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REVIEW ARTICLE

Application of nanotechnology in animal nutrition

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HIGHLIGHTS

> This review article aims to gather the materials and research that has been done to clarify the potential effects of nanotechnology on animal nutrition and its potential benefits and risks.

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ABSTRACT

In recent years, nanotechnology has gained much attention within the scientific community in many countries. Nano mechanism is no longer a connotation or notion for the modern scientist only, but it has overturned into a recent enabling technique over the years, with the huge possibility of transformation. The field of cultivation and domestic animal so evolved in these sections can be conveyed to avian and animal offspring systems with the aim enhancement production efficiency and meeting human needs for quality poultry and animal products. As a result of the small size of nanoparticles, their passage is very fast through the walls of the gastrointestinal tract, creating many important effects in various body systems, which provides the opportunity for researchers to deal with nanomaterials by studying many veterinary fields, including production, reproduction, disease control, dealing with biological materials such as the study of DNA and cellular molecules.

1. Introduction

About 50 years ago, scientists rediscovered clay minerals for medical purposes, even though eating clay was used for hundreds of years by indigenous animals and cultures across the planet to improve healing. Studies have begun on the effects of various clay minerals on the health of free-ranging farm animals. Wild animals seek out clay deposits and use these minerals to detoxify the body from anti-nutritional compounds in the feed or to reduce digestive disorders. The method of eating clay, i.e. geophagy, has been described by several authors for both animals and humans. Adsorption capacity and its ability to release micronutrients are important properties of clay minerals. The role of clay minerals in binding harmful compounds and then their excretion from the body and antibacterial effects were also investigated.

Since 2006, the ban on the use of antibiotics as growth promoters in the member states of the EU (Regulation, EC No 1831, 2003) has had a significant impact on animal health and growth. Antibiotics provided good health, particularly in young animals resulting in a high output of animals in the later stages of fattening. At present, farmers have to deal with post-weaning diarrhea caused by gastrointestinal infections, particularly in weaned piglets. Accordingly, it is necessary to develop new alternatives to feed strategies and additives to ensure good health conditions and a high output of animals. The use of clay minerals is one possibility, and due to their adsorption capacity and the absence of primary toxicity, clay minerals could become suitable feed additives that ensure good health and the growth of animals.

Clay minerals with very fine, small particles and high adsorbent properties are most suitable for use in veterinary sciences. Kaolin and smectite are mostly used in animal nutrition as growth stimulants and supplements to treat digestive disorders, especially diarrhea. However, the clear mechanism of action of clay minerals in the body is not clear. Only a few clay minerals have special properties suitable for medicinal purposes. Modification of clay minerals can be a possibility to obtain materials with special properties required. However, the price of modified minerals can play a role in their application for veterinary purposes [1].

Nano means "dwarf" in Greek. Which is a size of about 10^{-9} meters, which is one-billionth of a meter. Everything around us is made of atoms, and in fact, the atom is the

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smallest building block of matter. From the Stone Age to the later ages and the present age, which is the age of silicones, human beings have always realized how and by what laws, billions of atoms are placed next to each other, and at the same time a shape and a model. They create something special and create macroscopic properties [2]. So, each atom and molecule, on its own, has certain physical properties that can be actualized and used to build new devices with extraordinary properties. The science that does this is nanotechnology. The simplest definition of nanotechnology is the technology that provides the power of structure and organization at the atomic and molecular level that has occupied mankind in the 21st century and will revolutionize human societies over the next few decades. Nanotechnology, as a new science, has been able to improve the performance of feed and increase the efficiency and production of animals by manipulating and modifying a material at the nanoscale [3,4]. Nanotechnology can improve food evaluation and act as a new tool for delivering nutrients to target tissues and a tool for explaining the metabolism and physiology of nutrients. The mineral particle size acts as food additives in the shape of nanoparticles from the intestinal wall and enters the body cells faster than normal materials with a larger size, thus improving bioavailability. There are also challenges to the emergence of nano-nutrients, including changes in the metabolism, toxicity, and environmental effects of nanoscale mutants compared to micronutrients, and so many consequences must be considered. Therefore, Nanometer size feeds can increase the bioavailability of feeds, production performance, and safety status of an animal [5].

