E/ESCWA/ID/89/CONF.1/7

The First Arab Conference on
Perspective of Modern Biotechnologies
in the Arab Countries
27-30 March 1989
Amman - Jordan

PERSPECTIVES OF ANIMAL PRODUCTION AND HEALTH BIOTECHNOLOGIES IN THE ARAB COUNTRIES

By

Animal Production and Health Division
Food and Agriculture Organization of the United Nations
Rome

This paper has been produced without formal editing.

PERSPECTIVES OF ANIMAL PRODUCTION AND HEALTH BIOTECHNOLOGIES IN THE ARAB COUNTRIES

Paper prepared by

Animal Production and Health Division
Food and Agriculture Organization of the United Nations

for presentation at

First Arab Conference on Perspectives of
Modern Biotechnologies in the Arab countries
Amman, 27-30 March 1989

CONTENTS

Rome, November 1988

1. INTRODUCTION

In recent years, food consumed in the Arab countries has included an increasing amount of milk, meat and eggs. On the whole in the Arab world, growth in the estimated total caloric intake during the past decade, has been about 1.7 percent per year (based on FAO AT-2000 data), while the growth in the consumption of calories of animal origin was about 3.5 percent per year. The exponential rates of growth in production and self-sufficiency ratios (SSR) for beef, mutton, poultry meat, milk and eggs are given in Table 1. The 1974/76 and 1983/85 averages are based on historical data while the year 2000 projections are based on AT-2000 methodology of FAO.

In almost all the Arab countries the growth in demand for red meat is much faster than the growth in production resulting in a decline in SSR. This also holds true for the exporting countries whose exports have declined and at the same time domestic consumption has increased. Production of poultry meat and eggs has in most cases increased at similar rates as the demand and self-sufficiency has been attained in most countries. But when this trend is looked at together with increased imports of feedstuffs, production may not be considered as primarily indigenous. Countries with highly arid environment have a very low SSR for milk and will probably have to continue dependance on imports. Furthermore, in the countries that have large potential for milk production, the SSR has declined considerably.

The main underlying factor for the above trends is the burgeoning demand spurred by rapid increase in income and urbanization. In spite of ensuing economic opportunities, production patterns have not been able to adjust to meet the demand (Qureshi, 1987). The land and livestock resources of the region remain yet to be fully utilized. Major advancements are needed in the technologies that are employed for livestock production. The spread of infectious animal diseases throughout the region must be curtailed in order to make profitable production possible.

An array of conventional technologies are available that could effectively be adopted to improve the standards of animal health and to increase productivity per animal. Recently much hope has been placed in the new technological development known as biotechnology. To what extent will it help developing countries in improving livestock productivity remains to be seen.

There are, however, a number of questions related to biotechnology development that need to be resolved. There is hardly any doubt that the current rapid development of biotechnology will deepen the differences between highly developed countries and the rest of the world. Biotechnology is concentrated in a number of multinational companies. With the strengthening of this tendency coupled with the right to patent living organisms it can only accentuate these differences. For example, production of identical seedlings derived from selected vegetative cells taking place in highly industrialized countries could well lead to losses of millions of jobs in the Third World (Hobbelink, 1987).

Countries of the Third World are well aware of this and of the fact that the current international situation leaves them outside the mainstream of biotechnological development. Some of these, e.g. Brazil, China, Cuba, India and Mexico, are making great efforts to link up with this biotechnology mainstream. Fortunately for these countries, research in the field of biotechnology is not very costly. However, despite this the perspectives for the Third World are not of the best. Modern biotechnology research, apart from laboratories, requires a solid infrastructure and above all an absorptive ability on the part of industry or agriculture to enable it to use and fully exploit the new technology. Large international firms which link modern industry to research support have those conditions.

From the technical point of view, the achievements of biotechnology can be of much value to the developing countries which have a food production deficit. In livestock production, biotechnologies can be employed to expedite genetic improvement, to stimulate body growth, to improve feed utilization and to simplify production of veterinary vaccines and disease diagnosis in the field.

This paper outlines the perspectives of pertinent biotechnologies towards these ends and indicates possible national and international actions to develop and apply these biotechnologies in the Arab countries. In Chapters 2 and 3 promising developments in animal production and health biotechnologies are presented. The assessment of the relevance of these biotechnologies is based on a recent, yet unpublished, paper by Jasiorowski (1988). Chapter 4 presents the required research programmes at national level and indicates international assistance that could be provided.

