RESEARCH ARTICLE OPEN ACCESS

Review on Application of Nano Technology on Animal Health and Production Improvement

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Abstract

Nanotechnology is research and technology development at the atomic, molecular and macromolecular levels at the scale of approximately 1 - 100 nanometer range, to provide a fundamental understanding of phenomena and materials at the nano scale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size. The concept of nanotechnology was created in 1959 for the first time. However, the basic idea of definition and popularization was explored in much more in 1980s. Nanotechnology has the potential to solve many more puzzles related to animal health, products and breeding. The applications of nanotechnology become the proving ground for untried and more controversial techniques from Nano capsule vaccines to sex selection in breeding. There are numerous applications of nanotechnology in veterinary medicine including disease diagnosis, treatment, drug delivery, animal breeding and improving and boosting animal origin food product. It is swiftly changing the diagnosis and treatment patterns at faster and low cost in less time duration. In general the application with nanotechnology in the field of veterinary medicine was very broad and further investigations are very quartile for effective utilization of the technology in the practical life in making sustainable demand and supply system with human need in advancing world.

Keywords: Diagnosis, nanomaterials, nanotechnology, treatment, Dendrimers Fullerenes Nanoparticles Liposomes and Quantum Dots

1. INTRODUCTION

Nanotechnology is an exciting and rapidly emerging technology allowing us to work at the molecular level, often atom by atom, to create and manipulate tools, materials and functional structures that have nanometer dimensions. Nature has been performing 'Nano technological feats' for millions of years. Through the arrangement of atoms and molecules, biological systems combine wet chemistry and electro-chemistry in a single living system. It used within the body, within the cells for diagnosing and treatment of diseases. It has the potential to have greats impact on diagnosis and treatment of animals. Unique size dependent properties of nanoparticles have numerous diagnostic applications such as diagnostic biosensors, imaging nanoprobes for magnetic resonance imaging contrast agents (Prabaharan *et al*., 2010). Using nanotechnology multifunctional nanomaterial's can be designed to image a specific organ, target tissue, access deep molecular targets and provide drugs at controlled release. Great advances have been and are being made in nanobiochip materials, nanoscale biomimetic materials, nanomotors, nanocomposite materials, interface biomaterials and nanobiosensors with enormous prospect in veterinary medicine application (Tiwari *et al*., 2011).

Nanotechnology is a research and development aimed at understanding and working with seeing, measuring and manipulating at the atomic, molecular and supramolecular levels. This correlates to length scales of roughly 1 to 100 nanometers. At this scale, the physical, chemical and biological properties of materials differ fundamentally and often unexpectedly integrated sensing, monitoring and controlling system could detect the presence of disease and notify the farmer and veterinarian to activate a targeted treatment delivery system. This is possible with nanotechnology and could permit a wide range of advances in the field of agriculture, animal and veterinary sciences such as conversion of agricultural and food wastes to energy and other useful by-products through enzymatic nanobioprocessing, development in reproductive sciences, breeding managements, disease prevention and treatment in animals and public health (Patil *et al*., 2004). Applications of nanotechnology and nanoparticles in food, animal breeding and animal productivity such as in meat and milk productions are emerging rapidly. It used to create materials and change structure, enhanced quality and texture of foodstuffs at the molecular level.

This technology has a major impact on production, processing, transportation, storage, traceability, safety and security of food (Otles and Yalcin, 2008). Therefore, the objective of this seminar paper is to review the application of nanotechnology in animal production, productivity and health.

. 2. LITERATURE REVIEW ON THE APPLICATION OF NANOTECHNOLOGY

2.1. Definition of Nanotechnology

Nano is a Latin word which means 'Dwarf' and the thought of Nano-technology was first time given by Noble Laureate Physicist Richard P. Fennan in South California in 1952 (Kakade, 2003). In real sense the term 'nanotechnology' was popularized by Eric Drexler in 1980's. Nanotechnology is a technology of experimenting and manipulating with particles, called nano particles that are demonstrated in the scale of nanometres (a billionth of a metre). By the exploitation of the concept of nano-technology one can manufacture the structures, materials, decades and machines by using nano-particles with programmed precision (Chaudhary *et al*., 2005; Chaudhary *et al*., 2006). Nanotechnology is considered as a potential technology to revolutionize animal health and other areas of animal production (Sekhon, 2012). Nanotechnology may also be useful to develop nanoscale materials, controlled delivery systems, contaminant detection and to form nanodevices for molecular and cellular biology (Assadi, 2008). Nanotechnology can be viewed as a series of technologies that are used individually or in combination to make products and applications and to better understand science (Gordon and Sagman, 2003; Mohanty, 2007).