2. The place of Nanotechnology in animal production

Nanotechnology can be described as the nano-sensitivity development of functional materials, devices, and systems by manipulating and processing new properties of structures in atomic-molecular size (one billionth of a meter). It is emphasized that nanometer-sized materials show different properties from normal-sized particles [6–8]. Due to their properties, it is reported that they are utilized in medicinal uses to increase the bioavailability of drugs and target therapeutic agents to certain organs, and reach deeper into tissues [9,10].

Although research in veterinary medicine and animal production is very limited today, nanotechnology has a wide use potential in Livestock production systems. Among these are the use of foods that cannot be offered for human consumption as animal feed, the improvement of feed quality, digestibility, and absorption, the production of feed additives, the production of special biosensors in animal breeding, the prevention of the spread of diseases, the determination of new materials and protection systems in pathogen identification [11]. For example, sensors and nanocapsule vaccines can be used for embryo mass production with micro and nanofluid systems, effective delivery of drugs to some parts of the body, monitoring of biologically very active medicine components and areas where farm animals are found. On the other hand, miniature/microrobots (nanobots) have been developed that allow a close-up examination of neural details in animals and can scan all capillaries [12].

Scott [11] points out the existence of nanotechnology applications in matters such as the use of feed additives, drug applications, the diagnosis and treatment of diseases with nanoparticles that enable the detection and elimination of the cause of the disease without the need for surgery, and the identity registration of an animal and its product (meat, milk, egg, etc.). The researcher also highlights the importance of nanotechnology in reproductive management with hormonal immunosensors, such as the development of immunosensors based on nanostructures that can detect progesterone concentration in cow's milk and facilitate the detection of ovulation in these animals [13].

3. Nanotechnology in animal nutrition

After the prohibition of the use of ionophore group antibiotics, which are used to eliminate health problems in animals and increased productivity, in recent years, the tendency to biotechnological methods has increased especially in the nutrition of farm animals in terms of health, performance, production quality, and natural feed additives (such as probiotics, prebiotics, enzymes, organic acids) have been started [14]. Nanotechnology, on the other hand, is not very different from biotechnology applications but is a new approach that has the potential to increase the efficiency of nutrients and their efficiency at the atomic and molecular levels. Nanotechnology can also be called 'nanobiotechnology' in the field of animal nutrition. Nanobiotechnology is the management of living organisms with nanotechnology by fusing biological and non-biological materials [15].

Studies on the use of nanotechnology in animal nutrition have mainly focused on evaluating the effect of fortifying nanoparticles of minerals. Nanometer-sized nanoparticles are used to increase the bioavailability of feeds due to the advantage of size effect and high surface reactivity, such as larger specific surface area, higher surface activity, higher catalytic efficiency, and stronger absorption ability, unlike normal-sized particles. Thus, it is possible to increase the developmental performance of the animal, the nutritional value and digestibility of the feed consumed, and thus the conversion rate of the feed. For the nutrients to be used effectively in the animal body, a large number of substances such as micelles, liposomes, nanoemulsions, biopolymeric nanoparticles, protein-carbohydrate nanoscale complexes, solid nano lipid particles are required. The nanoscale application system has been developed. These systems have better adaptability to environmental stresses and processing effects, high absorption and bioavailability, better solubility and dispersibility in aqueous-based systems, and controlled release kinetics [16]. Micronutrients and bioactive substances contribute to improving the overall health of animals. They can help achieve and maintain an optimal physiological state. These systems can help increase the quantity and quality of products and reduce the financial burden of producers, as well as more efficient use of nutrients [17].

On the other hand, since the bioavailability of minerals obtained from inorganic sources is quite low, these minerals are added to the feed mixes consumed by animals 20-30 times more than their normal requirement, which is a factor that causes excessive excretion of inorganic minerals with feces and thus increases environmental pollution. Alternatives such as organic mineral sources with much higher bioavailability than inorganic mineral sources are being studied. However, until now, there is little information

on the suitability and efficacy of mineral nanoparticles in animal feeds [18].

