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BIOTECHNOLOGY IN ANIMAL SCIENCE: IMPACT IN AFRICA AND ISSUES RELATED TO BIOSAFETY

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ABSTRACT

Two environments are in danger of exposure to hazardous biotechnology products, namely, the developmental laboratory and the field where the technology is applied. Both scenarios require separate risk assessments to understand the physical, chemical and biological dangers involved and to develop appropriate safety regulations for each environment. The paper highlights the common hazardous substances and situations in biotechnology laboratories, and considers the need for safety regulations to protect the manufacturers, users, disposers and transporters of substances hazardous to health. Animal production achievements in Africa associated with biotechnological procedures are discussed.

Key Words: **Biotechnology laboratories, risk assessment, safety regulations**

RÉSUMÉ

Deux environnements sont en danger d'être exposés aux produits hasardeux de la biotechnologie, à savoir le laboratoire où l'on développe la téchnologie et le champ où la technologie est appliquée. Les deux situations nécessitent une évaluation séparée de risque afin de comprendre les dangers physiques, chimiques et biologiques impliqués et de développer des règles propres de sécurité pour chaque environnement. Ce papier met en évidence les substances et situations hasardeuses qui sont courant dans les laboratoires de biotechnologie, et considère le besoin de règles de sécurité pour protéger les fabricants, les utilisateurs, et ceux qui transportent des substances qui sont dangereuses à la santé. Des cas de réussite en élevage en Afrique qui sont associés à des procédures biotechnologiques sont discutées.

Mots Clés: **Laboratoires de biotechnologie, évaluations de risques, règles de sécurité**

INTRODUCTION

The development or refinement of biotechnological techniques is essentially a laboratory-based activity. The end products of this activity, either as novel assay systems, genetically modified organisms, or even recombinant vaccines, are intended to find their way outside the development laboratory either into the field, or into other less specialised, diagnostic, laboratory situations. The development and refinement of biotechnology techniques require safety frameworks which have different terms of reference from those needing to be applied during the field use of the outputs of the developmental biotechnology laboratory.

We have then two different scenarios for risk assessment; the first scenario aims principally at the protection of the environment and the protection and regulation of the developer who operates in a considerably more hazardous environment than his/her customer, and the second scenario aims at the protection of the customer and the environment when handling the output of the developer. The two should not be confused.

Safety concerns in laboratories developing biotechnological systems are complex. Side by side can be found chemical, physical and biological hazards, and the investigator for his own safety must become familiar with all of them (CRC, 1990). Chemical hazards are common to all laboratories and are generally well recognised. All chemicals in use are subject to stringent international labelling requirements, which announce the degree of caution to be used by the operator and graphically point out the mechanisms by which damage may be caused. Disposal and spill information is also contained in abbreviated form so that the chemicals can be properly disposed of in the event of an accidental spillage.

Developed countries have initiated systems for control of substances hazardous to health which have different names depending on the country, but aim to achieve the same ends. These systems are very labour intensive and time consuming but should have the merit of ensuring that the legal and moral obligations of all parties involved in the manufacture, use, disposal and transport of substances hazardous to health are enforced.

Physical hazards also exist: the risk of electric shock from high powered electrophoresis equipment, the danger of exposure to high intensity ultra violet radiation and precautions to be taken when handling liquefied gasses are just a few examples of significant hazards in the biotechnology laboratory working environment.

Radioactive compounds have been used for very many years as tracers and probes in biological systems and the control of their use and disposal is of great importance and has received much attention. Wherever possible, alternatives to radioactive detection methods are made use of, but certain applications are still easier and even better using radioactive substances. The principles which guide the control of use of radioactive materials are basically very simple. Firstly, it is essential to have proper records of which radioactive isotopes are being used in what quantities and by whom. Contamination levels should be kept As Low As Reasonably Achievable (the ALARA principle), and personnel dosimetry is also necessary, although in situations such as ours, it is not very informative. It is essential to have good working relations with the regulatory body which licences the laboratory to use radioactive isotopes. Accurate disposal records are also essential.

