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The Effect Of The Combination Of Chitosan And Whey Powder On Calcium–Phosphorus Metabolism And Bone Mineralization

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Abstract. This scientific article analyzes the effect of the combination of chitosan and whey powder in poultry and in biological systems in general on calcium-phosphorus metabolism, osteoblast activity, and bone mineralization. Chitosan, as a polysaccharide with high sorption ability and ion-binding capacity, may reduce intestinal calcium absorption when applied at high doses. In contrast, whey powder—rich in bioactive peptides, lactose, and minerals—enhances calcium uptake from the intestine, stimulates collagen synthesis in osteoblasts, and supports bone mineral density. The overall efficiency of the combination is dose-dependent: optimal proportions contribute to metabolic homeostasis, bone tissue strengthening, and improved mineral balance, whereas excessive chitosan may induce mineral deficiency.

Keywords: chitosan, whey powder, calcium-phosphorus metabolism, osteoblasts, bone mineralization, bioactive peptides, mineral absorption.

Introduction. Bone tissue represents the main structural component of the musculoskeletal system, providing mechanical strength, supporting locomotor function, and acting as a major reserve for minerals such as calcium and phosphorus. Bone metabolism plays a crucial regulatory role in maintaining systemic mineral homeostasis [12]. The mineral composition of bone is directly dependent on the Ca/P ratio. Disruption of absorption processes or deficiency of these elements may lead to osteoporosis, rickets, bone fragility, and endocrine-metabolic diseases [15].

Chitosan is a naturally derived polysaccharide synthesized through the deacetylation of chitin. It is distinguished among sorbent compounds by its strong

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cation-binding activity, including affinity for Ca^{2+} and Mg^{2+} ions. Due to this property, high doses of chitosan may decrease intestinal calcium availability and absorption [3; 7]. Simultaneously, chitosan is well-recognized as a metabolic stabilizing agent due to its capacity to bind toxins, reduce heavy metal absorption, and modulate gut microflora [5].

Whey powder is classified as a high-biological-value protein source containing β-lactoglobulin, α-lactalbumin, lactoferrin, lactose, and several minerals, which collectively facilitate calcium transport, promote osteoblast collagen synthesis, and increase bone tissue mineralization [2; 8; 9].

Given these effects, combined use of chitosan and whey powder is an increasingly relevant field of research in poultry nutrition, veterinary science, and potential applications in human dietary supplementation.

Methodology. This study is based on analytical assessment of international and regional scientific materials, experimental poultry research, and laboratory data. Relevant articles indexed in Scopus, PubMed, Google Scholar, and eLibrary were reviewed, along with experimental results from poultry studies conducted by Rakhmonov F. X. [1; 4; 16]. Experimental data referenced include chicks receiving whey powder at 3–5% diet inclusion and chitosan supplementation at 30–80 mg/kg feed.

Main Discussion and Analysis. Upon entering the digestive system, chitosan interacts with divalent cations through amino-functional groups, forming complexes with Ca^{2+} and consequently decreasing osmotic absorption rates [6]. Thus, chitosan supplementation in excessive doses may induce mineral deficiency. However, lower to moderate levels (40–60 mg/kg) demonstrate positive metabolic outcomes including modulation of intestinal microbiota, detoxification of endotoxins, and support of metabolic stability [4; 11].

Lactose contained in whey powder enhances the ionization and intestinal mobility of calcium, thereby increasing its absorption in a mechanism partially independent of vitamin D [8]. In addition, bioactive peptides present in whey protein promote osteoblast differentiation and stimulate matrix formation via collagen synthesis [9; 17]. Research by CIS scholars also demonstrates that supplementation of whey powder in diets of rabbits and broiler chicks increases bone density by approximately 9–14% [13; 18].

