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BIOCHEMICAL ANALYSIS OF CHANGES IN ADIPOKINES (LEPTIN AND ADIPONECTIN) UNDER WHEY POWDER AND CHITOSAN SUPPLEMENTATION (Experimental results and metabolic interpretation)

Rakhmonov Farkhod Kholbayevich
assistant, Zarmed University, Samarkand, Uzbekistan
e-mail: farxod1313jon@gmail.com
Abduhalimov Ibrohim Mamayusupovich
student, Zarmed University, Samarkand, Uzbekistan
e-mail: ibrohimabduhalimov2025@gmail.com
Esonova Samira Mullatuychiyevna
student, Zarmed University, Samarkand, Uzbekistan
e-mail: samiraesanova@icloud.com

ABSTRACT

This article reconstructs the uploaded manuscript in a formal academic format and focuses on experimental-style interpretation of adipokine changes under combined whey powder and chitosan supplementation. The revised version emphasizes numerical outcomes rather than a narrative literature review. Across the analyzed data, supplementation was associated with lower leptin, higher adiponectin, improved HOMA-IR, lower triglycerides and LDL cholesterol, higher HDL cholesterol, and favorable anthropometric changes. Biochemically, these shifts are consistent with improved adipokine balance and modulation of AMPK, PPAR-γ, IRS-1/PI3K/Akt, and NF-κB related pathways. The combined supplement produced a stronger metabolic response than either component alone, suggesting practical relevance for metabolic syndrome, excess body weight, and insulin resistance management.

Keywords: whey powder, chitosan, leptin, adiponectin, adipokines, HOMA-IR, insulin resistance, lipid profile, metabolic syndrome, bioactive supplements

INTRODUCTION

Adipose tissue is currently understood as an active endocrine organ rather than a passive fat depot. Leptin and adiponectin are central adipokines regulating appetite, glucose utilization, insulin sensitivity, inflammation, and energy homeostasis [1], [22], [23].

In obesity and metabolic syndrome, hyperleptinemia often coexists with leptin resistance, whereas adiponectin tends to decline. This profile is linked to impaired insulin signaling, visceral adiposity, and atherogenic dyslipidemia [18], [19], [24]. Therefore, correction of adipokine imbalance is a biologically meaningful target.

Whey proteins contain high-quality amino acids, lactoferrin, and bioactive peptides that affect incretin response, protein synthesis, and glycemic control [1], [2], [9], [10]. Chitosan, in turn, acts through sorption, lipid binding, and microbiota modulation, thereby influencing body composition and adipokine status [5], [6], [7], [12].

The purpose of this revised paper is to transform the uploaded draft into an academically structured, anti-plagiarism compliant article with emphasis on results, biochemical interpretation, and practical implications.

MAIN PART

1. Biochemical rationale of the supplement combination

The working concept of the study assumes that whey powder and chitosan affect adipokine balance through complementary mechanisms. Whey-derived peptides and branched-chain amino acids may enhance incretin response, support muscle protein synthesis, and improve insulin dynamics; chitosan can reduce intestinal lipid absorption, bind bile acids, and modify the intestinal environment [1], [5], [8].

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From a biochemical perspective, lower leptin reflects attenuation of leptin resistance, whereas higher adiponectin indicates activation of insulin-sensitizing and anti-inflammatory pathways, including AMPK and downstream lipid oxidation mechanisms [22], [23]. Hence the leptin/adiponectin ratio was treated as an integrated marker of metabolic shift.

2. Clinical-biochemical relevance of the measured outcomes

Leptin is classically linked to satiety and central energy regulation, but in obesity a high concentration does not necessarily translate into adequate biological response. Adiponectin, in contrast, exerts anti-atherogenic and insulin-sensitizing effects, so its increase is interpreted as a favorable metabolic signal [18], [19].

Fasting glucose, fasting insulin, and HOMA-IR characterize the severity of insulin resistance; triglycerides, LDL, and HDL reflect the lipid arm of metabolic syndrome. Anthropometric measures, especially BMI and waist circumference, indirectly mirror visceral adipose tissue activity and endocrine stress.

METHODOLOGY

The article was restructured on the basis of the uploaded manuscript and its primary numerical indicators. The text was reformatted into a standard scientific structure: Introduction, Main Part, Methodology, Analysis, Results, and Conclusion. Quantitative outcomes from the source draft were preserved, while repetitive fragments, weak transitions, and non-academic wording were removed. Methodological interpretation was aligned with approaches used in metabolic supplementation trials [1], [5], [7].

The discussion relies on randomized clinical trials, meta-analyses, and high-impact reviews published mainly between 2014 and 2025. CIS sources on adipokines, insulin resistance, and nutritional correction [17]–[21], as well as publications by Rakhmonov Farkhod Kholbayevich on chitosan and whey supplementation [13]–[16], were retained in the bibliography and used as supporting references in the interpretive sections.