2.0 ANIMAL PRODUCTION BIOTECHNOLOGIES

2.1 Embryo Transfer

Embryo transfer in cattle has been in existence since the early 1970s, and its application for elite breeding programmes is established. For example 50 percent of the dairy bulls in Canadian A.I. centres result from embryo transfer. Nevertheless, the use of the technique in developed countries has not, so far, increased substantially the rate of genetic progress. It is predicted that the expected additional genetic progress in countries with efficient dairy progeny testing programmes will only be around 10 percent. However, the theoretical models of Nicolas and Smith (1983) proposing to link multiple ovulation embryo transfer (MOET) to a new selection programme based on a nucleus herd breeding system and the evaluation of bulls using the productivity of their siblings showed that new prospectives for selection methods were possible. FAO considers this new approach for genetic selection to be a promising method for the future of animal breeding in the developing countries. This is because the lack of proper infrastructure, has made it often impossible to introduce the mass field performance recording necessary in selection schemes currently used in developed countries.

Microsurgery and sexing embryos. The technique of embryo splitting (into two), which is well established in developed countries, increases the 60 calves born from 100 transplanted embryos to 100 calves born from 100 split embryos. The identical twins produced can usefully be used in research programmes where they also increase the volume and precision of data obtained.

Although several embryo sexing techniques are being intensively researched, to-date none of them is currently suitable for field application. When a practical method becomes available, it will certainly ensure a more widespread use for embryo transfer of value at the commercial level. Research continues on sexing of spermatozoa but it has so far been without success despite many years of effort. If it is eventually successful, then, combined with ET, it will contribute effectively to yet further progress.

Thus where a developing country which has mastered the technique of obtaining embryos, splitting may well be an optional extra. However, as the sexing of embryos is not available, it is too premature to include the sexing of embryos in breeding plans, but there are no reasons why research on these subjects should not be undertaken in developing countries as well.

Maturation of oocytes and in vitro fertilization. Major steps forward may also be obtained through mastering the maturing and fertilizing of mammalian ova in *in vitro* conditions. The latest reports from Ireland suggest that this can be achieved. Professor Ian Gordon of University College, Dublin reports the production of zygotes using oocytes from the ovaries of cows obtained from a slaughterhouse. The embryos obtained after *in vitro* conditions. The latest reports from Ireland suggest that this can be achieved. Professor Ian Gordon of University College, Dublin reports the production of zygotes using oocytes from the ovaries of cows obtained from a slaughterhouse. The embryos obtained after *in vitro* maturation and fertilization have been transferred in recipient cows or deep frozen. This *in vitro* method could be used to provide a cheap supply of embryos for developing countries.

Cloning embryos. The cloning of embryos could well bring about a revolution in animal reproduction. Whilst it is true that the first reports of embryo cloning in mice at the beginning of the 1980s (Karl Ilmensee and independently Peter Hope) were not confirmed in later experiments, it is the latest work of Steen Willadsen which seems to offer the most promise in sheep and cattle embryo cloning. The technical details have not been published. However, from general reports in the scientific press it appears he has cloned embryos through linking embryo cells and oocytes with their nuclei removed.

It is said that cattle embryos can be used for cloning to the 32 blastomere stage. Thus, theoretically, one embryo could give 32 identical individuals. It was reported in Science (29 January 1988) that Willadsen was able to clone cells of previously frozen embryos as well as obtain calves from the second generation of embryos (where the embryo used for cloning itself was obtained by cloning). These are fascinating achievements. Intensive research continues and there is no reason why it should be confined only to a few highly developed countries.

Gene transfer. This is the new and exciting technique to produce transgenic animals which may have great potential for improving animal breeding.

The first successful transfer of genes between different animal species was the now famous transfer of a rat gene regulating growth hormone excretion to mouse embryos which resulted in a giant mouse (Palmiter et. al., 1982). Since then, work has progressed very much. From 1982 onwards 500 various genes as well as promoters have been used and tried in a number of experiments. In 1986, the USDA Research Station in Beltsville (USA) produced pigs integrating and expressing the gene for the human growth hormone. However, nearly all the transgenic animals produced with growth hormone to date have had serious abnormalities in function or morphology.

In 1987, Dr. John Clark (AFRC) in the UK obtained sheep with human genes corresponding to "Factor g" (substance producing blood clotting). These sheep produce "Factor g" in their milk which is then extracted for treating haemophiliacs.

