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POPULAR ARTICLE



## Addressal of Enhanced Reproduction and Food Safety Through Biotechnology

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### ABSTRACT

Increasing population, shift from plant-based to animal-based food consumption, scarcity of water and land resources are all escalating the world's food security issues. Biotechnology has developed as a powerful tool to improve a variety of sectors, including animal, plant, medicinal, and environmental etc. Animal Biotechnology is commonly used to raise not just the population of livestock, but also the demand for animal products around the world. Assisted reproductive techniques such as artificial insemination, in-vitro fertilization, embryo transfer technology and other related technologies of food-producing mammals. Along with their utilization in quality assurance programmes, improving quality of livestock products and production of various hormones and enzymes are discussed. Currently, several difficulties hinder the implementation of biotechnology due to lack of infrastructure and insufficient manpower. Therefore, funding from government is required if one has to enjoy the benefits of biotechnology.

**Keywords:** Animal Biotechnology, Assisted Reproductive Technologies, Food Safety, Livestock Products and Challenges.

### INTRODUCTION

Developing countries have been rising at a considerably faster rate in recent years. This growing population could have huge impact on global food consumption because food

habits are shifting solely from being vegetarian to omnivores i.e., animal-based products, fruits and vegetables (Fukase and Martin, 2020). Biotechnology has the potential to enhance animal productivity by increasing growth, carcass quality, improving nutritive value of animal products and feed utilisation. It can also be beneficial in increasing food production and overcoming hunger (Abdullah *et al.*, 2011).

Biotechnology is a branch of science that develops or creates products using biological systems, living creatures, or their components. Karl Erkey, a Hungarian engineer, coined the word biotechnology for the first time in 1919. Due to ability to change the genetic material (DNA) of organisms with the invention of genetic engineering in the 1970s, research in biotechnology and other related fields such as medicine, biology, and so on has grown significantly. Biotechnology now encompasses a wide range of fields (e.g., genetics, biochemistry, molecular biology, etc.). Every year, new technologies and products are developed due to advancement in biotechnology.

### **Biotechnology's Involvement in Animal Production**

In emerging nations, livestock production is one of the fastest-growing agricultural sectors. With growing population and rising per capita income, lifestyle and consumption patterns of food products are changing (Said *et al.*, 2020). Plant proteins are being replaced by animal proteins in global dietary protein demand. This rising demand for livestock products, termed as "Livestock Revolution," has the potential to improve the well-being of millions of under privileged people who rely on livestock for their livelihoods, and might become a vital tool for upliftment of socio-economic status.

It has been possible to improve animal productivity through biotechnology by increasing production and reproductive traits. Biotechnology plays vital role in enhancing the efficiency in resource utilization (Jacquelyn, 2008). It is now possible to select superior germ plasma and disseminate it by artificial insemination, embryo transfer, and other assisted reproductive methods that have been utilised to improve genetics and increase productivity of the livestock.

### **Major Reproductive Technologies in Animal Production**

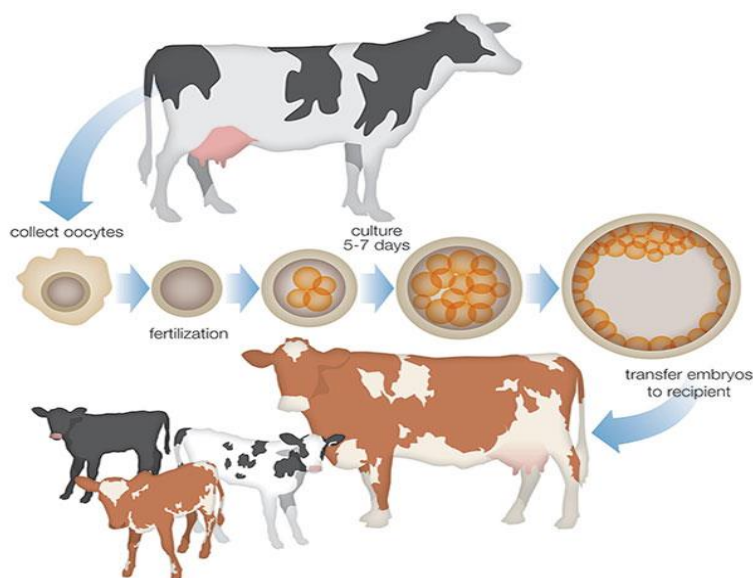
Many options for regulating the reproduction of the major large and small ruminants have become available over time. Artificial insemination (AI) and Sperm Cryopreservation are the two most often employed technologies. Embryo Transfer Technology (ETT), Sperm Sexing, Embryo Splitting, and *in vitro* Fertilization are some of the other approaches that can improve reproductive efficiency and pregnancy rates.