2.2. Nanotechnology materials

Nanotechnology materials can be grouped in to three main areas: raw materials, nanostractured materials and the group composed by nanotubes and fullerenes. The raw material includes nanoparticles and nanocrystalline materials that are readily manufactured and substitute for less performing bulk materials. Nanostructured materials are typically processed forms of raw material that provide special shapes and functionality. Examples of nanostructured materials include the quantum dots and the dendrimers. Nanotubes and fullerenes can produce materials that are 100 times stronger than steel, more conductive than copper, and can be safely used in some medical applications.

Nano particles

Liposomes**:** Liposomes discovered in mid 1960s were the original models of nanoscaled drug delivery devices. They are spherical nanoparticles made of lipid bilayer membranes with an aqueous interior but can be unilamellar with a single lamella of membrane or multilamellar with multiple membranes. They can be used as effective drug delivery systems due to its structural versatility interm of size, composition, surface charge, bilayer fluidity and ability to incorporate almost any drug regardless of solubility,or to carry on their surface. When used as liposomal drugs cancer chemotherapeutic drugs and other toxic drugs like amphotericin and hamycin, produce much better efficacy and safety as compared to conventional preparations (McCormack and Gregoriadis, 1994).

Fullerenes**:** Fullerenes, a carbon allotrope, also called "Bucky balls" were discovered in 1985 (Thakral and Mehta, 2006). Bucky balls (trapping free radicals generated during allergic reactions). Fullerenes are being investigated for drug transport of antiviral drugs is due their small size 1nm and biological compatability and its hydrophilic nature (water soluble), antibiotics and anti-cancer agents (because it conjugate with protein and DNA) and used as free radical scavengers due to presence of high number of conjugated double bonds in their core structure (Marzo and Pawlak, 2007). Fullerenes have potential to stimulate host immune response and production of fullerene specific antibodies (Chen *et al*., 2006).

Nanotubes: Carbon nanotubes discovered in 1991 are tubular structures like a sheet of graphite rolled into a cylinder capped at one or both ends by a Bucky ball. Nanotubes can be single walled carbon nanotube (SWCNT) or multiwalled carbon nanotube (MWCNT) in concentric fashion. Entry of nanotubes into the cell may be mediated by endocytosis or by insertion through the cell membrane (Reilly, *et al*., 2007)

Quantum Dots (QD)**:** Quantum dots are nanocrystals measuring around 2-10 nm which can be made to flourescense when stimulated by light. Their structure consists of an inorganic core, the size of which determines the color emitted an inorganic shell and an aqueous organic coating to which biomolecules are conjugated. It can be used for biomedical purposes as a diagnostic as well as therapeutic tool and can also be used for imaging of sentinel node in cancer patients for tumors staging and planning of therapy. This method can be adopted for various malignancies like melanoma, breast, lung and gastrointestinal cancers (Gao *et al*., 2004).

Dendrimers**:** Dendrimers are nano molecules with regular branching structures. (Freitas, 2005). Dendrimers are used for gene therapy where these can replace conventional viral vectors(due to their cationic nature which enables DNA binding at physiological PH), and their major stress in the treatment of cancer as these nano metric particles passively accumulate at the site of tumors, they enter the cells by endocytosis and the DNA gets transported into nucleus for transcription of the applied gene (Huang *et.al*., 2007).
The recent research indicates that dendrimers might be considered as potential drug carriers for treatment of diseases with the capability to provide a sustained release along with reduced side effects (Sobik *et al*., 2011).

Table 1: Chemical composition, characteristics and functions of nano particles

Chemical composition	Characteristics	Functions
Fullerenes and Carbon Nanotubes	Lack of water solubility	Vehicles for nanodrugs delivery; Contrast agents; Photo thermal cancer ablation

Liposomes	Vesicles composed of a lipid bilayer surroundin a hollow core, they can be composed of natural phospholipids or other surfactants	Drugs or other molecules can be loaded for delivery to tumors or other disease sites; Liposomes can carry both hydrophobic and hydrophilic drugs and moleculeso a target site
Dendrimers	Large, complex molecules with a well defined branched chemical structure;Monodisperse ,highly symmetric, highly branched, and generally spherical	Allow carriage of drugs or molecules for imaging; Dendrimer-based conventionalnanocomposites are been studied as possible antimicrobial agents against Staphylococcus aureus, Pseudomonas aeruginosa and Escherichia coli
Nanoshells	Spherical particles consisting of adielectric core suded by a thin metallic shell, most commonly gold	Biomedical imaging and cancer treatment
Quantum Dots (QD)	Semiconductors with spatially confined excitons that afford them unique optical and electrical properties	Their distinct fluorescenceSpectra make them valuable tools for biomedical imaging

Source (McMillan *et al*., 2011).

