**Biotechnologies in Animal Breeding and Genomics**

Over time, the emerging biotechnologies have replaced the conventional methods and techniques in various fields of science. Nowadays, biotechnology is being used in various aspects of animal breeding and genomics to sustain livestock productivity. Various methods of biotechnology are in use to improve animal health, develop nutritious food, and conserve the environment and animals. In addition, the use of biotechnology has enabled us to produce animals with desired characteristics. Some reproductive biotechnologies that have or being developed to increase reproductive potential of livestock include semen sexing, sperm encapsulation, sperm transcriptomics, seminal biomarker, in vitro fertilization, embryo transfer technology, and somatic cell nuclear transfer. The development of molecular markers has allowed us to locate genes underlying a phenotype to improve the genetic make-up of livestock. The contribution of biotechnology is likely to increase in animal breeding in the future as more methods are being developed.

**Semen Sexing**

Semen sexing is very beneficial for animal breeders as it allows them to produce offspring of the desired sex. It is based on the principles of flow cytometric separation of fluorescent-labeled X-chromosome bearing spermatozoa from the sperms carrying fluorescent-labeled Y-chromosome. Currently, this technology is able to analyze 10,000 sperms and sort 70,000 sperms in one second. Therefore, 15 million spermatozoa can be sorted into X- and Y- bearing sperms in an hour. Some other uses of semen sexing are increasing breeding male production, reducing risks of sex-linked diseases, and conserving rare animals. However, this technology has some limitations such as production of limited number of sexed sperms per unit of time and damages to sexed sperm such as destabilization of sperm membrane and capacitation like changes. These damages to the sorted spermatozoa shorten their life expectancy in the female genital tract. The development of a new generation flow cytometer which has high sperm sorting rate has opened new ways to increase the output of sorted sperm with minimal or no damage.

**Sperm Encapsulation**

 Sperm encapsulation increases the lifespan of spermatozoa in vivo as well as it allows releases of viable spermatozoa in various species including humans over several days. Bovine sperm microencapsulation is performed using standard procedure of encapsulation by utilizing capsules of different components such as cellulose sulfate-poly-diallyl-dimethyl-ammonium chloride (CS-pDADMAC), poly-l-lysine, calcium alginate, polyvinyl amine and protamine sulfate membrane. However, bovine spermatozoa with CS-pDADMAC based capsule exhibited the highest motility rates. The usual sperm capsule has sperm concentration of 45-180 million per milliliter with size ranges from 0.75 mm to 1.5 mm. CAPROGEN, CUE, and egg yolk-citrate-glycerol are some encapsulation extenders that have been used for sperm without any significant impacts on sperm. Thus, this technique sustains release of sperm, prevents cryocapacitation, and has higher conception rate. However, this technique has been applied to only certain species such as swine and cattle. Therefore, in order to use these techniques in other species, more sophisticated instruments for encapsulation and standardization are required.

**Sperm Transcriptomics**

This involves the study of mRNA during spermatogenesis. The sperm delivers paternal genes to the female egg cell and bring remaining mRNA emerging out of spermatogenesis. The transcripts are involved in various cellular processes as well as biological processes. The use of microarrays or next generation sequencing technologies to profile these transcripts has demonstrated a profoundly powerful instrument to study expression profile analysis of sperm mRNA and polymorphism in associated genes. It has been reported that the expression profile transcripts consisting of higher concentrations of extracellular space protein locations and membrane transcripts in high-fertility bulls are different when contrasted with the low-fertility bulls. These transcripts contain casein beta 2, thrombospondin receptor CD36, and protamine. These studies will clear route for explaining transcriptomic changes related with abnormal development in spermatogenesis and encourage the improvement of technologies for assisted reproduction and furthermore fill in as fertility markers. In any case, such analysis on fertility-related genes should be approved under field conditions that need huge expenses and human labor.

**Seminal Biomarkers**

Semen is identified as a biomarker for predicting fertility. CATSPER family proteins, fertility associated antigen, α-l-fucosidase, cysteine-rich secretory proteins, phospholipase A2 bovine seminal plasma proteins, cluster-of-differentiation antigen 9, A-kinase anchor protein 4, cathepsin D, cytochrome P450 aromatase, spermadhesin Z13, clusterin, osteopontin, PDC-109-like protein, and heparin/gelatin binding proteins are used as some of the semen biomarkers. All these proteins are crucial for regular motility of sperm as well as fertility of male. Therefore, the capacity to recognize bulls using these fertility markers could lead to enhanced pregnancy rate resulting in expanded calf crop. However, the studies using these proteins are at the initial stage and they still require significant expensive investment and complex instrumentation for approval to be utilized under field conditions.

**In-vitro Fertilization**

This technique involves the sperm and the egg fertilization outside the body of an animal under certain biochemical and environmental conditions. It reduces the risks such as non-responsive ovaries, quality and quantity of marginal semen in the male, blocked reproductive systems, and nearness of diseases. This technique can also be used to analyze the epigenetic modifications, pattern of gene expression, the developmental potential of embryos, and cytogenetic disorders in different species. However, in-vitro fertilization is not one of the highly efficient techniques.

**Embryo Transfer Technology**

Embryo transfer technology allows producing progenies from a superior female by transferring embryo one mother to a surrogate mother. The chosen females are instigated to superovulation hormonally and inseminated at a proper time comparative with ovulation relying upon the breed and species. The embryos are flushed out from the uterus of the donor after a week. The embryos are examined qualitatively and quantitatively microscopically and then inserted into the uterus lining of surrogate mothers. This technique has allowed to increase the reproductive pace of chosen females, reduce transfer of disease, and promote the advancement of uncommon genetic stocks.

**Somatic Cell Nuclear Transfer**

This technique was used in generating the Dolly. It involves the transfer of the somatic cell nucleus into the female egg cell which has its nucleus removed. This results in the generation of a new organism that is similar to the donor of somatic cell. Therefore, the technology creates opportunities for producing clones with superior genotype. Furthermore, this technology can be applied to assess the impacts of environment and genotype interactions and transgenics testing. Some limitations of the somatic cell nuclear transfer are higher rate of abnormal development because of inaccurate reconstruction of DNA (epigenetic inference), loss of pregnancy, and survival of the newborn. Besides that, this technique is also imperative to some of the ethical concerns.

**Molecular Marker-Assisted Applications**

The use of molecular markers guides breeders in selecting individuals expressing introgressed gene using molecular markers. Therefore, it has reduced the number of backcrossing cycles occurr during the selection and recognition of the desired individual. The molecular markers can also be utilized for the trait improvement activities such as development, disease resistance, meat quality, and production of quality milk in various animals. The physical defects and genetic diseases can be distinguished and followed using the molecular markers.

 Although the use of different biotechnologies has revolutionized the animal breeding industry including animal production and products derived from animals. At the same, these biotechnologies are facing some challenges such as the low efficiency rates, lack of investment and sophisticated instruments, and lack of expertise. Furthermore, these biotechnologies have been applied to the limited number of species which is shortening the scope of use of biotechnology in other livestock species.