Commentary

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Low Molecular Weight Chitosan in Animal Nutrition and Health

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Description

Chitosan (CHT) is a natural substance widely used in veterinary medicine, faces limitations in animal production due to its insolubility in pH ≥ 7. To address this, Low Molecular Weight Chitosan (LMWCHT) has emerged with unique characteristics like antibacterial activity and biodegradability, making it suitable for animal nutrition, husbandry and health applications. This review explores the utility of LMWCHT in these areas and its potential in chemotherapy delivery and as an alternative antibiotic.

Animal nutrition

Livestock plays a crucial role in global agriculture, employing millions and sustaining livelihoods, especially in developing nations. With a market value exceeding $1.4 trillion, livestock provides essential products like meat, milk and manure while supporting rural economies. However, challenges such as feed scarcity during the dry season and the high cost of conventional feedstuffs like soybean meal pose threats to livestock production. To address these challenges, researchers are investigating alternative, cost-effective feed ingredients. Additionally, escalating prices of cereals, protein concentrates, energy and pharmaceuticals have strained livestock production, particularly in the poultry industry.

In Sub-Saharan Africa (SSA), where livestock contributes significantly to GDP and employs a large portion of the population, ensuring adequate nutrition for animals is vital. The use of LMWCHT in animal nutrition shows promise in enhancing livestock health and productivity, thereby bolstering food security and rural livelihoods. This review highlights the importance of exploring innovative solutions like LMWCHT to address the challenges facing the livestock industry and secure its sustainability in the face of evolving economic and environmental pressures.

Immunity and metabolic processes

Feed additives utilized in animal nutrition serve to enhance immunity and metabolic processes while fostering overall livestock growth. Historically, antibiotics have played a pivotal role in disease treatment and agricultural advancement. However, the prolonged use of traditional antibiotics has raised concerns regarding microbial resistance and their residual impact on animal products. Consequently, alternative antibiotics and feed additives have emerged, with chitosan being a prominent example currently integrated into animal diets.

Chitosan, derived from alkali-deacetylation of chitin, consists of D-glucosamine and N-acetyl-D-glucosamine monosaccharides arranged randomly, forming a linear polysaccharide. It's versatile applications span various sectors, including agriculture and cutting-edge fields like biotechnology and nanotechnology. Chitosan-based films find use in food coating, acting as antimicrobial, flocculating and adsorbing agents. Research suggests its potential in delivering genes for siRNA technology, cancer treatment and gene therapy.

Moreover, chitosan's utilization extends to diverse domains such as creating 3D networks and micro-electrochemical systems, aiding in heart regeneration therapy and removing effluents from processing plants. It finds application in producing filter papers, biodegradable packaging, wood adhesives and fungicides. In cosmetic products, chitosan's fungicidal properties, UV absorption and biocompatibility make it a desirable ingredient. Its antibacterial attributes benefit plants by suppressing diseases and enhancing germination potential and root activity.

Chitosan's role in environmental remediation involves removing contaminants, while its derivatives serve as permeation enhancers in drug-delivery systems. Furthermore, it exhibits potential in creating solid-state batteries due to its ionic conductivity. Commercially available chitosan typically possesses a degree of deacetylation ranging from 70%-90% and a molecular weight between 50 and 2000 kDa, commonly sourced from crustacean shells.

The provision of food is crucial for the growth and health of animals. Yet, the inner workings behind how diets affect performance have long been a mystery. Only recently have studies revealed that nutrients act as signals, influencing gene expression and metabolism. Various pathways have been identified that allow cells to sense different nutrients. Despite progress in utilizing these signals for drug development and disease management, applying this knowledge to animal nutrition, both in terrestrial farming and aquaculture, is still in its early stages. Therefore, we outline potential research directions and practical uses for understanding nutrient sensing in animal diets.

Animal nutrition is essential for their well-being and development. Macronutrients like amino acids, fatty acids, and carbohydrates provide energy and essential components for maintaining balance and increasing biomass. Traditionally, nutrition research has focused on the processes of digestion, absorption, transport and metabolism. However, in recent years, there has been increasing interest in how cells and organisms perceive and respond to nutritional changes, known as nutrient sensing, which has become a prominent area of study in biology. Many studies have shown that nutrient sensing is crucial for regulating food intake, energy use, hormone release and metabolic functions in various animals, including humans.

Nutrient-sensing pathways, particularly the mTOR pathway, receive signals from external nutrients and environmental factors to control biomass growth and health. Dysregulated sensing pathways have been linked to diseases like cancer, cardiovascular disorders and neurodegenerative conditions. In mice, impaired mTOR activity leads to muscle weakness and stunted growth. Additionally, mTOR plays a key role in immune system regulation, influencing the function and activity of various immune cells. It also contributes to the growth and proliferation of stem cells and determines the fate of different cell lineages, particularly in the intestinal epithelium during repair processes after injury. This evidence underscores the significance of understanding and manipulating nutrient sensing in animals.