BAP -39

Nanotechnology Tools and Their Application in Livestock Production, Breeding and Reproduction: A Review

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Abstract
Nanotechnology is the engineering and art of manipulating matter at the nanoscale (1 – 100nm). It can be efficiently utilized to improve animal production through breeding and reproduction by using tools such as microfluidics, fixed time Artificial insemination technology (FTAI), biochips and nanotubes. Nanotechnology application in livestock breeding resulted in animals with better performance, improved immunity, and reduction in the use of antibiotics, reduction in manure odour, improved intestinal microflora and decreased diarrhea.

Keyword: Nanotechnology, livestock, breeding, reproduction, antibiotics, manure odour

Introduction

Nanotechnology research and development is aimed at understanding and working with seeing, measuring and manipulating matter at the atomic, molecular and supramolecular levels (NSTC, 2004). Nanotechnology manipulates matter at the nanoscale (1 – 100nm) at chemical, physical and biological properties than its normal size equivalent (Davies, 2006). The ability to manufacture and manipulate matter on the nanoscale has offered the opportunities to interfere with biology in new ways and with unprecedented precision. Researchers are able to handle biological materials in minute quantities. Nanotechnology can provide new tools for advances in the field of animal breeding management, development in reproduction science and many more.

This paper reviews the current information on nanotechnology tools and their application in livestock production, breeding and reproduction

Nanotechnology tools in animal reproduction

Animal reproduction remains a challenge not only in developing countries, but also in developed nations. Nanotechnology has the potentials to solve problems related to animal health and production, reproduction and breeding. Several technological fronts have been explored in order to improve animal reproduction. They include

Nanotubes: Detection of oestrus is a major challenge in reproduction management of farm animals. Thus management of animal breeding could be improved by the use of subcutaneous nanotubes. Nanotubes are being synthesized as implantable devices under the animal skin for detection of estrus (O'Connell *et al.*, 2002). This works by detecting changes in estradiol levels in animal blood to provide real-time measurement of blood estradiol. Thus the signal from this sensor can be incorporated as a part of a central monitoring and control system to activate breeding (Manuja*, et al.*, 2012). The natural follow up would be to have an implanted nanocapsule of semen triggered on demand to fertilize an egg.

Biochips: A biochip or microarray is a device typically made of hundreds or thousands of short strands of artificial DNA deposited precisely on a silicon circuit. In DNA arrays, each DNA strand acts as a selective probe and when it binds to materials in a sample (eg blood) an electrical signal is recorded. Biochips might be used in animal breeding to remove genetic diseases. One goal is to functionalize biochips for breeding purposes. With the mapping of the human genome behind them, geneticist are rapidly sequencing the genomes of livestock hoping to identify gene sequences that relate to commercially valuable traits such as disease resistance and leanness of meat.

Microfluidic technology

Microfluidic and nanofluidic systemsanalyse by controlling the flow of liquids or gases through a series of tiny channels and valves thereby sorting them. Microfluidic channels often etched into silicon can be less than 100nm wide and these allows them to handle biological materials such as DNA proteins or cells in minute quantities usually nano-liters or picoliters. Microfluidic is used today in animal science to significantly simplify traditional *invitro* fertilization procedures used in animal breeding. They are being used to segregate male sperm from female egg for sex selection in animal (Patil*et al.*, 2009). Microfluidic devices can not only sort sperm and eggs but also brings them together in natural reproduction. This technique would make mass production of embryos cheap quick and reliable.

Fixed-Time Artificial Insemination (FTAI) Technology

This technology depends on the regulation of progesterone administered through a silicone matrix. The procedure has substantial drawbacks including inefficient and irregular dispersion of hormone, disposal issues, being labor intensive, and requiring multiple animal handlings for each attempt. Animal hormone level can be monitored using implanted nanotechnology-enabled sensing device with wireless transmission capability, thus the information of optimal fertility period can become available in real time to assist the livestock operators for reproduction decision making (Afrasiabi, 2010).

Atomic force microscopy (AFM)

This a powerful high-resolution technique for imaging the surface topography of biological samples, including live fixed cells, allowing the surface topography imaging at the sub-nanometer resolution and the elucidation of the interactions at the molecular level (Silva and Rech, 2013). AFM has revolutionized the perspective in which microscopists explore biological structures and processes from micrometric cells to nanometric biomolecules because of its capacity to observe nanometric details of the samples(Silva and Rech, 2013). Thus AFM is redefining the concept of microscopy and emerging as complementary and even sometimes foremost tool in several scientific areas, including reproduction science (Carvalho*et al.*, 2013).

