have access to global data bases on the subject and network with similar regulatory agencies and consumer organisations in different parts of the world. It should comprise scientists (social, political and biological), legal experts, and, of course, representatives of industry, consumer organisations and environmental groups.

Animal biotechnologies may assume significant importance for improving consumption of livestock products within the country as well as for boosting exports. The global markets are unlikely to ignore the issues affecting the way animals are fed, reared or processed. The livestock, we should also note, is far more unevenly distributed than land. The high income and employment elasticity of the livestock sector is an added factor for giving it greater attention in future developmental strategies. But as in any technological change process, the gains can be ensured for either a few or many. It is here that we have to make our value and ethical position explicit.

NOTES AND REFERENCES

1. Paper presented at the National Workshop on 'Commercialisation of Biotechnologies for Agriculture and Aquaculture', Indian Institute of Management, April 23-24, 1992. Prof. Anil K. Gupta belongs to CMA in IIM Ahmedabad.
2. George R. Seidel Jr. (1991). 'Biotechnology in Animal Agriculture'; In: *Agricultural Biotechnology at the Crossroads: Biological, Social and Institutional Concerns,* NABC Report 3, Ed. J.F. Macdonald, National Agricultural Biotechnology Council, Ithaca, New York, pp. 97-110. In view of this being one of the most comprehensive reviews, I have taken the liberty of developing my arguments to elaborate on Seidel's observations.
3. This section depends entirely on the review of fish biotechnology given in *Biotechnology and Development Monitor,* June 1991, (7) 3-9.

ANNEXURE

Table 1: Examples of biotechnologies In widespread use commercialised before 1980

Selective breeding
Nutrient requirements of animals
Feed analysis
Vaccination
Veterinary diagnostics and therapeutics
Artificial insemination (mostly cattle and poultry)
Crossbreeding
Regulation of reproductive cycles
Embryo transfer
Ultrasound to measure carcass fat

Table 2: Examples of biotechnologies In widespread use commercialised after 1980

Growth promotants (other than DES) and ionophores
Use of bypass (of rumen) protein and fat
Monoclonal antibodies for diagnostics
Storage of embryos in liquid nitrogen
Ivermection to treat parasites
Ultrasound for veterinary diagnostic purposes

Table 3: Examples of biotechnologies In use commercially In early 1990s

Bovinesomatotropins to improve milk production
Vaccines inducing antibodies distinguishable from those due to natural infections
Cloning embryos by nuclear transplantation
Sexing embryos
In vitro maturation of oocytes from slaughterhouse ovaries
In vitro fertilisation and culture of embryos
Oral melatonin to control seasonal breeding in sheep and goats
Induced twinning in cattle

Annex, contd..

Annex, contd.

Table 4: Examples of findings or biotechnologies that are likely to have application In production agriculture In the future

Transgenic procedures
Polymerase chain reaction
Sexing semen
Embryonic stem cells
Homologous recombination
Artificial chromosomes
Somatotropin and beta agonists for meat production
Growth factors
Second messenger systems
Transcription factors and other regulators of gene expression
Early pregnancy factor
Trophoblast-specific interferons
Marker-assisted selection

Table 5: Biotechnologies! needs in animal agriculture

Gene maps
Basic information about all aspects of animal biology, especially appetite, stress, disease
Sexed semen (eggs for poultry)
Improved techniques to cryopreserve popultry semen
Cloning animals from adult cells
Reliable and simple transgenic technology
Early pregnancy tests
In vitro gametogenesis
Methods of modifying animal products for fat and other characteristics
Quality control for salmonella, etc.
Very inexpensive diagnostics for on-farm use
Immunocastration
Reprogramming layin hens

Table 6: Bottlenecks to applying biotechnology to animal agriculture

Complexity of organisms
Diffuse, underfunded efforts
Instability of funding
Secrecy due to proprietary considerations with many sources of funding.
Research climate that discourages young scientists
Costs of FDA approval process
Regulatory costs of doing research
Time required.to prepare proposals, get committee approvals, prepare progress reports, etc.
Narrow Training and experience of most life scientists
Lack of clear goals
Remoteness of many scientists from needs of farmers

Source: Siedel 1991 (Tables 1 to 6)