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Biotechnology in Animal Production in Developing Countries

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Abstract. Biotechnology in animal production is widely used to increase not only the number of a species of livestock animals to meet the requirement for world demand of animal products but also for endangered species to enhance the propagation and sustaining the current levels of biodiversity and genetic diversity. Animal production biotechnology can be defined as the application of scientific and engineering principles to the processing or production of materials by animals or aquatic species to provide goods and services for the well being of human population (NRC 2003). Examples of animal biotechnology include generation of transgenic animals or transgenic fish (animals or fish with one or more genes introduced by human intervention), using gene knockout technology to generate animals in which a specific gene has been inactivated, production of nearly identical animals by somatic cell nuclear transfer (also referred to as clones), or production of infertile aquatic species. However, the only alternative way to improvement or increase the animal production performance is through application of assisted reproductive techniques (ART) in the farm practices. The techniques are such as semen cryopreservation, artificial insemination (AI), oestrus synchronisation and superovulation, laparoscopic ovum pick-up (LOPU), *in vitro* maturation, fertilisation and culture (IVMFC), intracytoplasmic sperm injection (ICSI), embryo sexing, embryo/oocyte cryopreservation, cloning, stem cell, embryo transfer, ultrasonography (pregnancy diagnosis) and radioimmunoassay (RIA).

Keywords: Animal production, Biotechnology, Developing countries

1. Introduction

According to the estimation by Food and Agriculture Organisation of the United Nations (FAO), 70% of world population will be in hunger in 50 years from now (2060). It has been reported that the world human consumption for the animal protein was 29 g per capita daily (or 10 kg per capita consumption). Especially in the advanced countries, the human consumption was approximately 90 kg animal protein per capita consumption. However, the trend toward increased per capita demand for animal source foods is occurring primarily in developing countries (80% of world population).

Through biotechnology, it has the potential to improve the productivity of animals via increase growth, carcass quality and reproduction, improved nutrition and feed utilisation, improved quality and safety of food, improved health and welfare of animals and reduced waste through more efficient utilisation of resources. Therefore, the biotechnology of livestock production is growing faster than any other sectors; and by 2020 livestock is predicted to become the most important agricultural sector in terms of value-added commodity [1].

The global meat production in year 2000 is 229 million metric tones; and it has been predicted will increase up to a 465 million metric tonnes in year 2050. Therefore, the application of biotechnology in production of livestock animal is a need and must to meet the worldwide demand as well as for the genetic improvement in the animal diversity. However, in order to meet this challenge we need the requirement of global efforts to develop and use sustainable practices.

Through the biotechnology activities in production of livestock animal, it has the ability and potential to increase the income and sustained growth in per capita income and changes in diet and lifestyle of human population. It has been reported that the livestock production currently accounts for about 43% of the gross

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value of agricultural production [2]. In developed countries, livestock accounts for more than half of agricultural production, while in developing countries the share is about one-third [1].

2. Implications of Biotechnology in Animal Production

Purchasing power of the poor increases *(average incomes and access to staple food products are improved)*. Rapid growth of animal production stimulates demand for land and increased the value of land, labour and non-agricultural goods and services, leading to economic growth [3, 4]. Poor people spend this additional income due to animal improvement through biotechnology to buy food. Consequently, nutrition, prevention of disease and health-care will be improved. However, biotechnology should be tailored specific to socio-economic situation of a country (e.g. aids in infrastructures and marketing mechanism). However, studies have revealed that the commercialisation of agriculture has reduced the nutritional security of the poor [5, 6]. Therefore, technology, infrastructure and related institution with multi-enterprise are essentials and carefully planned and implemented to ensure animal production is economically viable and sustainable, particularly for the developing countries.

The introduction of multi-enterprise systems in agricultural diversification is seen as the way forward for agriculture in the economic growth especially in developing world; such systems could lift small-scale and marginal farmers out of poverty [7]. Through the introduction of this multi-enterprise system into the production of livestock animal would enhance the purchasing power of farmers and would help them to obtain food security. Besides that, these systems may also support the natural environment and contribute to the wealth creation, thus leading to higher overall growth in the agricultural economy [1].

3. Livestock Industry in Malaysia

The livestock industry in Malaysia comprises the large and highly commercialised sub-sector of poultry and pigs. In Malaysia, the ruminant sub-sector products are highly dependent on importation, for examples 70% of beef, 90% of mutton/goat meat and 95% of milk and milk products are imported annually to meet the local demand. Correspondingly, Malaysia has attained self-sufficiency in poultry meat, egg and pork, but only 30% self-sufficiency in beef, 10 % in mutton/goat meat and 5% in milk. While, for the source of fish, marine fisheries account for over 90%, whereas aquaculture accounts for about 10%.

The priority areas of animal biotechnology in Malaysia are as follows: 1) animal production improvement through reproductive technology, 2) animal feed improvement from local sources, 3) application of biotechnology in aquaculture health management, and 4) production of biological reagent through recombinant DNA technology (such as vaccines, diagnosis system and vaccines delivery). In other words, the specific research priority areas in Malaysia are focused on genetic engineering of animals for improved production and quality, improvement of reproductive technologies, development of cheap feedstuff from local resources, novel vaccines and drug delivery systems and development of rapid diagnostic kits. Animal reproductive biotechnologies are essential to improve the genetics of animals at a rapid rate, to multiply the population of animals at a rapid rate, to facilitate import and export of animals through cryopreservation of gametes and embryos and to increase the income of entrepreneurs and farmers especially in developing countries.