It is human nature that the bigger, more real, more threatening and dangerous a hazard is, the more attention and respect it gets. Conversely, the further away the hazard is, the less attention it gets and as a result, laboratory safety practices and rules are designed to inform and protect individuals working in the immediate vicinity of a hazard, and to ensure that they remain aware of other peripheral hazards which are not perhaps their immediate concern. Safety procedures for laboratories have always been written with these conditions in mind, and as a result may appear very daunting to a member of the public unacquainted with the reasons for their existence.

I believe it to be the case that the high level of safety awareness necessary in a developmental laboratory can contribute greatly to reservations on the part of the end user in accepting the outputs. A member of the public in a developing country walking casually through a research laboratory is quite likely to view the ongoing activities with some awe and as a result treat the outputs with considerable reserve. The impression given to the general public, can be one of, "Well they protect themselves to such a great extent, and then expect us to live with what they have produced with no protective measures at all." So the general public can feel itself in a very difficult situation with no apparent support from people they feel they can trust. This situation can be illustrated by the example of the progress of recombinant DNA (rDNA) research at the International Livestock Research Institute (ILRI).

The first rDNA work performed in ILRI took place in specially designed and built filtered cabinets with the operators wearing masks and

gowns to protect themselves against any potential hazard. Nowadays the techniques are performed on the open bench with minimal protection. The assessment of the risk has been done and the level of containment necessary has been reduced to levels appropriate to the actual risk. The reality is that the techniques are safe and are nowadays simply general laboratory practices which are well understood. They are also in routine use for genotyping animal populations, and as research tools.

Many of the techniques in the field of biotechnology have evolved in this way, from beginnings in developmental laboratories with stringent safety regimes through assessment, and into the field. If the nature of this process is not communicated to the general public and to government officers then resistance will still exist when the outputs of biotechnology are being offered to the customer.

BIOTECHNOLOGY IN ANIMAL SCIENCE

Let us consider some of the biotechnological procedures which have arisen in animal science over the years, have a look at their impact and see if their acceptance has been influenced by their origins in developmental laboratories.

Animal production has benefited from biotechnology in many ways. Artificial insemination procedures have, when properly managed, led to improvements in livestock production. Artificial insemination has an impact in production systems and perhaps the acceptability of the technique nowadays is not linked to any origins the technique may have had within a developmental laboratory, but more to the perception of the customer as to whether or not it will work and whether or not it is likely to be beneficial to the customer's particular situation. In this case the passage of time and familiarity with the technique have removed any concerns on the part of the customer as to the safety or otherwise of the technique. Instead, an informed judgement can be made as to the suitability of the biotechnological system for their needs.

Reproductive performance in cattle can be measured using a variety of indices such as age at puberty, number of calves produced per year or lifetime, intercalving interval, period of interval to heat after calving and others. Ideally what is required is a single parameter that can be measured with precision and accuracy in a quantitative way, in a group of animals at a particular location. An excellent candidate for this is the hormone progesterone. Levels of progesterone in blood and milk rise and fall during the oestrus cycle and an assay following accurately the levels of progesterone should allow the reproductive status and performance of the animals to be assessed, with consequent improvement in production. An excellent radioimmunoassay exists for the detection and quantification of progesterone and this has been produced and distributed, and its performance checked by the Food & Agricultural Organisation/International Atomic Energy Agency (FAO/IAEA) Co-ordinated Research Programme. The information on baseline reproductive parameters produced as a result of the use of the kit are considerable. However, the kit relies for its optimal performance on the activities of a trained technician in a diagnostic laboratory. That laboratory must be equipped with advanced facilities including those for counting and handling radioactive samples.

We have, then, two biotechnology systems which differ considerably in their acceptability or suitability for their use in developing countries, yet both having tremendous potential for improving returns on livestock. Artificial insemination has gained acceptance and in properly trained hands offers a great deal. The radioimmunoassay system for progesterone is not a system which can be operated outside a laboratory in its present form, and is unlikely to be adopted by local private or public enterprises.

These two techniques could be used as examples of biotechnological systems which have different levels of development: one has developed sufficiently to be accepted and assessed by the customer and the other, although beneficial, has not evolved that far. It is apparent that for a biotechnological system to achieve great impact and acceptability, it must have reached a certain stage in its evolution. The next step in the evolution of the radioimmunoassay for progesterone, for example, is to transfer the system to an enzyme

linked assay which is more stable and does not include the use of radioisotopes.

