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ECO-BIOTECHNOLOGY: INNOVATIVE APPROACHES IN POULTRY PRODUCTION

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In the ever-evolving field of biotechnology, the synthesis of phytonutrient functionalised nanoparticles has emerged as an innovative technology with great potential in poultry production. This cutting-edge approach, known as eco-biotechnology, promises to revolutionise the way poultry are raised and housed, while addressing the environmental concerns associated with traditional farming methods. Before delving into the specifics of eco-biotechnology and its application in poultry farming, it is important to understand the basic principles behind this innovative industry. Nanoparticles are particles of matter with a diameter of 1 to 100 nanometres (nm). Nanoparticles can be made from many different materials, including metals, semiconductors, polymers and ceramics. Nanoparticles have unique physical, chemical and biological properties that differ from their larger counterparts. These properties are due to the high surface area to volume ratio of nanoparticles. Surface area is the amount of surface in contact with the environment. Volume is the amount of space occupied by a particle. The large surface area of nanoparticles

allows them to interact more easily with other substances than larger particles. This makes them useful in a variety of applications, such as electronics, energy, biology, medicine, agriculture, and ecology (environmental remediation: cleaning up pollution or removing harmful substances from soil and water [2, 15, 16]. By functionalising these particles with phytonutrients, which are natural compounds found in plants, we can increase their biological activity and tailor them to specific applications.

The synthesis of phytonutrient-functionalised nanoparticles is achieved through a combination of advanced biotechnological methods, including green chemistry, nanotechnology and molecular biology. These techniques allow scientists to create nanoparticles with the desired properties, such as size, shape and surface charge, and to incorporate phytonutrients that have bioactive properties beneficial to poultry health [13]. One of the key benefits of eco-biotechnology is its ability to improve the absorption and utilisation of phytonutrients in poultry. Phytonutrients, such as polyphenols and carotenoids, have been widely studied for their antioxidant, anti-inflammatory and immunomodulatory properties.

It has been established that the addition of flavonoid compounds as natural feed additives can have an impact on antioxidant, immune, antimicrobial and overall performance of poultry and animals [6, 14].

However, the bioavailability and stability of phytonutrients in the intestine of animals can be limited. By binding them to nanoparticles, we can protect flavonoids from degradation and improve their absorption by the poultry digestive system. In addition, phytonutrient-functionalised nanoparticles offer a new approach to address the growing problem of antibiotic resistance in poultry production. Antibiotics have traditionally been used as growth promoters and to prevent the spread of disease in poultry. However, their overuse has led to the development of antibiotic-resistant bacteria that pose a serious threat to both animal and human health. Ecobiotechnology offers an alternative solution by harnessing the innate antimicrobial properties of phytonutrients, which can be further enhanced by encapsulating them or forming bioconjugates with nanoparticles [10]. These nanoparticles can act as carriers, delivering phytonutrients directly to the site of

infection and minimising the need for antibiotics.

In addition to their direct impact on poultry health, phytonutrient-functionalised nanoparticles can also benefit poultry production on a broader scale [1]. For example, these nanoparticles can be used to increase the nutritional value of poultry feed. By incorporating essential nutrients and vitamins into nanoparticles, we can provide poultry with a balanced diet, leading to improved growth rates and overall productivity [4, 8, 9].

Moreover, the use of nanoparticles functionalised with phytonutrients can contribute to sustainable and environmentally friendly poultry production [3]. Traditional farming methods are often associated with environmental problems such as water pollution, greenhouse gas emissions and land degradation. Ecobiotechnology offers a more sustainable approach by reducing the need for chemicals and minimising the environmental impact of poultry farming. In addition to direct applications in poultry production, the synthesis of functionalised nanoparticles with phytonutrients opens up a wide range of opportunities for future research and development. For example, these nanoparticles can be further engineered to target specific signalling pathways in the poultry body, leading to the discovery of new therapeutic interventions and disease prevention strategies [1]. By unravelling the complex links between nanoparticles, phytonutrients and signalling pathways, scientists can unlock a wealth of knowledge that could revolutionise animal health and welfare.

Another innovative approach is the use of certain strains of lactobacilli that can efficiently grow and biotransform inorganic selenium (sodium selenite) into organic forms. These bacteria accumulate selenium intracellularly, produce selenium nanoparticles and form selenocysteine, the most bioavailable form of selenium, which is then incorporated into the structure of selenoproteins. The synthesis of selenocysteine and selenoproteins is activated by adding the amino acid serine to the bacterial culture medium, which activates the formation of selenocysteine. Monitoring of lactobacilli capable of synthesising two different forms of selenium simultaneously will facilitate the development of products biofortified with available

selenium and their use as food and animal feed [12].

In summary, eco-biotechnology is an innovative approach to poultry farming that harnesses the power of nanotechnology and phytonutrients to improve poultry health, enhance feed quality and promote sustainable development, as well as reduce the environmental impact of poultry farming.

By immobilising phytonutrients on the surface of nanoparticles, creating a functional stabilising shell, we can overcome the limitations of traditional methods of using micronutrients and modernise agriculture and pave the way for a more efficient and environmentally friendly future. The potential of this new industry is enormous, and further research and development in eco-biotechnology will undoubtedly shape the future of poultry farming. There are concrete examples of how phytonutrient functionalised nanoparticles are being used in modern poultry production. Nanoparticles with curcumin, a phytonutrient with antioxidant and anti-inflammatory properties, improve the growth and performance of broiler chickens [8]. Nanoparticles loaded with resveratrol, a phytonutrient, a polyphenolic derivative of stilbene widely found in grapes and red wine, which is widely known for its antioxidant and anti-inflammatory properties, have been shown to reduce the incidence of cancer [7]. Resveratrol nanopreparations have been shown to protect resveratrol from degradation caused by environmental factors, as well as to increase stability, solubility, bioavailability and control the delivery of resveratrol, ensuring its effectiveness. Resveratrol-loaded nanodelivery systems demonstrate its slow release at the injection site, which is considered a great advantage associated with a lower risk of side effects. In addition, the selective cytotoxicity of resveratrol nanopreparations is limited to cancer cells, which makes the nanotechnology-based approach superior to free resveratrol [7]. Studies [5] have shown a positive effect of resveratrol-loaded liposomal nanocarriers on broiler chickens suffering from heat stress: increased productivity, activated sirtuin expression, and reduced markers of oxidative stress. In a study [11], chitosan nanoparticles loaded with quercetin, a flavonoid widely distributed in food plants with numerous biological effects, the antioxidant and antiradical activity of quercetin-functionalised nanoparticles was

demonstrated and it was found that the incorporation of quercetin into chitosan nanoparticles could be useful for improving the bioavailability of quercetin. These are just a few examples of how the functionalisation of nanoparticles with phytonutrients and the antioxidant properties of these nanocarriers make them suitable candidates for targeted delivery and may open up new opportunities to combat oxidative stress in vivo. As research in this area continues, it is likely that more innovative and effective ways to use these technologies will emerge in the future.

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