As for the animal breeding and reproduction, the thrust areas are *in vitro* conservation and use of animal genetic resources from indigenous domestic and wild animals and genetic improvement of ruminants using reproductive biotechnologies and recombinant DNA technology. The stage is now set to expand the available technologies to accelerate genetic improvement for identification of individual genes to increase the accuracy of predicting breeding performance.

For the animal nutrition and production, the thrust areas include enzymes and microbial additives, growth promotants and regulators, manipulation of rumen ecosystem and bioprocessing of low quality feed. Feed constitutes a major portion of the total animal production costs. Efficient utilisation of feed to produce meat, milk and eggs can therefore significantly reduce overall production costs.

For the fish production and health, the thrust areas encompass genetic improvement of selected food and ornamental fish, disease diagnosis and control, conservation of genetic resources and fish as a sensor of pollution. Genetic manipulation and gene transfer can improve production and quality of both cultured and ornamental fish. Studies are also needed on conservation of genetic resources by cryopreservation and use of fish as a sensor of pollution of the aquatic environment.

For the animal health, the thrust areas include development of diagnostic reagents and kits, development of vaccines and food safety. Effective disease control is a major prerequisite in enhancing livestock productivity. Effective rapid diagnostic tests to identify the causative agents are either not commercially

available or they are too expensive to be cost effective. Food safety and zoonotic diseases are also of major concern.

4. Major Technologies in Animal Production in Developing Countries

In the developing countries, application of animal biotechnology is essential to improve animal production and to conserve the indigenous animal genetic resources. Specifically, animal reproductive biotechnologies will be useful in augmenting reproduction, implementing embryo transfer and related technologies, diagnosing diseases and controlling and improving nutrient availability.

One application of animal biotechnology is through the production of transgenic animals which is also known as genetically modified organism. Currently, no genetically modified animals have yet been released on farms. However, active research activities have been made globally to develop transgenic animals targeting specific genetic traits of interest, such as growth hormone gene (to increase growth rate), phytase gene (to reduce phosphorous emissions from pigs) and keratin gene (to improve wool of sheep). At this point in time, development of transgenic animal technologies is at its infancy and at research level due to high costs, inefficiency of the gene transfer technique and low reproductive rate of animals. However, human therapeutic proteins in their milk, have organs for xeno-transplantation and resistant to diseases have been produced satisfactorily through application of animal cloning research.

In an effort to improve health through vaccines development, two approaches to develop vaccines using rDNA are proposed: 1) deleting genes that determine the virulence of the pathogen (producing attenuated organisms to produce live vaccines) and 2) identifying protein subunits of pathogen that can stimulate immunity. This approach to improve human and animal health through vaccination is one of the most effective and sustainable methods of controlling diseases in the future.

As for diagnostics and epidemiology, it is important for epidemic disease to pinpoint the source of infection in order to control the diseases and to enable to identify the agents causing diseases (e.g. viruses, bacteria and fungi) by nucleotide sequencing, enabling their origins to be traced.

The nutrition and feed utilisation of livestock animals in developing countries include shortages of feed and increase cost of feed ingredients, improvement of nutrient availability and animal productivity currently used through biotechnology approaches {(enzymes, probiotics, single-cell protein and antibiotics in feed) and (gene-based technologies modifying feed to be more digestible or modifying digestive and metabolism systems to use feed efficiently)}.

5. Major Constraints on Applying the Technology in Developing World

The constraints and limitation of biotechnology in animal production in developing countries are due to factors such as the poor conditions of the human population in such countries that include poverty, malnutrition, disease, poor hygiene and unemployment [8]. In other words, the progress of biotechnology applications is hampered by physico-edu-medico-socio-economic situations of the developing countries.
The major constraints have been specifically listed out by Madan (2003), which include:

- Lack of database on livestock and animal owners in most of the developing world
- Biodiversity within species and breeds
- Biotechnologies development in developed countries not suitable for developing countries
- Uniqueness of animal breeds in developing world (each has its own developmental, production, disease resistance and nutrient utilisation characteristics)
- Lack of trained scientists, technicians and field-workers
- Absence of mechanism between industry, universities and institutions for technology transfer
- Expensive technology to be purchased from developed world
- High cost of technological inputs
- Poor biosafety measures of biotechnology developed in developing countries
- Negligible investment in animal biotechnology
- Lack of clear policy and commitment from the government

6. Conclusions

Biotechnology in animal production in developing countries has been applied only in a few areas such as conservation, animal improvement, healthcare (diagnosis and control of diseases) and augmentation of feed resources. Adopting biotechnology has benefitted by in animal improvement and economic returns to the livestock entrepreneurs and small producers. However, developing countries has to address issues relating to political commitment, trained manpower, infrastructure and funding in research development as well as

industries. In a nutshell, investing in animal production and biotechnologies is a must because it can bring social sustainability, economic prosperity, food security and safety, rural wealth creation and health improvements especially to poor populations in the developing countries.

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