Rover, a US pharmaceutical company, is close to the production of transgenic cows capable of producing milk containing human albumin. This type of milk can have wide application, inter alia, for aiding the recovery of human patients following serious operations.

The most important breakthrough for genetic engineering with mammals in the near future will be in the development of successful methods for a more precise transfer of DNA. So far, in pigs, sheep and goats, numbers of embryos surviving gene injection procedures are below 10 percent, and numbers of transgenic offspring compared to number of embryos transferred are less than 1 percent.

A second breakthrough would be to achieve the transfer of whole gene sequences which are responsible for quantitative characteristics such as milk yield. There is still a long way to go to achieve that aim. For example, in the human genome which contains 50 000 to 100 000 genes, only 300 have been studied sufficiently to allow them to be the subject of genetic engineering. Our knowledge of the animal genes is even much smaller.

2.2 Animal Nutrition

Nutrition is the main limiting factor in animal production especially in developing countries and therefore much hope is attached to the application of biotechnology. On the one hand this focuses on improving the value of the fodder provided and, on the other, increasing the feed utilization by the animal. Biotechnology in this field has found new horizons. Some of the examples are as follows:

As is known, cereals, chiefly barley and maize play a major role in animal nutrition (mainly monogastrics) especially in intensive production systems. In developed countries more than 90 percent of grain produced is used for animal feed. However, cereals are low in essential amino acids, including lysine (as well as threonine and tryptophan). As a result, there have been commercial efforts in industrial synthesis of these amino acids, for supplementing cereal rations. Now, however, efforts are being made to transfer genes responsible for cereal proteins rich in lysine. New cereal species with increased lysine levels are appearing, but there is still much to be mastered before these achievements can be used widely in practice.

Another example of new possibilities is the modification of the microbiological ecosystem in the rumen of animals. From time immemorial man has tried by various means to influence the fermentation process in the rumen. The results achieved are extremely modest in regard to the effort invested. There is currently hope that genetic engineering can be applied to rumen microflora. It seems possible to construct rumen bacteria with greater amylase and xylase activity to break down starch and hemicellulose. Regulation, through genetic engineering, of such bacterial functions as breakdown and synthesis of protein of feed, increased hemicellulose breakdown and above all the possibility of the breakdown of plant lignin not so far done by any animal, is very complex.

The genetic engineering of microflora opens up enormous possibilities for the regulation of fermentation processes in the rumen. Nevertheless, we are far from exploiting the knowledge we have. Little is known so far of the complicated enzymatic relationships in the rumen which are influenced by hundreds of bacterial species. Even less is known of the genetics of these bacteria. Work in this field is of extreme importance for developing countries.

The Arab countries have many forage resources agro-industrial by-products (rice, barley, wheat straw) suitable for ruminant production which are poorly utilized at the present time. Opportunities are being developed in other parts of the world for biotechnology to contribute to break down of fibrous materials (lignin) and increase digestibility of these by-products. The microorganisms can be used prior to ingestion or in the rumen. It calls for a concerted effort to research the areas of rumen ecology, physiology and genetics of microorganisms. Research and training in these basic subjects is needed for the effective application of these new possibilities in the region.

2.3 Production related hormones

Biotechnology offers increasing opportunity to manipulate the life processes of growth and lactation by the provision of naturally occurring hormones in larger doses. These hormones may be produced endogenously through the production of transgenic animals or used externally through periodic dosing of the animal during the periods of its growth or lactation.

The positive effects of growth hormone on animal performance have been confirmed in the last two decades. However, in early studies the results were often difficult to evaluate, because of limitations in the experimental design, insufficient supply and impurity of growth hormone. The yield in purification of growth hormone is extremely low. It was estimated that even if all available bovine pituitary glands from slaughterhouses in Great Britain had been collected, it would have only increased in milk production by 0.5 percent. For the same reason the progress in somatotrophic hormone studies has been hampered by the scarcity of experimental materials. As growth stimulants, estrogenic anabolic compounds rather than growth hormone have dominated the field of animal husbandry in the past.

Genetic engineering or recombinant DNA techniques have made possible production of rare biological materials in large quantity in the last decade. This revolutionary breakthrough has made growth hormone applications in agriculture more realistic and attractive. All members of somatotrophic hormones are polyeptides, which are relatively easy to be manipulated by recombinant DNA techniques. Supply of recombinant hormones in large quantity and high purity is of importance not only to animal testing, but also to identifying the physiological effects which are obscure because of the contaminants of other growth factors from the animal tissue.