1. **Artificial Insemination (AI):** Artificial insemination (AI) is the technique of manually transferring semen from a male animal into a female's reproductive tract. It is utilized in animals as diverse as the honeybee and to the elephant. AI will only become more effective when farmers have access to significantly superior technical and organisational resources.



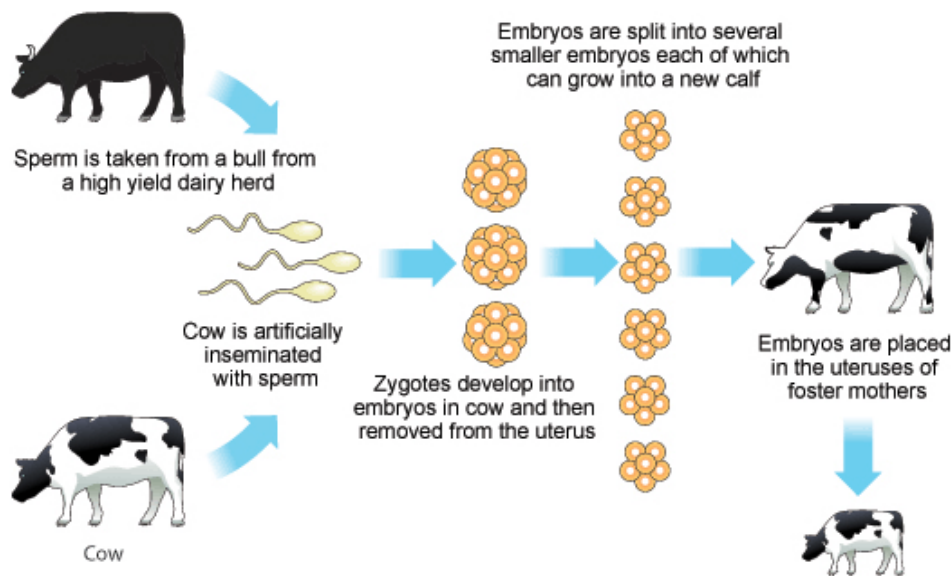
Artificial Insemination in Cattles

2. **Sperm Cryopreservation:** The process of cryopreservation exposes the cells to very low temperatures for preserving their structural and functional entity for a longer period of time. Reduced temperature, dehydration of the cell, freezing, storage, and thawing are steps of cryopreservation of sperm. Cryopreserved sperm can be used for artificial insemination and helps to use the semen of elite animals to inseminate more animals in order to improve the germ pool.
  
3. **Embryo Transfer Technology (ETT):** One of the most important reproductive technologies is Embryo Transfer that has been used to improve the genetics of cattle. It is a technique by which embryos are collected from donor female and are transferred to recipient female which serves as surrogate mother for the remaining period of pregnancy. Walter Heape was the first to successfully transplant mammalian embryos in 1890. Embryo transfer involves three steps: superovulation with the use of follicle-stimulating hormones, embryo collection surgically or non-surgically, and embryo transfer to the recipients. By using this technique, 100 calves can be produced from genetically superior female as compared to only 8–12 calves that are normally produced in her life time. NDDDB launched the country's first ETT programme in 1987, when it established a central ET laboratory at Sabarmati Ashram Gaushala (SAG) in Bidaj.