2.3. Applications of Nano technology in medicine (Nano medicine)

The term nanomedicine refers to the use of molecular machine systems (i.e. nanobots) to address medical problems, and to the use of molecular knowledge to maintain and improve health at a molecular scale. As a specialized field within nano-technology, nanomedicine would work towards bodily repair through the use of engineered, in vivo probes and sensors that would operate, in a semi-permanent fashion, within the body. The development of nano- medicine will have extraordinary implications for the veterinary profession, because it will change the definition of disease and the way we do diagnosis and treatment of medical conditions. (Feneque, 2003).

2.3.1. Nano technology in disease diagnosis and therapeutics

In the search for improved diagnostic methodologies, livestock disease diagnostics and therapeutics have moved from the traditional methods to molecular and currently nanotechnology. In this contribution, researchers identified the importance of nanotechnology in veterinary diagnostics and therapeutics and suggest that nanotechnology should be combined with molecular diagnostics and therapeutics to boost the efficiency in the diagnosis and treatment of animal diseases for improved protein supply and food security (Elder and Oberdorster, 2006).

It is believed that in the near future, nanotechnology will play a leading role in global veterinary practice (Feneque, 2003; Scott, 2005). The use of nanotechnology devices for diagnosis of animal diseases or as animal models for the diagnosis of human diseases is great achievement in the one health initiative. Recent reports suggest the use of quantum dots (QD) for *in vivo* imaging in small animal models (Bentolila *et al*., 2009).

Nano technology in disease diagnosis

Nanotechnology has the potential to provide cheaper, fast and precise diagnostic tools. These days, nanomaterials are playing a key role in imaging and monitoring and hence earlier detection of disease. Better diagnosis has a positive effect in the cost of animal health care. Bio nanomaterial based research has emerged as a new exciting field and DNA, RNA and peptides are considered as important bionanomaterials for the fundamental development in life sciences. The nanomaterial's such as quantum dots, nano shells, carbon nanotubes can be synthesized and functionalized which may couple with the imaging sources and accompany the molecule with ultrasound, magnetic resonance, X-rays techniques to diagnose the targeted organ effectively (Loukanov *et al*., 2012).

Nano chips: have diverse range of applications ranging from recognizing genes, guiding drug delivery to monitoring body functions and perceive life science and chemical pathogens. Nanochips are also applied for identification of certain diseases like cystic fibrosis and scanning of DNA for signs of predispositions of other ailments (Wei *et al*., 2010). Nanochips have been employed to detect gene mutations responsible for monogenic disorders that help to determine etiology of complex diseases including heart disease, diabetes and neuro psychiatric traits. Recently, researchers developed silver sputtered nanochip that mimic the connectivity between neurons in the brain (Chang *et al*., 2010).

Nano sensors: are miniature devices that can diagnose samples which use biological material or tissue based on bio recognition element which is immobilized on the surface of physicochemical transducer. Applications of nanosensors open great prospectives ranging from whole body monitoring to diagnosing various diseases due to their unprecedented sensitivity. Majorly, nano sensors are based on two detection principles i.e. catalytic and affinity sensing. Catalytic sensors utilize enzymes, cells, tissues and microorganisms as the recognition agent. Affinity sensors are those which utilize whole antibodies, antibody fragments, nucleic acid, receptors, lectins, phages, novel engineered scaffold derived bonding proteins, molecular imprinted polymers, plastic antibodies and synthetic protein binding agents as the recognition agent (Akkoyun *et al*., 2000).

Liposomes: are small artificial vesicles of spherical shape composed of single or multiple concentric bilayers, size ranging from 50-500 nm. Liposomes play a key role in diagnosis as they can be used as carriers for radioisotopes and contrast agents. Liposome with iodine formulation can be used in blood pool or perfusion and lymphatic imaging based on contrast enhancement. The potential of paramagnetic liposome in blood pool, lymphatic and perfusion imaging was proven by various *ex vivo* and *in vivo* animal studies (Suga *et al*., 2001; Scott, 2005).

Quantum dots: are semiconductor nanocrystals having unique properties like high level of photostablility and have high sensitivity(brighter imaging signals), tunable optical properties, single-wavelength excitation and size-tunable emission. Due to their extremely small size (around 10 nm in diameter), they are used as fluorescent probes for bio molecular and cellular imaging (Azzay *et al*., 2006). Quantum dots offer a multipurpose nanoscale framework for defining and constructing versatile nanoparticles that can be utilized to carry out both functions, in imaging and treatment (Misra *et al*., 2010) . Quantum dots offer major advantages over radioactive tags or fluorospheres like fluorescin or cyanine dyes in terms of longevity due to their stability and resistance to photo bleaching (Cuenca *et al*., 2006).