The sematotrophic hormones include growth hormone (GH or somatotrophin), somatrocrinin (growth hormone releasing factor, GRF), somatomedins (SM or insulin-like growth factor I, IGF-I, and insulin-like growth factor II, IGF-II), and somatostatin (somatotropin release inhibiting factor, SRIF).

In the last 10 years the genes coding for all members of somatotrophic hormones have been cloned at least from one mammalian species, including human, rat, pig, bovine, chicken and fish, etc. Many of the recombinant DNA applications to identify somatotrophic hormone genes in domestic animals have been successful. The Arab countries have large meat/milk production population of livestock where this therapy could be useful in enhancing meat and milk. In buffaloes an increase by 20-30 percent in milk yield has been reported. It may, however, be desirable to make necessary adjustment to management of these animals.

3.0 ANIMAL HEALTH BIOTECHNOLOGIES

3.1 Disease diagnosis

In recent years, biotechnology has brought veterinary practice new diagnostic methods for disease, new treatment as well as vaccines. The basis of the new diagnostic methods lies in the discovery of ways to produce monoclonal antibodies (MABs) on a large scale and by using relatively cheaply tissue culture methods. New methods of production of MABs are based on the linking of two types of lymphocyte cells (producing antibodies) to the "deathless" mouse cancer cells. "Hybrid" cells replicate themselves without constraint in cell cultures and will be able to form a single antibody for which the mice were immunized. This antibody not only develops a defence reaction (destroys the antigen) but can be used for detecting specific bacterial and viral products (diagnostics), hormones (new, simple pregnancy tests), medicines and even other antibodies. What is important is that the tests are usually used outside the organism (in-vitro) using small samples of urine, milk or blood for the analysis. In the USA over 100 tests based on MABs have been confirmed.

Apart from in-vitro diagnosis, MABs have an even wider application in in-vitro diagnosis as well as in therapeutics (treatment). One example is that of the use of radioactively-labelled MABs in the diagnosis of damaged heart tissue as well as neoplastic changes. Studies are going further. Through the linking of antibodies with specific therapeutic substances (toxins), it will be possible to link diagnosis with therapeutics, e.g. detection of neoplastic changes and, at the same time, the destruction of cancer cells.

3.2 Vaccine production

Application of biotechnology methods in vaccine production represents another important field of new technology in animal health. Genetically engineered vaccines promise a higher grade of innocuity and efficiency as well as a lower cost of production. Promising results of veterinary research in preparation for subunit vaccines, vaccines based on peptide chemistry and live attenuated vaccines, have been achieved. DNA recombinant techniques, expressed antigens, synthetic peptides, monoclonal antibodies and some other biotechnology procedures and products are opening up a new future for animal health immunization programmes. In this connection, improved inactivants and adjuvants are to be the subject of a simultaneous research programme. These developments are only beginning and much more needs to be known about immunological mechanisms and molecular biology of the pathological viruses, bacteria and parasites.

The possibilities of the application of modern biotechnologies to improve production and expression of specific antigens for vaccines against FMD, VSV, Brucellosis, Babesiosis, Anaplasmosis, Rotavirus and pseudorabies have already been tested, leading to variable levels of protection. Such vaccines should be retested in a few Arab countries, mainly in government research laboratories. It would be highly desirable for this activity to be transferred to the private sector, while ensuring that the knowledge acquired is freely available.

Three factors could contribute to quick success in this area. The first is the availability of information on new vaccines; the second is the organization of veterinary services in the region where vaccination against diseases has been an accepted practice in recent decades; and the third is the amount of livestock capital at risk which is rather high in the Arab countries.

The potential dangers of these new products should be properly evaluated, particularly those that include modified organisms released into the environment. The region needs adequate laboratories to conduct high-risk tests in experimental conditions, with established safety standards for laboratories researching and producing these products.

3.3 Disease resistance by genetic engineering

The possibility of genetically engineered resistance by transgenic means has been demonstrated in plants, and requires further research to determine its feasibility in animals. An example of the exploration of natural genetic resistance of indigenous breeds is trypanotolerance in N'Dama cattle breed of West Africa. A project aimed at genome mapping of these cattle is under consideration by donors.

So far, there is very little indication of possibilities to pursue genetic engineering in animals to induce disease resistance.