### Embryo Transfer Technology

4. **Sperm Sexing:** Sex determination prior to conception can be useful for reproductive biotechnologists. Sperm sexing is useful since the ability of sperm harbouring X or Y to create progenies of a desired sex, either female or male, is previously known (with about 80-90 % accuracy). Pre-sex determination will speed up genetic progress while reducing the quantity of unwanted bull calves.
  
5. **Embryo Splitting:** Also known as embryo twinning, is the process of splitting a single embryo to produce twins. During this procedure, a blastomere biopsy detaches a few cells from an embryo that has reached the 8-cell stage and only the genetically normal blastocyst is dissected into two groups of multiple cells, each of which is returned to incubator for further development and grow as identical siblings. It is the most effective and rapid method of increasing number of offspring obtained from embryo transfer program.
  
6. ***in vitro* Fertilization (IVF):** Fertilization is the process in which gametes (an egg and sperm) fuse together to form a zygote. As the name suggests, *in vitro* fertilization, egg cells are fertilized by sperms outside the body. IVF is an integral part of embryo transfer (ET) process used for production of bovine embryos. The first calf produced from IVF technique was in 1981 and in 1990, "Pratham" was the first IVF buffalo calf produced in India . The process includes: harvesting of eggs, maturation and fertilization outside the body i.e., *in vitro*. Further the eggs are cultured and transferred for successful pregnancy.