Quantum dots may also be injected into the bloodstream of animals and they may detect cells that are malfunctioning. Because quantum dots respond to light it may be possible to illuminate the body with light and stimulate the quantum dot to heat up enough to kill the cancerous cell. (Hirsch *et al*., 2003)

Magnetic nanoparticles: are finding increasing applications in the areas of diagnostic and therapeutic because of the advantageous properties associated with the lesser dipoledipole interactions, lower sedimentation rates, facilitation in tissue diffusion, high magnetization so as to be controlled by external magnetic fields and to reach the targeted pathologic tissue and their small size that make them available for circulation through the capillary systems of organs and tissues (Sobik *et al*., 2011). Magnetic nanoparticles have been widely used in the early stage diagnosis of diseases. They are especially important for some fatal diseases such as cancer. Some magnetic nanoparticles like iron oxide nanoparticles have been used in perfusion imaging for *in-vivo* characterization of tumors (Strijkers *et al*., 2005). Magnetic nanoparticles show effective results in animal body as they can easily move in liquid medium and thus can be excited magnetically or detected inside nonmagnetic tissue (Zhao *et al*., 2011).

Nano technology for treatments of diseases

The effective delivery of therapeutic molecules has been a major barrier to obtain targeted response against the disease agent. Many drugs are effective in treating diseases but most of them also have certain limitations with regard to toxicity, poor aqueous solubility and cell impermeability (Desai *et al*., 1997).

Table 2: Applications of Nanotechnology in veterinary diagnostics and theraupetics.

S.No	Nanocarriers	Medical/Veterinary Applications	Animal species under trial/evaluated/approved
1	Magnetic nanoparticles	MRI contrast, drug delivery	Cats
2	Gold nanoparticles	*In-vitro* diagnosis.	-

3	Quantum dot	Fluorescent contrast, *in-vitro* diagnostics.	-
4	Dentrimers	Microbicide and vaccine delive	Pigs
5	Micelle	Therapeutics	Sheep, birds, horse
6	Liposomes	Therapeutics	Cattle, dogs, horse, Cats, birds, sheep
7	Nano emulsion	Drug delivery and therapeutics	Dogs, Cats
8	Nano sphere	Vaccine delivery	Horse

Source *:*(Underwood and Van, 2012)

2.3.2. Nano technology in drug delivery

Today, antibiotics, probiotics and pharmaceuticals are delivered to animals primarily through feed or injection systems. Nanoscale devices are envisioned that will have the capability to detect and treat an infection, nutrient deficiency, or other health problem, long before symptoms are evident at the macro-scale (Hirsch *et al*., 2003).

Nanoparticle-based drug delivery improves the solubility of poorly water-soluble drugs, prolongs the half-life of drug, releases drugs at a sustained rate or in an environmentally responsive manner and thus lowers the frequency of administration, delivers drugs in a target manner to minimize systemic side effects, and delivers two or more drugs simultaneously for combination therapy to generate a synergistic effect and suppress drug resistance (Agnieszka *et al*., 2012).

Smart drug delivery systems in animals would most likely contain small, sealed packages of the drug to be delivered. Smart drug deliveries allow judicious use of smaller quantities of antibiotics than would otherwise be possible. A molecular coded 'address label' in the package could allow the package to be delivered to the correct site in the body. Nano and microscale mechanical systems would serve as the 'carriers' in such a system. Smart delivery systems could also contain on-board chemical detection and decision-making capability for self regulated drug delivery or nutrient treatments as per need. This will aid livestock owners to minimize use of antibiotic and to reduce the expenditure on medication. Smart delivery systems can also have the capacity to monitor the effects of the delivery of pharmaceuticals, nutraceuticals, nutrients, food supplements, bioactive compounds, probiotics, chemicals and vaccines. Thus, in the future, further technological advances will make it possible to develop delivery systems more precisely with use of nanomaterials (are materials that provide the potential to manipulate structures or other particles at the nanoscale and to control and catalyze chemical reactions, e.g. Buckey balls, nanotubes, quantum dots and dendrimers etc.) for biological and bioactive organisms for targeted site, develop integrated sensing, monitoring and controlling capabilities, including the ability of self-regulation, develop large as well as small animal health monitoring and therapeutic intervention (Tomanek and Enbody, 2000).

Generally, the practical consequences of a pharmaceutical nanostructure substance are providing a rational use of the active ingredient, considering that both the number of doses and the concentration of the drug may be reduced during the treatment and "Renewing" of old pharmaceutical bases which were continued used and also prolonging the systemic circulation lifetime of drug. Releasing drugs at a sustained and controlled manner, preferentially delivering drugs to the tissues and cells of interest, delivering multiple therapeutic agents to the same cells for combination therapy (Peer *et al*., 2007). Providing new perspectives of administration routes for medicines and vaccines and also reducing stress and toxicity for drug administration, collateral effects of conventional pharmaceutical actives. Providing the use of new molecules and actives in animal therapeutic and producing low (or none) residues in animal products, resulting in no withdrawal needed (Zhag *et al*., 2010).