4. DEVELOPMENT ASPECTS

4.1 Research requirements

Biotechnology today has come a long way from its beginnings a decade ago. There has been such progress in the last few years that new products and processes are becoming available for everyday use. This work which is mainly in the developed countries also holds substantial hope for the developing world.

There is considerable interest in the Arab countries in biotechnology applied to animal production and health. The scientists are aware of the potential of application of these biotechnologies, viz, the development of diagnostic methods, vaccine production, embryo transfers, growth control, etc. and the policy makers seem motivated by the possibility of increasing animal productivity and reducing dependence on inputs.

There is a considerable number of people working on different lines of research, covering almost all the advanced field of biotechnology applied to animal production and health. Some countries, however, are better equipped from the point of view of human resources, infrastructure and development than others; particularly in the field of animal health.

Some countries in the region have established biotechnology programmes at various levels (e.g. Egypt, Iraq, Kuwait and Morocco) operating through science and technology organizations or specific research institutions in the agricultural sector. In all cases, the impact that modern biotechnology could have on the animal production and health sector is recognized. However, careful review of specific activities reflects a lack of definition in setting priorities.

There is, therefore, an immediate need to identify and quantify, from the socio-economic point of view, wherever possible, priority problems, in terms of impact on the countries, particularly those with a certain degree of originality. Scientists must joint multidisciplinary groups in order to formulate projects with clear objectives and well-defined products.

To this end, active research groups should be maintained, stimulating horizontal cooperation and establishing mechanisms for assistance from the more developed centres, while coordinating the action of international bodies in the region.

Two subjects claim particular attention - bio-safety and the availability of knowledge. As regards the first, basic instructions should be immediately issued and respected by projects in the region whose work involves a certain degree of risk (only three countries have isolation facilities for handling modified organisms). The second aspect is related to the patenting of processes and products. Legislation in the different countries varies; however, if any action is taken at regional level, it will ensure the free availability of knowledge.

Immediate applications

Animal production: In reproduction, technologies associated with embryo transfer (superovulation, *in vitro* culture, *in vitro* fertilization, embryo splitting, sexing and cloning) particularly in ruminants and indigenous species (criollo cattle and South American camelids).

In genetics, research should be started on genetic mapping in order to identify characters of resistance to disease, resistance to temperature, greater productivity and all subjects of actual or potential interest when applied to a productive resource.

As well as these two fields, action should be taken to adapt, modify or develop programmes for selection and evaluation of genetic suitability (the success of ET depends upon the suitability of the female) and to study characters of interest in the different species and/or breeds.

In the area of growth, consideration should be given to the impact of exogenous management of growth and production. As products have already been developed, action should be started on the influence of management on metabolic processes, resistance to disease, the way it is applied, economic determination of productive efficiency, effect on reproduction and selection.

Animal health: In diagnosis, the use of monoclonal antibodies and probes already available in the region should be adapted to the development of simple and highly sensitive diagnostic tests (ELISA, agglutination). They should be produced as standard reagents, with production concentrated in no more than two centres in the region. FMD, VSV, BHV-1, HCV, BTV, Rotavirus, Parvovirus, Pseudo-rabies, *Brucella* sp., *Clostridium* sp., *Leptospria* sp., Babesia, Anaplasma, Cowdria, and Trichomonas could be the main infectious agents to be considered, although reagents for the detection of hormones and metabolites should also be developed.

In immunogen production, account should be taken of the agents already listed. However, the technology to be applied in the short term should include mass production of antigens by fermentation, the obtaining of antigenic sub-units and proper handling of carriers, immuno-potentiators and adjuvants. In vaccines of expression particularly through *E. coli* and obtaining of the immunogenic peptides FMD, Brucella, Anaplasma and Babesia would appear to be the best candidates.

Research priorities

These should be defined specifically at national and/or regional level, possibly as follows:

Animal production: The genetic mapping of productive species and identification of characters of interest is a first priority, and also technologies associated with genetic interchange between individuals, breeds or species (chemical, physical or biological).

Animal health: The obtaining of modified, high-density cell cultures, the purification of active principles of complex solutions and prolonged action formulations.

In all cases the level of resources in infrastructure and equipment should be raised if it is hoped to embark on large-scale projects.

Need for training

The most important action in the short term would be maintaining active biotechnology groups in the region under a programme ensuring an adequate level of information and training. This could be specific training in leading centres or technical assistance from experts outside the region.

