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EFFECTS OF A CHITOSAN–WHEY POWDER COMBINATION ON HEPATIC GLYCOGEN CONTENT AND LIPID METABOLISM INDICATORS IN BROILER CHICKENS

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Abstract: *This article presents a biochemical assessment of the effects of a feed composition containing chitosan and whey powder on hepatic glycogen reserves and serum lipid metabolism in broiler chickens. The control group, chitosan group, whey powder group, and combined supplementation group were compared under the same management conditions. The combined additive increased liver glycogen concentration, reduced total cholesterol, triglycerides, and low-density lipoproteins, and increased the proportion of high-density lipoproteins. In parallel, the decline in malondialdehyde indicated attenuation of oxidative stress. These findings suggest that the chitosan–whey combination acts as a promising bioactive composition capable of normalizing carbohydrate and lipid metabolism, improving hepatic energy reserves, and optimizing the overall metabolic status of broilers.*

Keywords: *chitosan, whey powder, broiler chicken, liver glycogen, lipid metabolism, cholesterol, triglycerides, LDL, HDL, malondialdehyde, AMPK, PI3K/Akt*

Introduction

Maintaining a balanced carbohydrate and lipid metabolism is essential for sustaining high growth rate and feed efficiency in broiler production. In broilers, hepatic glycogen is a central marker of energy homeostasis, whereas serum total cholesterol, triglycerides, LDL, and HDL reflect the direction of lipid metabolism [1], [2], [3].

Chitosan is a natural cationic biopolymer capable of modulating metabolic responses by binding bile acids and lipid complexes in the intestinal lumen, reducing fat absorption, and activating AMPK-related signaling pathways [1], [4], [5]. Whey powder, in turn, is a source of high-biological-value proteins, lactose, and bioactive peptides that support insulin signaling, hepatic glycogen synthesis, and protein-plastic metabolism [2], [6], [7].

From a metabolic perspective, the joint use of chitosan and whey components may produce a synergistic effect: chitosan decreases the lipid burden, while whey proteins and peptides strengthen the anabolic side of energy metabolism [6], [8], [9]. Therefore, experimental evaluation of the effects of a chitosan–whey combination on hepatic glycogen reserves and lipid-profile indicators in broilers has both theoretical and practical relevance.

Main part

The scientific premise of this study is that dietary chitosan reduces absorptive lipid load by binding fatty acids and bile acids in the gut, whereas whey powder supports

glycogenogenesis and insulin sensitivity through β-lactoglobulin, α-lactalbumin, and whey-derived peptides [2], [4], [6]. Such an approach may enhance hepatic glycogen deposition while simultaneously reducing atherogenic lipid fractions.

Biochemically, the effect of the combination is expressed at three levels. First, intestinal binding of lipids and bile acids by chitosan promotes their excretion, thereby easing cholesterol and triglyceride metabolism [1], [4]. Second, proteins and peptides contained in whey activate glycogen synthase through the PI3K/Akt pathway, which facilitates glycogen storage [2], [7]. Third, both components attenuate oxidative stress, as evidenced by lower malondialdehyde concentrations and improved hepatocellular membrane stability [9], [10], [11].

Methodology

The experiment was carried out under comparable zoohygienic conditions at a broiler farm in the Samarkand region. A total of 120 one-day-old Ross-308 chicks were assigned by the principle of analogs into four groups (n=30 per group). Group I served as the control and received the basal diet. Group II received the basal diet supplemented with 0.2% chitosan, Group III received 5% whey powder, and Group IV received a combination of 0.2% chitosan and 5% whey powder.

The experiment lasted 35 days. At the end of day 35, blood and liver samples were obtained from 10 birds per group. Hepatic glycogen was determined spectrophotometrically using anthrone reagent and expressed as mg/g tissue. Serum total cholesterol, triglycerides, LDL, and HDL were measured by enzymatic colorimetric methods, whereas MDA was assessed using the thiobarbituric acid reaction [10], [12], [13].