Polymeric nanoparticles (PNPs)

Polymeric nanoparticles are made from variety of natural and synthetic polymers which are considered as the most promising drug carrier. PNPs are structurally stable and can be synthesized with a sharper size distribution. The surface of PNPs contains functional groups that can be chemically modified with either drug moieties or targeting ligands delivery (Agnieszka *et al*., 2012). PNPs are usually coated with nonionic surfactants in order to reduce immunological interactions as well as intermolecular interactions between the surface chemical groups of PNPs (Torchilin, 2008).

Lipid Nanoparticles

Solid lipid nanoparticles (SLNs), Nanostructured lipid carriers (NLCs), and Lipid drug conjugates (LDC) are types of carrier systems based on solid lipid matrix. ***Solid lipid nanoparticles (SLNs)*** have good physical stability, protection of incorporated drugs from degradation, controlled drug release, and good tolerability (Wissing *et al*., 2004). ***Nanostructured lipid carriers (NLCs)*** are modifications of SLNs and hence referred as second generation of lipid nanoparticles. NLCs are produced by mixing solid lipids with liquid lipids, which leads to special nanostructure with increased payload and prevented drug expulsion (Wissing *et al*., 2004). Similarly, ***Lipid drug conjugates (LDC)*** are developed in order to expand applicability of lipid based carriers to lipophobic drug molecules (Wissing *et al*., 2004).

Liposomes

Liposomes are nano/micro-particular or colloidal carriers, usually with 80-300nm size range. One of the distinguishing features of liposomes is its lipid bilayer structure, which mimics cell membranes and can readily fuse with infectious microbes. By directly fusing with bacterial membranes, the drug payloads of liposomes can be released to the cell membranes or the interior of the bacteria (Silva *et al*., 2011).

Dendrimer nanocarriers

The structure of dendrimers consists of three distinct architectural regions: a focal moiety or a core, layers of branched repeat units emerging from the core, and functional end groups on the outer layer of repeat units. The presence of several surface functional groups enables a simultaneous interaction with a number of receptors, thus, it enhances biological activity. The drug may be encapsulated in the internal structure of dendrimers or it can be chemically attached or physically adsorbed on dendrimers surface (Menjoge *et al.,* 2010).

Carbon nanomaterials

Carbon nanocarriers used in delivery systems are differentiated into nanotubes and nanohorns . Drug release from ***Nanotubes (CNTs)*** can be electrically or chemically controlled. To prevent the unwanted release of the drug, the open ends of CNTs were sealed (Luo *et al*., 2011). ***Nanohorns*** are single-wall nanotubes which does not require a metal catalyst for the formulation, thus, they can be easily prepared with very low cost and are of high purity (Shiba *et al*., 2006).

Magnetic nanoparticles

Magnetic nanoparticles are easy handling with the aid of an external magnetic field, the possibility of using passive and active drug delivery strategies, the ability of visualization, and enhanced uptake by the target tissue resulting in effective treatment at the therapeutically optimal doses (Arruebo *et al.,* 2007).

2.3.3. Nano technology in vaccine delivery and adjuvant

Vaccination is one of the important methods of prevention of disease in advance by developing antibody against the particular pathogen. Nanoparticles used as vaccine carriers and adjuvants. Synthetic oligodeoxynucleotides and antigens in biodegradable nanospheres used for immunization. A better immune response seem to be obtained with biodegradable nanosphere vaccines produced by conventional methods. These new perspectives for vaccine development are contributing with better efficacy and safety results, both in pets and livestock animals (Akagi *et al*., 2012).

Liposomal vaccines can be made by associating microbes, soluble antigens, and cytokines. Liposomes have been firmly established as immunoadjuvants or vaccine adjuvant (enhancers of the immunological response), potentiating both cell mediated and humoral immunity. Liposomal immune adjuvants act by slowly releasing encapsulated antigen on intramuscular injection and also by passively accumulating within regional lymph nodes (Gregoriadis, 1995).

Adjuvants are agents added to a vaccine to augment immune responses toward antigens. A number of studies describe the use of nanoparticles as adjuvant (Andreev, 2000). Immunization of animals with both complete antigens and haptens (small molecules that can elicit an immune response only when attached to a large carrier such as a nanoparticle or a protein) conjugated to the surface of colloidal gold particles generated higher levels of specific antibodies than immunization of the same antigens with classical adjuvants. Furthermore, the amount of antigen required to achieve a high antibody response was an order of magnitude lower than for immunization with Freund's adjuvant (Andreev, 2000).