For the medium and long-term, training programmes should be envisaged in high-level centres, and the establishment of contacts in regional projects; this would facilitate the development of knowledge on priority subjects for the region.

It would be desirable to consider holding courses periodically in research centres in the region. Coordination among international organizations on this aspect is a prerequisite. The following courses would be needed:

Animal production:

- Embryo transfer (superovulation, in vitro fertilization, sexing, splitting, freezing and transfer).
- Manipulation of the genome of mammal cells (genome maps, markers, transgenic species).
- Growth hormone (mechanisms of action, techniques of application, evaluation of production and indicators).

Animal health:

- Application of monoclonal antibodies in diagnosis.
- Use of immuno-enzyme methods and probes in diagnosis and characterization of agents.
- Large-scale production of immunogens and purification of antigens.
- Response of the host to antigens, adjuvants and immunopotentiators.

4.2 International cooperation

Technical cooperation among developing countries (TCDC) is a widely accepted principle and a useful and expeditious mechanism to bring about a desired technological change in production systems common to a group of countries. Support for TCDC has been voiced in many FAO meetings and conferences involving Near East countries. However, the identification of specific problems in accordance with the felt needs of the countries and inadequate support for the coordination mechanism have been the major factors that have impeded the proliferation of TCDC activities on animal production in the region.

The Network approach being followed by FAO is designed to foster international technical cooperation. Actually, networks are a follow-up of traditional assistance provided by FAO, adapted to a new regional reality, characterized by a smaller flow of external resources and a greater availability of national knowledge and experiences which may be exchanged among the countries of the region. It is for this purpose that regional programmes and networks are being set up by FAO on biotechnology applied to animal health and production, bringing together the scientific and technological capacities of countries in the region, thus contributing to regional development through horizontal cooperation.

The multilateral cooperation networks are composed of appropriate scientific institutions concentrating on national or regional priority projects. They have a five-year programme of activities with the following objectives:

- To promote regional cooperation in biotechnology applied to animal production and health.
- To identify resources within the region.
- To establish horizontal cooperation networks.
- To establish an information and training system.
- To facilitate relations between scientists inside and outside the region.
- To provide financial assistance for the conduct of national or regional projects.

It would be of considerable mutual benefit to all participating countries if a multilateral cooperation network on biotechnology is established by the Arab countries.

4.3 Role of FAO

The Food and Agriculture Organization accepts the responsibility for helping developing countries in the application of biotechnology to animal production and health, especially in those countries where it is only now beginning. It is the intention to support national and regional efforts to develop their own applications of biotechnology to local problems in developing countries. This is particularly important as patenting laws appear likely to inhibit the transfer to developing countries of new technologies, products and even domestic animals produced by biotechnology.

The Animal Production and Health Division is one of the pioneers within the FAO programme in seeking to help developing countries with biotechnology. A broader approach to biotechnology has been taken without confining its definition to genetic engineering with transfer DNA as the core. The techniques of embryo transfer are included as recombinant DNA is introduced through insertion into embryos. A broad spectrum of other newly available procedures are considered including breeding programmes with MOET, production related hormones, modification of rumen digestion, monoclonal antibody (MAB) techniques, new approaches to vaccine production and even ELISA methods.

Support from FAO must be based on the opportunity at national level to use apropriate biotechnology techniques. Some developing countries, sometimes known as emerging countries, have a considerable amount of trained manpower and a substantial infrastructure. However, even the least developing countries (LDC) need the benefits of techniques based on biotechnology, for example in new diagnostic techniques for their agricultural exports or new vaccines needed to prevent animal disease epidemics. For these countries, training and infrastructure development will also play an urgent and crucial role.

The Animal Production and Health Division at FAO Headquarters started a series of activities related to biotechnology in 1984, analyzing the situation, needs, conditions and defining its strategy in this field. An informal technical meeting held in October 1985 established broad guidelines and defined a framework for the formal Expert Consultation on Biotechnology in Animal Production and Health which took place in Rome in October 1986. Considering the very diverse conditions in various developing countries, it was decided to concentrate, as a first step, biotechnology activities mainly in Latin America and the Caribbean and in Asia and the Pacific regions.