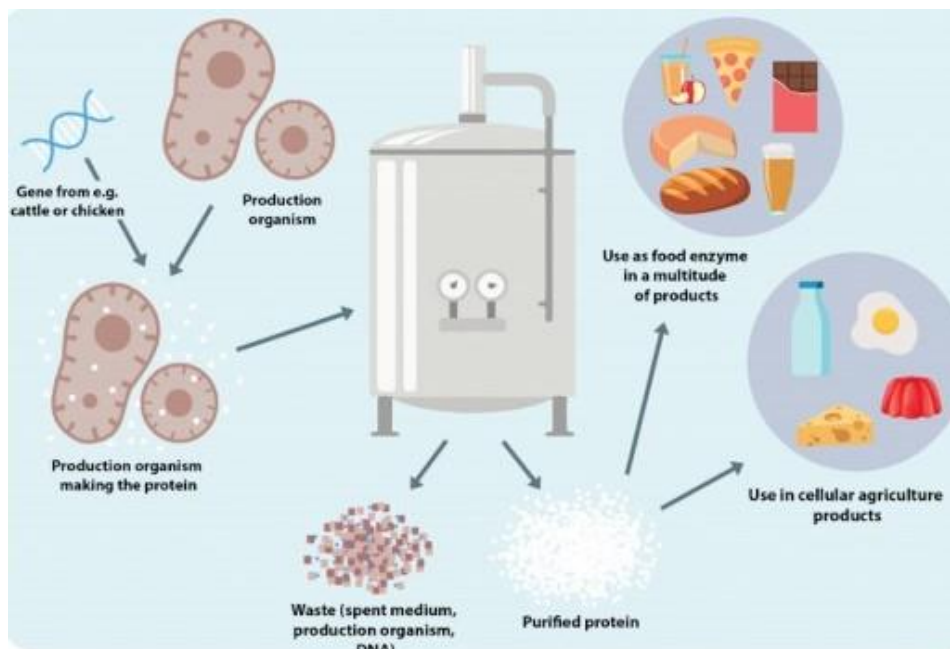
### *in vitro* Fertilization in Cattles

## Applications of Biotechnology in Improving Livestock Products

- 1. Livestock with improved germplasm & increased productivity is produced:** Transgenesis is a process that allows genes of one organism to be manipulated and then transferred into the genome of another organism of the same or of different species such that the genes are not only expressed but also passed on to the progeny. Biotechnology has been used to create transgenic animals such as mice, rats, rabbits, pigs, sheep, and cows. For example, Lactoferrin (LF), a prominent bioactive glycoprotein found in human milk, is now being produced using transgenic cows to provide milk with specific human proteins. (Parc *et al.*, 2017).
- 2. Improved quality of livestock products:** Some of the most significant parts of biotechnology research and development are the identification, isolation, and modification of valuable genes. Pork is a cheapest source of high-quality animal protein that is being consumed by humans. Major genes for pork quality offer great potential for improving meat quality while reducing variability. Gene (genome) editing methods based on ZFN, TALEN, and CRISPR/Cas9 as editors are now available to delete, insert, or change DNA sequences at particular places in the genomes of animals (including pigs) and bacteria. Pigs that have been genetically edited to express bovine growth hormone, bacterial phytase, and *C. elagan* fatty acid desaturases lack Myostatin (involved in myogenesis) have been created so far (Wu and Bazer, 2019).
- 3. Production of hormones:** Somatotropin (ST), a hormone produced by the pituitary gland, helps in improving growth and carcass composition. Pigs

injected with ST produce fat free meat (Itana and Duguma, 2021). On the other hand, purification of ST requires 25-100 pituitary glands, which is not cost-effective. To resolve this, recombinant DNA technology is employed, in which the gene for ST protein is transferred into a lab strain of *E. coli* that can be produced on a massive scale and ST can be purified and concentrated (Gupta and Savalia, 2012).

4. **Production of Enzymes:** The hydrolysis of  $\beta$ -galactopyranosides (lactose) occurs when milk is treated with  $\beta$ -galactosidase, resulting in a variety of transgalactosylation products or galacto oligosaccharides (GOS) that can provide a variety of health benefits as prebiotics. Because these enzymes are expensive, biotechnology can aid in their manufacturing and utilisation.  $\beta$ -galactosidase is made commercially from yeasts (*Kluyveromyces lactis*) and moulds (*Aspergillus niger*) (Xavier *et al.*, 2018).



Role of Biotechnology in Various Food Products

5. **Meat authentication:** Raw products from farm animals are often processed into meat and cheese products in the food industry. For a number of economic, religious, and health reasons, identifying the meat origin from processed meat products is a current source of concern. DNA-based approaches promise to provide reliable species identification. The polymerase chain reaction (PCR) is employed in most DNA-based technologies because of its simplicity and sensitivity. Species differentiation is performed either by amplification of distinctive DNA fragments with species-specific primers or by using universal primers followed by sequencing in the consensus PCR approach (Chen *et al.*, 2008). For species-specific identification of the amplicons, restriction fragment

length polymorphism (RFLP) analysis is used (Chen *et al.*, 2010; Wang *et al.*, 2010).

### **Challenges in implementing these technologies:**

Poverty, starvation, poor health conditions, poor hygiene, and unemployment are major constraints in the developing world. Biotechnology must be applied to address these issues. But in order to apply technology, a number of issues must be considered. Application of biotechnology in animal production is hampered by a number of factors which includes:

1. Inability to conduct programmes due to the lack of an accurate and full database of livestock rearing.
2. A shortage of trained manpower in both the public and private sectors to develop and apply these technologies.
3. The lack of a link between industry and universities that is required to put technologies into products.
4. The high cost of technological inputs including materials, equipment's and machinery.
5. The minimal amount of money being spent in animal biotechnology sector.

### **CONCLUSION**

Biotechnology combines the revolution in production and quality with the wholesomeness and nutritional value of food products. Biotechnology adoption has benefited livestock entrepreneurs and small producers in terms of animal improvement and economic returns. Biotechnology is critical for improving the quality of livestock products and maintaining level of biosafety for consumers. Developing countries, on the other hand, must address concerns such as political commitment, skilled manpower, infrastructure, and finance in both research and industry development. Biotechnology has the potential to open up new possibilities in the preparation of nutritional food products with longer shelf lives, better quality, and greater customer acceptance.

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