Embryo transfer represents perhaps the most striking example of a biotechnique which in Africa is on the verge of developing from a laboratory or research based tool, to a technique which can be routinely applied, assessed and understood by governments such that the full potential of this system, which allows essentially disease free embryos to be transported from one place to another to enhance the productivity of local cattle, can be exploited.

Success has been achieved with embryo transfer in relocating exotic breeds from the developed countries onto the African continent, and interchanges also exist within Africa. Examples are the transfer of the Ndama cattle from West to East Africa, and the transfer of Boran cattle from East Africa to Southern Africa. The evolution of this technology will probably be complete when sufficient experience has been gained in the safety aspects of handling frozen embryos, and the possibility of disease importation using the technique has been sufficiently evaluated to make it unnecessary for the frozen embryos to undergo quarantine procedures.

Vaccination procedures based on tissue culture vaccines for a range of animal diseases have been in practical use for many years in Africa with considerable impact in restricting losses to livestock. Indeed it is one of the aims of ILRI to develop vaccination systems for cattle diseases which are currently constraining livestock productivity in Africa. In the pursuit of this goal novel vaccine delivery systems are being evaluated which are in their developmental phase but which show great promise.

Recombinant attenuated live vaccinia virus has been used as a carrier for the hemagglutinin and the fusion gene of rinderpest with great success in producing neutralising antibodies and in protection (Giavedani *et al.*, 1991). This recombinant vaccinia product is an example of the form of biotechnology which this workshop addresses. It is a defined end product of a developmental laboratory which has been generated by the use of rDNA techniques.

In the USA, recombinant live vaccinia virus has been used in trials as a carrier for the glycoprotein of rabies (Whitor *et al.*, 1984). Recombinant vaccinia also offers tremendous promise as a vaccine delivery system for the protection of animals against East Coast Fever. In support of this ideal ILRI has converted laboratory facilities such that they are capable of handling the vaccinia vector safely, and is currently in the process of building a new expanded containment facility, in which it will be possible to conduct vaccination trials using the products of this research, which will be recombinant vaccines whose aim is to develop effective immunity against East Coast Fever.

Recombinant vaccinia is, then, an example of a technology which is nearing the output stage of its development. It is hoped that in several years time the use of recombinant attenuated pox virus vaccination will be commonplace, and the farmer or extension worker will be as comfortable with it as with any other tissue culture or otherwise derived vaccine. This process can be expedited only if guidelines for biosafety, where these refer specifically to the assessment of possible problems after release of the genetically modified organisms, have been written.

The reality also exists of the production of transgenic animals. The most successful work is in goats and sheep, but transgenic cattle have been made which have been shown to have incorporated foreign DNA (Bowen *et al.*, 1994). This technology is another example of true biotechnology given the rDNA base of the work, and although it is very much still under development it will one day reach the level of understanding and acceptance that will facilitate transfer to the field for traits, and this will only occur in the presence of biosafety guidelines.

Cattle nutrition has benefited from studies on rumen ecology, another area of biotechnology which has been expanding. Pre-treatment of animal fodder has been carried out to allow greater ease of digestion of lignified material in plants. The selection and manipulation of rumen bacteria to enhance their ability to detoxify harmful plant toxins which would otherwise prove fatal, has allowed animals to browse on pastures otherwise denied them.

CONCLUSION

I have tried to show that the impact of biotechnology in animal science in Africa is evolving, just as the techniques which are used themselves evolve. I have also tried to draw attention to the problem that when developmental work is done, the environment in which it takes place is necessarily one in which safety precautions must be on a higher plane than that which is appropriate to the customer. Also, those safety precautions are a completely different set of concerns to the those affecting judgements as to the risks associated with release of genetically modified organisms into the environment. The two must be kept separate, but it must be remembered that the very existence of the stringent safety precautions needed for development will influence the acceptability of the outputs unless the legislators and the general public are better informed. It would be a great shame if the speed of uptake of biotechnological techniques and advances were to be restrained by lack of communication and sharing of knowledge.

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