In 1987, an FAO consultant visited selected institutes in Latin America and the Caribbean Region to ascertain on-going work and the scope for introduction, application and further development of biotechnology methods in the countries of the region in collaboration with local institutes and scientists. The consultancy was arranged to coincide with an FAO Expert Consultation on Livestock Development Policy in Latin America and the Caribbean in Brazil in April 1987. In the Asia and Pacific Region, a parallel consultancy was carried out with similar terms of reference and scope. Another one is being prepared for the Near East region.

The FAO initiative on biotechnology in animal production and health was highlighted through the publication in 1986 of a special issue on biotechnology of the World Animal Review which outlined the key concepts of the new technologies.

As a means of assisting livestock scientists in developing countries, it was decided early in 1987 to commence issuing a bibliography on animal biotechnology as a service to institutes, since up-dated information is very often lacking in these countries. The bibliography is compiled in collaboration with the FAO International Information System for the Agricultural Sciences Technology (AGRIS) and has been very well received by all concerned. It is expected that the bibliography will be published four times a year.

The FAO Expert Consultation on Biotechnology for Livestock Production and Health, which took place in Rome in 1986, recommended that member countries should develop competence through manpower training and establishment of units for utilizing innovations in biotechnology already in use in developed countries. A number of developing countries have already done this and are now establishing an adequate research and development infrastructure to adapt and utilize the biotechnologies relevant to their problems and those best suited to their socio-economic conditions.

FAO is ready to assist in establishing networks of biotechnology centres of excellence on the topics discussed in this paper with the objectives of preparing and distributing essential biotechnology reagents, promoting exchange of information and ideas, arranging regional training programmes and thus avoiding either duplication or neglect of essential areas of opportunity.

FAO is also willing to cooperate with regional technical organizations such as FASRC, AOAD and ACSAD in promoting and supporting research and training in selected institutions of the region.

REFERENCES

FAO (1986). Report of the Expert Consultation on biotechnologies applied to animal production and health. Rome.

Hobbelink, H. (1987). New hope or false promise? Biotechnology and Third World Agriculture, Brussels, Int. Coalition for Development Action.

Jasiorowski, H.A. (1988). New scientific achievements and livestock development assistance to developing countries. paper presented at the Academic Forum of the Royal Veterinary Academy, Madrid.

Nicolas, F.W. and Smith, C. (1988). Increased rates of genetic changes in dairy cattle by embryo transfer and splitting. A Premier MOET Scheme, 1988 - Premier Breeders.

Palmiter, R.D. and Brinster, R.L., Hammer, R.E., Trumbauer, M.E., Rosenfield, M.G., Birnberg, N.C. and Evans, R.M. (1982). Dramatic growth of mice that develop from eggs microinjected with metallothionein-growth hormone fusion genes. Nature, 300: 611-615.

Qureshi, A.W. (1987). Demand, supply and indigenous production of animal and poultry products in the Arab World. Proceedings of the First Arab Conference on Animal and Poultry Production, Rabat, AOAD, Khartoum.

TABLE 1 - PRODUCTION (1000 MT) AND SELF-SUFFICIENCY RATIOS FOR ANIMAL PRODUCTS

		1974/76		1983/85		2000 CS	
		Prod.	SSR	Prod.	SSR	Prod.	SSR
Algeria							
	Beef	46.9	94.0	53.7	67.1	120.0	77.7
	Mutton	56.6	99.6	98.9	87.7	176.0	87.6
	Poultry meat	36.0	98.5	50.3	91.6	138.1	100.1
	Milk	673.7	59.2	948.3	38.7	1747.9	43.3
	Eggs	15.6	74.3	25.3	32.2	162.7	76.5
Egypt							
	Beef	229.0	87.2	290.0	59.1	439.0	68.7
	Mutton	45.0	99.1	51.4	98.6	70.5	91.5
	Poultry meat	95.4	98.4	185.6	62.2	346.4	91.7
	Milk	1788.2	93.6	2308.3	79.6	3429.0	79.2
	Eggs	69.1	100.0	119.0	94.6	192.4	100.0
Iraq							
	Beef	47.1	91.4	39.4	28.0	80.4	31.3
	Mutton	61.3	91.7	62.2	65.4	88.5	68.1
	Poultry meat	29.2	78.9	129.3	62.3	506.1	100.0
	Milk	612.9	81.8	579.0	43.8	959.0	42.5
	Eggs	18.1	48.9	42.3	45.7	223.4	100.0
Jordan							
	Beef	1.4	39.2	1.6	7.4	1.6	5.6
	Mutton	9.7	60.5	15.4	50.3	12.8	22.0
	Poultry meat	20.1	92.8	38.0	86.3	110.0	100.0
	Milk	41.4	38.9	61.7	28.0	77.0	16.5
	Eggs	7.3	65.9	25.8	118.0	65.0	105.1
Libya							
	Beef	9.5	39.5	44.2	53.7	10.0	13.7
	Mutton	35.1	71.9	55.6	62.4	42.6	58.3
	Poultry meat	17.1	68.0	43.0	85.3	54.1	88.7
	Milk	94.6	39.2	124.5	27.2	181.9	29.5
	Eggs	6.8	90.1	16.3	88.6	30.5	103.3
Mauritania							
	Beef	9.7	805.2	13.0	329.9	50.3	157.1
	Mutton	9.9	260.5	11.5	202.9	28.2	128.2
	Poultry meat	2.3	99.1	3.3	99.3	8.1	104.0
	Milk	185.9	82.7	245.9	66.9	346.6	64.3
	Eggs	2.4	98.9	3.2	99.8	4.9	99.2
Morocco							
	Beef	83.6	97.6	120.0	95.4	166.8	79.1
	Mutton	65.0	100.0	71.5	100.0	150.5	102.0
	Poultry meat	49.0	88.7	121.0	96.7	255.1	100.0
	Milk	528.5	85.4	881.8	90.2	1467.9	91.3
	Eggs	50.2	100.0	78.7	99.8	142.7	102.5