Nanobiosensors

Nanobiosensors are very sensitive devices equipped with immobilized probe biomolecules and which are made up of nano-materials such as nanoparticles, nanotubes, nanowires, nanofibresetc (Monerris*et al.*, 2012). Nanobiosensors are mainly applied in environmental monitoring and clinical diagonistic (Sagdevan and Perisasamy, 2014). The development of nanobiosensors for the detection of diseases, oestrus, hormone levels and metabolite profile provide to such systems the status of an important and promising tool for reproductive management (Monerris*et al*., 2012). Critical advances are made every year in nanobiosensors for reproduction processes; however, these advances must be made to ultimately reach the reproductive chains. Nanosensors can be fitted in the animals to identify the gene sequence that relates to traits such as disease resistance and slenderness of meat. Thus the best breeder, its gene sequence can be known with these probes and best breeds can be prepared.

Nanoparticles for Sterilization of Animals

Nanoparticles can cause toxic and deleterious side effects towards living organisms despite its advantages at optimizing reproductive performance in animals (Love *et al*., 2012). This toxicity can equally be used for reproductive technologies on the basis of contraceptive approaches (Jha*et al*., 2014). Forexample cadmium at low to moderate concentrations may lead to sterility in a dose-dependent fashion (Jha*et al*., 2014) metal nanoparticles can be actively driven to reproductive and related organs such as the pituitary gland by targeting molecules (e.g. antibodies) and thus avoiding or at least minimizing the systemic toxicity (Manuja*et al*., 2012).

Nanoparticles for Cryopreservation of Gametes and Embryos

Preservation of gonadal tissues, sperm, oocytes and embryos through cryo-techniques has brought about novel and exciting field in animal reproduction (Saragusty and Arav, 2011). Cryopreservation of cells by the use of biocompatible metal nanoparticles when incorporated into cryopreservation techniques can be used to achieve fast cooling and also achieve rapid and homogenous rewarming of the biological materials under near physiological conditions.

Application of Nanotechnology in Livestock Production

Chicken: Disease is one of the most important risk factors of livestock and poultry breeding. Clean and healthy breeding places are the premise of the healthy growth of livestock and poultry, which is also very important for the safety and health of staff and improvement of the surrounding air and water environments. In recent years, nanotechnologies have been applied more and more in the field of animal breeding. Not only can it improve animal immunity and reduce the use of antibiotics, but also can reduce the manure odor of livestock and poultry, which is conducive to bring environmental improvement.

The nano vitamin D3 and ordinary vitamin D3 were added to the feed of laying hens, respectively. On the condition of same feed dosage, the production performance and shinbone quality of hens which were fed nano vitamin D3 were better than those fed ordinary vitamin D3 (Yang *et al.,* 2014).Mannan oligosaccharides nano-liposomes can increase the average daily gain of healthy chickens, lower feed conversion, regulate immune function of chicken, play the role of resisting disease and promote growth (Hu *etal*., 2012). Nano-selenium has the advantages of high absorption rate, high antioxidant capacity, high egg-laying capacity, and good growth performance (Cai *et al*., 2013). Nano Selenium has biological characteristics of high oxidation resistance, high immune regulating, high biological activity, and low toxicity.Nano-863 was used to treat water and feed, which was then given to Israeli recessive white roosters. The chickens in the experimental group were healthy and lively, their appetite was rich, and feathers were lustrous and smooth, while the chickens in the control group had fluffy feathers.

Pig: Diarrhea is a common intestina1 disease with high morbidity and mortality, seriously affecting the growth performance and survival of piglets. Due to the restricted use of antibiotics, new feed additives or drugs have evolved. Nano-zinc oxide and montmorillonite were widely used as anti-diarrhea agents in piglets (Qing and Xiao, 2013). Se and Znare the important additives of feed and prevent diarrhea and death of weaning pigs, and promote healthy growth of fattening pigs (Bian *et al*., 2010). Supplemental chitosan nanoparticle-loaded copperhas beneficial effects on immune and antioxidant function in weaned pigs, which also can increase growth performance and decrease diarrhea and has a potential to substitute antibiotics.

Conclusion

Nanotechnology is in constant development. It can be efficiently utilized to improve animal production through breeding and reproduction. This paper tried to provide a brief overview of various nanotechnology tools and applications in livestock breeding and reproduction. The results in experimental animals suggest that nanotechnology and its products can be extremely useful in livestock production.

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