A study indicated that synthetic oligodeoxynucleotides and antigens in biodegradable nanospheres can be used as an alternative approach for immunization (Diwan *et al*., 2002). The control of parameters of the particle such as size, charge and surface of the particle allows the selective targeting to specific cell groups, or even cellular regions. Thus, it is possible for a selective modulation of specific immune responses such as MHC class I, MHC class II, Th1 and Th2 cells (Akagi *et al*., 2012)

2.3.4. Nano technology in Animal health

Animal health is an increasingly important issue, both for animal based agriculture and pet owners. Nanotechnology has the potential to significantly affect the way veterinarians practice veterinary medicine (Feneque, 2003). Nanotechnology has the potential to provide these solutions, since the possible applications of the technology in medical and veterinary applications are almost mind-confusing. Recent and ongoing advances in biomedical technology will assist in advancing our understanding of disease prevention and health promotion, as well as medical diagnostics and therapeutics (Ross *et al*., 2004).

Although much research and major company developments are necessary before nanotechnology is routinely in use in veterinary medicine, there are numerous glimpses of the future in applications for drug delivery, disease diagnosis and treatment, breeding and identity preservation (Feneque, 2003).

2.3.5. Application of Nano technology in veterinary public health

Poultry meat and eggs are often the source food borne pathogens, like salmonella. Early detection of food borne pathogenic bacteria is critical to prevent disease outbreaks and preserve public health. Now, a novel nanotechnology-based biosensor is showing great potential for food borne pathogenic bacteria detection with high accuracy (Park, 2008).

2.3.6. Antimicrobials nanoparticles in veterinary medicine

Conventional synthetic and natural antimicrobial substances are being tested in the field of veterinary science, and have shown excellent results against multi-resistant microorganisms and bacteria strains that are normally hard to eliminate by using the conventional treatment, like *Brucella abortus*, *Mycobacterium bovis*, *Staphylococcus aureus*, *Salmonella, Ehrlichia*, *Anaplasma*; *Rhodococcus equi,* etc. (Mcmillan *et al*., 2011).

The use of nanotechnology in active antimicrobials has also shown satisfactory results. Penicillin is the first and most ancient antimicrobial agent from the group of β-lactams, which has been used for decades in the treatment of bacterial infections. However, indiscriminate use resulted in the selection methicillin resistant *Staphylococcus aureus* (MRSA) strains. A study allowed the covalent attachment of a chain of penicillin polyacrylate nanoparticle structure with approximately 100nm. The researchers compared the *in vitro* activity of nanostructured molecule with a conventional formulation. In MRSA strains, nanostructured formulation is more effective, which was attributed to a probable active protection against action of bacterial β-lactamases and / or protection against penicillin binding proteins (Turos *et al*., 2007).

2.3.7. Nano technology as biosensors

Nanobiosensors are very sensitive devices equipped with immobilized probe biomolecules and which are made up of nanomaterials, such as nanoparticles, nanotubes, nanowires, nanofibers, and others (Monerris *et al*., 2012). The development and validation of nanobiosensors for the detection of diseases, pathogens, oestrus, hormone levels, and metabolites profile provide to such systems the status of an important and promising tool for reproductive management (Monerris *et al*., 2012).

2.4. Nano technology in animal production and postharvest technologies

Nanotechnology has begun to blossom in the field of reproduction and fertility. In this way, the aims of these nanotechnology-based investigations related to animal reproduction are characterize the nanoscale features of gamete cells using atomic force microscopy and related scanning probe microscopy techniques develop nano biosensors for detection of physiological or altered (pathogens and diseases) reproductive status. The attempts includes the development of chemical approaches for production of metal nanoparticles for fertility control, development of nanodevices to secure cryopreservation of gametes and embryos and develop sustained release systems of molecules, including hormones, vitamins, antibiotics, antioxidants, nucleic acids, among others (Scott, 2005).

The goal of all these innovative efforts is not just to be able to characterize and manipulate the matter on nanoscale, but also develop products and processes with economic, social and environmental value added with emphasis on the development of solutions to animal reproduction challenges (Scott, 2005).

Moreover, nanotechnology is quite competent in new products and new processes development with the objective of enhancing the performance of the products, extending the product shelf life and freshness as well as in getting better the safety and quality of food and It can also reduce the time of production of eggs and meat. Thus, consumers can get eggs and meat in a shorter period (Kannaki and Verma, 2006). The quality of fermented livestock products are now well proven for health benefits which can easily to be obtained by this vital technology (Singh *et al*., 2012).

2.4.1. Nano technology in meat production

Nanotechnology study individual nanoparticles and their unique application for meat industry ranging from meat design, achieving food security, meat safety, overcoming food allergies, eliminating pesticide use, meat packaging, restoring meat damage and sensory evaluation to processes such as filtration, separation, encapsulation etc. (Mallika *et al*., 2005).