Results were expressed as M±m. Intergroup differences were assessed using Student’s t-test. Differences were considered statistically significant at $p<0.05$.

Analysis

The results demonstrated that the combined supplementation group exhibited the most favorable shifts in hepatic energy reserves and lipid profile. Liver glycogen was highest in the combined group, whereas total cholesterol and LDL were the lowest. This suggests enhanced hepatic glucose phosphorylation and glycogen deposition together with reduced peripheral lipid overload.

In the chitosan-only group, lipid indices improved markedly, but the increase in glycogen remained moderate, indicating that chitosan acts primarily at the intestinal-resorptive level. In the whey-only group, the elevation in glycogen and HDL was more pronounced, but the decrease in cholesterol and LDL did not reach the magnitude observed with the combination. Thus, the mechanisms of both components complement one another and generate a synergistic effect [2], [6], [9].

The decline in MDA is another important marker of metabolic correction. Lower MDA indicates reduced lipid peroxidation, which in turn suggests improved membrane integrity and stabilization of enzymatic systems [10], [11]. Reduced oxidative stress also creates a more favorable environment for insulin signaling and glycogen synthesis.

Results

Table 1. Effects of the chitosan–whey composition on hepatic glycogen and major serum lipid indicators (M±m, n=10)

Group	Liver glycogen, mg/g	Total cholesterol, mmol/L	Triglycerides, mmol/L
Control	28.4 ± 1.2	4.86 ± 0.18	1.72 ± 0.07
0.2% chitosan	31.6 ± 1.4*	3.84 ± 0.15*	1.43 ± 0.06*
5% whey powder	33.7 ± 1.5*	4.21 ± 0.17*	1.48 ± 0.05*
0.2% chitosan + 5% whey powder	38.9 ± 1.6*#	3.22 ± 0.13*#	1.19 ± 0.05*#

** significant difference versus control (p<0.05); # significant difference versus the single-additive groups (p<0.05).*

As shown in Table 1, the combined supplementation group had the highest hepatic glycogen content (38.9±1.6 mg/g), which was 36.9% above the control value. At the same time, total cholesterol and triglycerides decreased by 33.7% and 30.8%, respectively. This indicates simultaneous enhancement of glycogen storage and reduction of metabolic lipid burden.

Table 2. Changes in lipoprotein fractions and oxidative-stress markers (M±m, n=10)

Group	LDL, mmol/L	HDL, mmol/L	MDA, nmol/mL
Control	2.21 ± 0.09	0.92 ± 0.04	5.84 ± 0.24
0.2% chitosan	1.57 ± 0.07*	1.01 ± 0.05	4.63 ± 0.19*
5% whey powder	1.74 ± 0.08*	1.08 ± 0.05*	4.41 ± 0.18*
0.2% chitosan + 5% whey powder	1.32 ± 0.06*#	1.18 ± 0.05*#	3.76 ± 0.16*#

The data indicate that the combined supplementation was the most effective in normalizing lipid fractions and reducing oxidative stress.

According to Table 2, LDL decreased by 40.3% in the combined group, whereas HDL increased by 28.3%. The 35.6% reduction in MDA confirms attenuation of lipid peroxidation. These findings support restoration of hepatic energy and antioxidant balance and suggest improved metabolic stability in broilers.

Conclusion

The experimental data showed that the combination of 0.2% chitosan and 5% whey powder increased hepatic glycogen reserves in broiler chicks, decreased total cholesterol, triglycerides, and LDL, increased HDL, and reduced MDA concentration.

The high efficacy of the combination can be explained by the complementarity between the sorption-detoxifying properties of chitosan and the insulinotropic and plastic effects of whey proteins and peptides. As a result, hepatic energetic status, lipid metabolism, and antioxidant defense improve in a complex and coordinated manner.

From a practical standpoint, this composition may be recommended as a promising nutritional approach for preventing excessive hepatic lipid accumulation, reducing metabolic burden, and supporting physiological stability associated with broiler productivity.

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