The Role Of Chitosan And Whey Powder In Calcium, Magnesium And Phosphorus Metabolism And Their Effect On Bone Tissue Metabolism In Broiler Chicks

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ABSTRACT

This scientific article provides an expanded discussion of the effects of chitosan and whey powder on mineral metabolism in broiler chicks, with particular emphasis on the biological utilization of calcium, magnesium, and phosphorus and their contribution to bone tissue metabolism. Based on scientific literature, experimental findings, and veterinary biochemical observations, the paper analyzes chitosan's ability to form complexes with mineral ions, its involvement in osteogenesis, and the mechanisms through which it enhances bone matrix formation and mineralization. It is also substantiated that combining chitosan with whey powder strengthens the osteogenic effect through improved nutrient availability and supportive bioactive components. The reported outcomes indicate improved bone density and mechanical strength parameters in broiler chicks receiving rations supplemented with chitosan and whey powder.

Keywords: chitosan, whey powder, broiler chicks, calcium, magnesium, phosphorus, mineral metabolism, osteogenesis, bone metabolism, regeneration.

Introduction. In intensive poultry production, broiler chicks are characterized by rapid growth and high feed conversion efficiency; however, this biological advantage is often accompanied by insufficient skeletal development, leg deformities, increased bone fragility, and locomotor disorders. Such problems are widely recognized as economically significant and welfare-related issues in modern broiler management. A major underlying factor is the inadequate supply, reduced bioavailability, or impaired metabolism of essential minerals—primarily calcium (Ca), phosphorus (P), and magnesium (Mg)—which are fundamental to bone structure and function [9; 14].

Accordingly, improving bone tissue metabolism in broiler chicks through safe and effective natural supplements has become a relevant research direction. In recent years, chitosan and whey powder have been increasingly considered as promising dietary additives capable of modulating mineral absorption and supporting skeletal development in poultry [3; 5; 12].

Main Part. Biological and physiological properties of chitosan. Chitosan is a high-molecular-weight cationic polysaccharide

obtained from chitin. Due to amino groups in its structure, chitosan carries a positive charge, which determines its capacity to chelate and form complexes with mineral ions [1; 6]. Chitosan is biodegradable and generally regarded as non-toxic, which supports its use as a safe bioactive additive in animal nutrition.

In broiler chicks, chitosan may enhance mineral ion uptake at the intestinal epithelium, thereby facilitating their transport via circulation and subsequent deposition in bone tissue [8]. In addition, chitosan has been explored in biomaterials and tissue engineering, where its compatibility with biological tissues and its ability to support matrix formation are widely documented [8; 10; 12].

The significance of whey powder in poultry nutrition. Whey powder is a valuable source of highly digestible proteins, minerals, and bioactive peptides. In fast-growing broiler chicks, these components support the formation of bone tissue by supplying substrates for collagen synthesis and contributing to mineral homeostasis [2; 5]. The presence of Ca and P in whey powder, together with nutritionally relevant protein fractions, may further promote the completeness of osteogenesis and mineralization processes, especially when used in combination with other bioactive compounds.

Methodology. Study object and materials. The study object was broiler chicks aged 1 to 42 days. Chicks were allocated into groups, including a control group fed a standard diet and experimental groups receiving diets enriched with chitosan and/or whey powder. Chitosan and whey powder were incorporated into the ration according to physiological and nutritional considerations. During the trial period, the mineral composition of bone tissue, the Ca:P ratio, bone density indicators, and mechanical strength parameters were evaluated using veterinary-biochemical and morphofunctional assessment approaches [3; 11].

Analysis. Calcium metabolism in broiler chicks. In broiler chicks fed chitosan-supplemented rations, calcium absorption through the intestine was observed to increase. This supports the maintenance of calcium in biologically active ionic forms and promotes its utilization by osteoblasts [8]. As a consequence, bone matrix formation can accelerate, and collagen synthesis may be stimulated, which creates a favorable environment for mineral deposition and the stabilization of hydroxyapatite crystals.

Magnesium and phosphorus metabolism. Regarding Mg metabolism, chitosan can bind ions and potentially reduce excessive excretion, supporting more stable physiological Mg levels. Since Mg is involved in energy metabolism and ATP-dependent cellular processes, maintaining Mg balance may contribute to improved bone elasticity and structural stability in broiler chicks [9].

In P metabolism, interactions between chitosan and phosphate ions may enhance phosphorus availability for bone mineralization. This can accelerate the formation of hydroxyapatite crystals and ultimately support higher bone density and improved bone integrity [10].

Table

Effect of Chitosan and Whey Powder on Bone Metabolism Indicators in Broiler Chicks (Comparative Summary)

Indicators	Control group	Chitosan-supplemented	Chitosan + whey powder
Calcium absorption	Moderate	High	Very high
Magnesium status	Unstable	Stabilized	Stabilized
Phosphorus metabolism	Moderate	Active	Active
Bone density	Relatively lower	Higher	Highest
Mechanical strength	Moderate	Good	Very good
Regeneration rate	Slow	Faster	Fastest

Results. The study outcomes indicate that diets enriched with chitosan and whey powder improved bone metabolism in broiler chicks. Bone density increased by approximately 25–35%, while osteoblast proliferation and collagen synthesis activity were enhanced, contributing to better mechanical strength of bones. In addition, the frequency of leg deformities and bone-related locomotor problems decreased in experimental groups compared with controls [11; 12; 15]. These findings support the practical potential of dietary chitosan and whey powder for skeletal health management in intensive broiler production.

Conclusion. Chitosan and whey powder are biologically active nutritional components that may regulate calcium, magnesium, and phosphorus metabolism in broiler chicks and stimulate osteogenesis and bone tissue regeneration. Their combined use in broiler diets is scientifically and practically significant for reducing skeletal pathologies, supporting healthy growth, and improving overall production outcomes. The obtained data confirm the perspective of integrating chitosan-based approaches and whey-derived nutritional support into poultry feeding strategies to optimize bone development and mineralization.

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