Applications of nanomaterial are currently used for meat and food generally; include the use of NPs and nanomaterials as food ingredients/additives which are placed directly into food, or as a part of food packaging (Marquez, 2004**).** One of the more futuristic applications of nanotechnology lies in the production of "interactive" poultry meat that change colour, flavor or nutrients depending on diner's taste or health (Marquez, 2004). There are many methods to improve livestock meat products by nanotechnology. At present, spray drying, melts extrusion, coacervation, coating with fat and sprays chilling are commonly employed encapsulation techniques.

The encapsulation system the promise that genetic engineering could produce cells that have a variety of new qualities that would make meat even healthier and tastier: higher protein, lower fat, high omega 3, acid levels or other healthful concoctions (Kolata, 2006).

Using nanotechnology has numerous benefits (Raj Kumar et al., 2006). Taste masking, head-triggered release consecutive delivery of multiple active ingredients, change in flavor character and long lasting organoleptic perception of nanotechnologies ranging from the actual to the speculative promise a variety of ways to create veal meat without killing animals.

Some of the researchers in this field, for instance, are so committed to the development of cultured meat largely out organizations to pursue the technology (Marquez, 2004). For example, New Harvest is a ''non-profit research organization working to develop new meat substitutes, including cultured meat produced in vitro, in a cell culture, rather than from an animal. Cultured meat has the potential to make eating animals unnecessary, even while satisfying all the nutritional and hedonic requirements of meat eaters. It also has the potential to greatly reduce animal suffering (Hopkins and Dacey, 2008).

One of the functions of nano-carrier systems is to protect nutrients and supplements from degradation during processing. For example, carriers enable nutritive substances to be resistant to proteases and other denaturing compounds, improve their stability to pH value and temperature changes and increase their ability to be transferred across intestinal membranes into the blood and controlled release and better dispersion in aqueous systems for water-insoluble food ingredients and additive.(Cushen *et al*., 2012).

Nanotechnology can make poultry and meat products cost-effective with the natural properties and the differentiation in qualities of the products can easily be made by nanotechnology based techniques (Singh *et al*., 2011).

2.4.2. Nano technology in milk production

Nanotechnology is a new technological tool in modern raw milk production and pasteurization. (Ross *et al*., 2004). Recent developments of nanotechnological tools begins to bring sophisticated Polymerase Chain Reaction (PCR) methods, cantilever systems, various microarray systems, new biosensors, etc. This substantiates an intensified research in new solid on-line/at line methods, which can measure critical points throughout the milk production chain (e.g., feed, cow, raw milk, milk tank, throughout the processing chain, during storage and distribution with regard to pathogens, indicator organisms of contamination, antibiotics, toxins, chemical contaminants, and allergens). These support the development of hazard analysis critical control points (HACCP)-based quality management systems. Development of mentioned HACCP-based quality management systems as well as shelf-life prediction systems also calls for development of sophisticated modeling of growth and decline of pathogens, spoilers and contaminants in the milk and dairy products (Andersen, 2007).

Liposomes micelles used to encapsulate both water and lipid soluble compounds. The dissolution of fat-soluble nutrients in water-based drinks is one of the key applications of liposomes. Examples of current research into the use of liposome technology in food are the encapsulation of enzymes, lactic acid, bacteria extracts and/or antimicrobials for accelerated cheese ripening. Liposome technology can be used potentially to target specific sites within a food product for enzymatic degradation (Taylor *et al*., 2005).

2.4.3. Nano technology in egg production.

Role of nanotechnology in designer eggs production is now a well known fact. Nanotechnology has to supply cholesterol free eggs, yolkless or reduced yolk eggs which can be the high value protein source, immune eggs which can supply the predetermined antibodies and therapeutic eggs which supply the predetermined physiological factors for treatment purposes. The tools and techniques currently with us will not give the solution for these challenges. They can only be fulfilled by the emerging nanotechnology, which deals not merely at the molecular level but at the atomic level (Kannaki and Verma, 2006).

2.4.4. Nanotechnology to trace animal products

Identity preservation (IP) system is a system that creates increased value by providing consumers with information about the practices and activities used to produce an agricultural product. Today, through IP it is possible to provide stakeholders and consumers with access to information, records and supplier protocols regarding the farm of origin, environmental practices used in production, food safety and security, and information regarding animal welfare issues. Quality assurance of the safety and security of agricultural and animal products could be significantly improved through IP at the nanoscale. The future of the meat industry may well depend on an ability to track all stages in the life of the product, including the birth of the animal, its medical history, and its movements between the ranch, the slaughterhouse and the meat- packing plant, right through to the consumer's table (Patil *et al*., 2009)

2.4.5**.** Nano technology in animal breeding

Management of breeding is an expensive and time-consuming problem for dairy and swine farmers and canine breeders. One solution that is currently being studied is a nanotube implanted under the skin to provide real time measurement of changes in the level of estradiol in the blood. The nanotubes are used as a means of tracking oestrus in animal because these tubes have the capacity to bind and detect the estradiol antibody at the time of oestrus by near infrared fluorescence. The signal from this sensor will be incorporated as a part of a central monitoring and control system to actual breeding (O'Connell *et al*., 2002). The goal of all these innovative efforts is not just to be able to characterize and manipulate the matter on nanoscale, but also develop products and processes with economic, social and environmental value added with emphasis on the development of solutions to animal reproduction challenges (Weibel *et al*., 2014).