4. The physiological role of nanoparticles

In this section, we will briefly describe how nanoparticles function in the body:

- It increases the surface area of the compounds, allowing the opportunity for biological reactions
- Increased persistence in the gastrointestinal tract
- Minimize the effects of intestinal secretory mechanism
- Due to their small particles, they penetrate deeply into the tissues through the tiny capillaries
- Crossing organs with epithelial tissue (e.g., liver)
- Enabling better absorption in cells brightens up
- Efficient transfer of active ingredients to the desired sites in body tissues [3].

5. Nanotechnology intervention in animal feed

Nanotechnology has four possible applications in animal nutrition. These four uses are:

- Prescribing medicine, nutrients, probiotics, etc.
- Diagnosis and treatment of diseases with nanoparticles allows to identify and eliminate the cause of this disease without the need for surgery.
- An identity register that allows you to track the history of animal products.
- Reproductive management with hormonal immunosensors.

Nanoparticles can also be used as additives to improve livestock production. Nanocapsules are also used as carriers of essential oils, flavors, antioxidants, vitamins and minerals, and phytochemicals for bioavailability [19].

6. Digestion and absorption

Nanoparticles can enter the gastrointestinal tract in a variety of ways, including water and food and using it as nanopharmaceuticals (swallowing pathway), as well as nanoparticles that enter through the respiratory tract. They also enter the gastrointestinal tract after purification in the respiratory tract (airway). The gastrointestinal tract is through the mucosa. Therefore, the smaller the particle size, the faster its release from the gastrointestinal mucosa occurs and ultimately causes rapid absorption through the gastrointestinal tract into the blood [20].

7. The role of nanoparticles in ruminal fermentation

The rumen is a complex ecosystem in which the consumed nutrients are digested anaerobically by microorganisms such as bacteria and fungi and the final product of food fermentation is VFAs, which are used by the host ruminants. The relation between the beneficial bacteria and the host animal results in an equivalent relevance that permits ruminants to digest fiber-affluent and minimal-protein materials. The fermentation process in the rumen is highly inefficient because it produces some final compounds like methane and ammonia. To improve the efficiency of microbial digestion, many food systems have been followed to change the path of microbial digestion in a way that serves the efficiency of the digestive process without affecting the health and productivity of the animal, to achieve this goal, the employed of minerals in the diet of animals has been directed towards, including nanoscale minerals because of their importance in improving the digestion process, As a result, its tiny particles along with the provision of a with its availability. Hassan et al, indicate that the addition of nano zinc at a dose of 20 mg/kg feed led to reduced methane production and improved level of antioxidants. This positive effect of nanoparticles by reducing the level of methane gas can be attributed to reducing the numbers of bacteria producing it or re-directing the hydrogen flow to bind to the receptors for producing propionate. The positive effect of these minerals also lies in their improvement of some digestive enzymes in the alimentary channel [3].

8. Potential risks associated with the use of nanotechnology in animal feed

What is needed is to assess the risk of nanotechnology in food and its impact on animals and humans. There is also a need for further research on the toxicological impact and potential hazards of nanoparticles for animal, environmental and human health. Potential hazards associated with nanoparticle nutrition include:(1) Increased bioavailability of nanoparticles compared to large shapes of the same material, (2) the prominent role of ROS-induced nanoparticles in gastrointestinal inflammatory diseases (3) Potential effects of nanoparticles on the stability and function of proteins and enzymes whereby metabolic processes may be disrupted or nutrient bioavailability may be altered, (4) Potential effects of storage, heating, and aging on the biomass complexes of nanoparticle molecules in feed [21].

9. Conclusion

In short, nanotechnology is a science that can be used in livestock diets to improve the bioavailability of nutrients, production performance, and the safety and health status of livestock. However, much research is needed in Relate to the usefulness and efficiency of nanotechnology and whether it is harmful or less harmful to the environment and humans.

Compliance with Ethical Standards

There is no conflict of interest to disclose.

Conflict of Interest

The author(s) declares no known competing financial interests or personal relationships.

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