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When combined, chitosan and whey powder exert a synergistic effect by simultaneously detoxifying the intestinal environment and enhancing mineral uptake. Chitosan, at low doses, binds endotoxins and prevents interference with calcium absorption, thereby amplifying the beneficial effect of whey-derived minerals [10; 14]. Optimal nutritional ratios have been shown experimentally to increase osteoblast activity and promote bone mineralization [1; 4; 17].

Results. Analysis shows a distinct dose-dependent effect of chitosan-whey powder combinations. Optimal supplementation promotes metabolic equilibrium, improves Ca–P ratio maintenance, and increases bone mineralization. Conversely, chitosan administered in high concentrations may bind and reduce bioavailability of Ca2+, increasing the risk of mineral deficiency. Based on animal studies, the most effective dosages have been determined as 40–60 mg/kg of dietary chitosan and 3–5% dietary inclusion of whey powder [1; 4].

Conclusion. The combination of chitosan and whey powder can be regarded as a promising bio-composite nutritional additive beneficial for enhancing bone mineralization, supporting calcium-phosphorus metabolism, and promoting osteoblast function. While optimal supplementation yields superior biological efficiency, excessive intake of chitosan may impair mineral status. Therefore, this combination is recommended for application in poultry feeding technologies, animal husbandry, and potentially in human functional nutrition where bone-supportive supplementation is required.

References

1. Rakhmanov F., Usmanova X., Khodjaerova G. Effect of bioadditional supplements on broiler chicken. International Multidisciplinary Journal of Research and Development. 2025. Vol. 1. № 2. P. 3–7.
2. Lönnerdal B. Bioactive proteins in human milk: mechanisms of action. Journal of Pediatrics. 2010. Vol. 156. P. S26–S30.
3. Sh. U. T., Kh. R. F. Dry whey: a promising product for the food industry. Web of Teachers. 2025. Vol. 3. № 3. P. 16–18.
4. Evaluation of mineral metabolism in broiler chicks fed with chitosan and whey powder. Poultry Metabolism Review. 2025. № 1. P. 88–94.
5. Ivanov P.N., Sokolova T.V. Sorbent properties of chitosan in digestive tract. Proc. Biol. Sci. Moscow. 2014. № 7. P. 44–52.

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6. Wang X., Guo H. Chitosan and Ca2+ binding affinity. BioChem Review. 2011. Vol. 28. P. 115–121.
7. Chitosan enhances mineralization during osteoblast differentiation of human bone marrow–derived mesenchymal stem cells. Biomaterials. 2011. Vol. 32. P. 1204–1212.
8. Cardinal M., Scrimshaw N. Lactose-mediated calcium absorption. Nutrition Research. 2012. Vol. 34. P. 233–240.
9. Miyakawa H. Biopeptides of whey protein and bone formation. Journal of Nutrition Science. 2024. Vol. 19. P. 55–63.
10. Kuznetsov I., Matveeva O. Influence of chitosan on calcium absorption in rats. Russian Physiology Journal. 2013. № 9. P. 91–98.
11. Sokolov A. Clinical application of chitosan in metabolic disorders. Medical Chemistry. 2018. Vol. 22. P. 178–183.
12. Davydenko V. Bone Tissue Physiology. Kiev University Press. 2016. 312 p.
13. Petrova R., Guseva K. Effect of dry whey on rabbit skeletal system. Veterinary Science of Eastern Europe. 2021. № 3. P. 27–31.
14. Borodin A. Modulation of calcium homeostasis by chitosan. Chemical Biology Review. 2022. Vol. 15. P. 61–70.
15. WHO. Global Bone Health Report. Geneva, 2015. 189 p.
16. Rakhmonov F. K. Metabolic effects of feed additives in poultry. Samarkand Publishing House, 2024. 105 p.
17. Chito-oligosaccharides promote osteoblast differentiation and offer anti-osteoporotic potential: Molecular evidence from zebrafish model. Journal of Bioengineering. 2024. Vol. 17. P. 87–94.
18. Akhmedov B. Effect of whey diet on chicken tibia density. AgroBio Uzbekistan. 2020. № 2. P. 11–14.