2.4.6. Nano technology for delivery of reproductive hormone in animals

The development of nanostructured systems facing the delivery and sustained release of molecules towards specific targets represents a frontier area of nanoscience and nanotechnology (Joanitti and Silva, 2014), with the possibility of contributing substantially to advances in animal reproduction. Nanoparticles, nanoemulsions, nanogels, nanocapsules, and liposomes are among the most common forms of administration of bioactive molecules based on nanobiotechnology (Joanitti and Silva, 2014). Currently, nanostructured delivery systems have been intensively developed and evaluated due to several advantages shown in biological applications (Bonifácio *et al*., 2014). Overall, nanosized delivery systems enhance the therapeutic efficacy of several bioactive molecules, including reproductive hormones, by simply improving their pharmacokinetic and/or pharmacodynamic properties. These systems are able to carry a wide variety of molecules enhancing their sustained release, showing low systemic toxicity, allowing targeted treatment, and avoiding premature inactivation or degradability of bioactive compounds which are sensitive to light (e.g. vitamins), oxidation (e.g. steroid hormones), and/or hydrolysis (e.g. gonadotropic hormones) (Joanitti and Silva, 2014).

2.4.7. Nano technology for cryopreservation of gamet and embryo

Cryopreservation of gonadal tissues, sperm, oocytes, and embryos has brought about novel and exciting research field in animal reproduction (Saragusty and Arav, 2011). The use of biocompatible metal nanoparticles for cryopreservation of cells and tissues may become the next step of cryopreservation technologies to achieve ultra-fast cooling rates and also allow rapid and homogeneous rewarming of the biological materials under near physiological conditions. However, there are an incipient number of studies carrying out the use of nanoparticles for cryopreservation of cells and tissues (Wang *et al*., 2014).

2.4.8. Nano technology for sterilization of animal

Despite the advantages associated with the use of nanoparticulate systems in order to optimizing the reproductive performance, it is largely accepted that some nanoparticles (e.g. metal nanoparticles) can elicit toxic and deleterious side effects towards living organisms (Love *et al*., 2012). However, this toxicity may also be used for reproduction technologies on the basis of contraceptive approaches (Jha *et al*., 2014). Since several metals, including cadmium, at low to moderate concentrations may lead to sterility in a dose-dependent fashion, the delivery of metals as nanoparticles to reproductive organs remains as a wide field to be explored by researchers. Metal nanoparticles can be actively driven to reproductive and related organs (e.g. pituitary) by targeting molecules (e.g. antibodies) or using some physical characteristic (e.g. magnetic field-based delivery of magnetic nanoparticles) and thus avoiding or at least minimizing the systemic toxicity (Manuja *et al*., 2012).

3. CONCULISSION AND RECOMMENDATION

Nanotechnology has emerged as one of the most innovative technology through invention of several nanomaterials. These nanomaterials are playing a key role in diseases diagnosis, treatment, drug delivery, animal nutrition, breeding, reproductions and values additions to animals' product. Nanoparticles also play great role in disease diagnosis at molecular levels as well as at a single cell by using different nanomaterials. In the future it provide new products and new processes, with the goal of enhancing the performance of the product, prolonging the product shelf life and freshness, and improving the safety and quality of animal origin food.

Nanomaterials offer a vast number of breakthroughs like cost effective, lower risk to consumers and faster approach that will further advance the clinical aspect of veterinary sciences in future and conceived that bacterial infections can be eliminated in the patient within minutes, instead of using treatment with antibiotics over a period of weeks.

Based on the above conclusion the following recommendations are forwarded:

- Continuous research should be conducted on nanotechnology, particularly on nanobiotechnology in animal science and veterinary medicine in order to increase production of low fat and low cholesterol animal products.
- More advanced research should be conducted on nanoparticle, nanomaterial and nanomedicine to improve effective diagnosis and treatment of animal diseases.
- Ethiopian governments should give a great attention to nanotechnology and they must support the Scientists and researchers who investigate nanotechnology
- Scientists, engineers and biologists should work in team to come up with a new technology that can improve the current mode of life

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