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Nanotechnology - Importance and applications of Nanotechnology in Animal science

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Abstract

The sustainability of human existence is under danger owing to food scarcity since the world's population is expanding at an unsustainable rate. By 2050, there will be 9 billion people on Earth. To address these concerns, there is a larger need for an increase in the supply of high-quality, nutritious food. By generating milk, meat, and eggs, animals contribute significantly to the production of high-quality food. However, there needs to be a considerable improvement in germplasm due to the existing condition of animals, notably in India and third-world nations. This is possible thanks to effective reproductive technologies that enable the development of more elite breeds. Cattle and buffalo frequently experience reproductive problems such repeated breeding, poor-quality sperm, and estrus absence. It looks that nanotechnology is a recent technology that is gradually taking over.

Keywords: world population, food quality, Reproduction, current trends, Nanotechnology

Introduction

The population is predicted to reach 9 billion people by 2050, which is 60 percent more people than are currently needed. The food options and technology that are currently accessible cannot satisfy these needs. In both animal health and production, there is a greater need to think creatively and rethink currently used scientific technologies. These technologies should address widespread issues such endometritis, hormonal delivery, animal calving intervals, sterile sperm, pregnancy troubles, and delayed ovulation. Despite their modest size in modern studies, nanoparticles are becoming major players in reproductive biology.

Effect of nanoparticle on steroidogenic pathway of ovary

The primary female sex hormones produced in the ovaries or placenta during pregnancy in females are oestrogen and progesterone. It was shown that nanoparticles can influence the expression of genes encoding proteins involved in steroidogenesis, such as genes producing oestrogen and/or progesterone (Brohi et al., 2017). According to studies, various harmful substances such as heavy metals, herbicides, radiation, and heavy metals might cause infertility (Barkhordari et al., 2013). Given that nanoparticles have the ability to travel to various human organs and pass through the cell membranes of virtually all types of cells, it is conceivable that they may reach the granulosa cells of the ovarian follicle and disrupt steroidogenesis. Additionally, it was discovered that AuNPs reaches the granulosa cell's cytoplasm as well as several subcellular organelles, including vacuoles, lipid droplets, and mitochondria. The secretion and accumulation of estradiol by granulosa cells were enhanced by the 10 nm AuNP particle's penetration. The cause of this might be mitochondrial damage that lowered the conversion of cholesterol to pregnenolone to such an extent that it prevented the synthesis of E2. With these research findings, AuNPs were discovered to influence sex steroid production at larger doses or for longer periods of time, which may result in animal reproductive impairments.

Additionally, in the buffalo granulosa cell model, the interactions between the expression of the -Hsd and Cyp19A1 genes and progesterone accumulation are modulated by gold nanoparticles and graphene oxide. Therefore, it is plausible to say that AuNP and GO may represent a distinct class of ovarian endocrine regulating chemicals and can dramatically disrupt sex steroid production, which has the capacity to control reproductive activities in both humans and animals (Lyngdoh et al., 2020).

Nano technology in Male Reproductive system

Semen preservation

Generally, cryopreservation of semen causes oxidative stress leading to significant reduction in fertilization capacity. Cesium oxide Nanoparticles are able to store oxygen and act as ROS scavengers to protect sperm (Ram) cell viability during cryopreservation (Falchi et al., 2018).

Nano selenium has also been used as a scavenger of ROS. It has ability to aid in motility and DNA integrity. In addition, SeNP augment spermatogenesis against oxidative damage induced by cisptalin, an anticancer agent with male reproduction toxicant properties. Cryopreservation of semen typically results in oxidative stress and a significant loss in fertility. When sperm (Ram) cells are frozen during cryopreservation, cesium oxide nanoparticles can store oxygen and act as ROS scavengers to preserve their viability (Falchi et al., 2018).

As a ROS scavenger, nano selenium has also been employed. It can support DNA integrity and motility. SeNP also protect spermatogenesis against oxidative damage caused by cisplatin, an anticancer drug with harmful effects on male fertility.

Additionally, seminal plasma antioxidize activity, expression of copper zinc superoxide dismutase, and epidydimal semen quality have all demonstrated the effectiveness of nano zinc (Yazdanshenas et al., 2016)

Nano zinc has also proven to be effective in epidydimal semen quality, seminal plasma antioxidize activity and expression of copper zinc superoxide dismutase and improved seminal mitochondrial activity (Yazdanshenas et al., 2016).

Semen purification

Fe_3O_4 NPs have been conjugated with peanut (PNA) or Pisum sativum (PSA) lectin to specifically bind to glycan expressed on acrosomes or with anti-ubiquitin antibodies with specific binding to defective spermatozoa with nano purify frozen thawed semen (Huang & Juang, 2011). These materials are known for their magnetization, biocompatibility, and biofunctionalization properties. it will raise the pregnancy rate (Odhiambo et al., 2014).

Sperm selection

In animal farming, sperm sexing offers a bigger financial benefit. Recent developments in nanotechnology have made it possible to use the cell-SELEX (Systematic Evolution of ligand by Exponential Enrichment) approach for enhanced selection (Farini et al., 2016). Super paramagnetic Fe_3O_4 NPs coated in avidin can specifically bind to spermatozoa with ruptured membranes using synthetic DNA aptamers. The semen quality and conception rate have improved dramatically as a result of this method.

Sperm sorting

Nano particles have become a valid alternative to fluorochromes and flowcytometry for sperm sorting and targeting specific sperm sequences. Usage of AuNPS as DNA tags have been proven to produce encouraging results (Barchanski et al., 2015). Specific sites on Y-chromosome were bio conjugated by oligonucleotide functionalised AuNPs and produced successful results (Gamrad et al., 2017)

Biological cargos

Additionally, biological transport is being replaced by nanotechnologies. Without affecting fertility, they serve as biological cargos that transport biological components to particular locations within tissues or cells (Makhluf et al., 2006). It has been demonstrated that PVA-Fe_3O_4 NPs conjugated with an antibody raised against protein kinase C facilitate both the functional activity of the antibody in binding its specific antigen and uptake of the antibody/NPs cargo by sperm cells (primarily in the post-acrosomal and upper regions of the head). This finding implies that nanocarriers have a significant capacity for delivering functional cargos into spermatozoa, making them a promising tool for protein identification in target tissues or cells (Makhluf et al., 2008).

Similar to this, mesoporous silica nanoparticles (MSNPs) functionalized with aminopropyl-triethoxysilane and loaded with cargo (nucleic acid/protein) were created to form potent interactions with boar sperm without impairing sperm functions like sperm viability, acrosomal reaction, and DNA fragmentation (Barkalina et al., 2015).

Conclusion

Application of nanomedicine in farm animal reproductive biology is still in infancy and practicality need to be validated in larger population before coming to any conclusion.

Nevertheless, in coming days, the versatile properties of Nanoparticles and their wider applications will keep them as big players in reproductive biology.

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