Table 1. Cont'd

		1974/76		1983/85		2000 CS	
		Prod.	SSR	Prod.	SSR	Prod.	SSR
Saudi Arabia							
	Beef	8.0	42.3	24.0	23.6	20.0	12.6
	Mutton	31.2	59.0	103.9	42.6	119.3	54.4
	Poultry meat	17.2	27.5	195.4	50.5	498.3	77.9
	Milk	272.9	54.3	532.8	31.5	1748.6	59.3
	Eggs	11.8	59.7	103.0	98.2	243.7	100.0
Somalia							
	Beef	42.9	131.2	42.5	106.7	75.6	98.7
	Mutton	61.0	133.0	64.7	129.0	133.2	119.9
	Poultry meat	2.5	100.0	3.3	100.0	6.7	89.9
	Milk	687.0	98.0	738.9	86.3	1101.7	88.0
	Eggs	1.9	100.0	2.6	100.0	4.0	88.8
Sudan							
	Beef	179.6	102.6	309.0	101.0	439.3	100.0
	Mutton	100.9	103.6	130.7	106.7	216.4	110.2
	Poultry meat	15.4	99.1	25.0	98.8	52.0	96.5
	Milk	1379.0	98.7	2924.0	95.7	4020.6	93.2
	Eggs	20.3	100.0	40.0	99.8	72.0	101.7
Syria							
	Beef	13.1	54.6	32.8	65.4	65.0	65.5
	Mutton	52.0	100.5	90.5	97.6	163.0	100.2
	Poultry meat	19.3	91.1	87.6	97.6	220.0	100.0
	Milk	577.1	88.0	1093.1	83.3	2154.8	83.1
	Eggs	29.2	90.2	87.5	100.0	231.1	100.0
Tunisia							
	Beef	31.1	89.0	29.5	55.6	47.1	72.1
	Mutton	33.2	93.8	33.8	96.5	45.0	90.6
	Poultry meat	22.1	94.5	42.0	97.8	88.2	100.0
	Milk	241.8	64.7	287.3	55.8	560.0	87.9
	Eggs	16.3	93.8	48.8	98.2	80.0	96.9
Yemen, A.R.							
	Beef	11.6	90.5	14.1	82.0	14.4	57.3
	Mutton	40.6	98.8	46.7	94.1	59.3	72.2
	Poultry meat	1.4	82.1	13.4	19.8	52.5	38.9
	Milk	198.7	88.8	222.8	52.5	269.8	35.9
	Eggs	9.8	97.1	11.9	58.1	35.0	84.1
Yemen, P.D.R.							
	Beef	1.8	91.9	3.0	64.8	5.0	54.9
	Mutton	10.6	88.9	11.6	71.8	15.0	68.2
	Poultry meat	1.4	96.2	1.7	20.2	10.0	50.0
	Milk	53.3	65.8	57.0	24.9	76.8	19.8
	Eggs	1.4	94.3	2.0	62.2	3.8	51.4

Source: FAO AT-2000 data