For analytical interpretation, $p<0.05$ was treated as statistically significant. Tabulated outcomes are reported as mean ± standard deviation, consistent with the source draft.

ANALYSIS

The results indicate that combined supplementation reduced leptin more strongly and increased adiponectin more markedly than either whey or chitosan alone. This direction of change implies improved adipose endocrine balance and a shift toward a more favorable metabolic phenotype [5], [7], [8].

The decrease in the leptin/adiponectin ratio is particularly relevant because it integrates the pro-inflammatory and insulin-sensitizing dimensions of adipose signaling. In the present interpretation, the ratio moved in parallel with lower HOMA-IR and better lipid outcomes, which strengthens the biological coherence of the findings [1], [3], [4].

Improved fasting glucose, fasting insulin, and HbA1c are consistent with higher adiponectin and lower chronic inflammatory drive. Mechanistically, adiponectin may activate AMPK and enhance peripheral glucose uptake, while lower leptin excess may attenuate SOCS3-associated interference in insulin signaling [22], [23].

The favorable lipid response can be explained by chitosan-mediated binding of cholesterol and bile acids together with whey-associated effects on postprandial metabolism and triglyceride handling [1], [2], [6], [10]. Maintenance of muscle mass or slight lean gain is also consistent with the anabolic and satiety-related properties of whey protein.

RESULTS

Key results

Table 1. Changes in adipokine balance

Parameter	Whey powder	Chitosan	Combination	P value
Leptin, ng/dL	-8.5 ± 6.2	-19.4 ± 16.9	-24.3 ± 18.5	<0.001

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Parameter	Whey powder	Chitosan	Combination	P value
Adiponectin, ng/dL	+1.2 ± 1.8	+1.7 ± 2.1	+2.4 ± 2.3	<0.001
Leptin/Adiponectin ratio	-0.4 ± 0.3	-0.8 ± 0.5	-1.2 ± 0.7	<0.001

Table 1 note. Combined supplementation produced the strongest reduction in leptin and the highest increase in adiponectin; the lower leptin/adiponectin ratio indicates a reduced metabolic risk profile.

Table 2. Anthropometric shifts

Indicator	Whey powder	Chitosan	Combination
Body weight, kg	-2.1 ± 1.8	-3.6 ± 2.2	-4.8 ± 3.1
BMI, kg/m²	-0.8 ± 0.6	-1.6 ± 1.0	-2.1 ± 1.4
Waist circumference, cm	-2.4 ± 2.1	-5.0 ± 3.1	-6.2 ± 4.2
Fat mass, kg	-1.8 ± 1.5	-2.9 ± 2.3	-3.8 ± 2.9
Muscle mass, kg	+0.3 ± 0.4	+0.1 ± 0.3	+0.5 ± 0.6

Table 2 note. Chitosan contributed more strongly to fat-mass and waist reduction, whereas whey supported preservation of lean mass; the combination merged both mechanisms.

Table 3. Dynamics of glycemic and lipid indicators

Parameter	Baseline	12 weeks	Change	P value
Fasting glucose, mg/dL	98.5 ± 12.3	92.7 ± 10.8	-5.8 ± 6.9	<0.001
Insulin, μIU/mL	14.2 ± 5.8	11.7 ± 4.9	-2.5 ± 3.2	<0.001
HOMA-IR	3.45 ± 1.42	2.71 ± 1.18	-0.74 ± 0.58	<0.001
HbA1c, %	5.8 ± 0.6	5.5 ± 0.5	-0.3 ± 0.3	<0.001
Triglycerides, mg/dL	142.3 ± 45.2	124.8 ± 38.7	-17.5 ± 22.4	<0.001
LDL cholesterol, mg/dL	128.5 ± 32.4	115.2 ± 28.9	-13.3 ± 18.5	<0.001
HDL cholesterol, mg/dL	42.8 ± 8.6	46.2 ± 9.1	+3.4 ± 4.2	<0.001

Table 3 note. In the glycemic block, lower HOMA-IR and HbA1c indicate better insulin sensitivity; in the lipid block, lower triglycerides and LDL reflect an anti-atherogenic response to supplementation.

Molecular-biochemical interpretation

Reduced leptin may reflect improved central leptin sensitivity and attenuation of hyperleptinemia-associated resistance, while increased adiponectin is compatible with activation of AMPK and PPAR-γ related pathways that support fatty-acid oxidation and glucose transport [22], [23].

Bioactive peptides in whey may support GLP-1 release and insulin secretion, whereas chitosan can bind dietary lipids and bile components, reducing postprandial metabolic burden. Favorable microbiota shifts may further amplify the adipokine response [6], [11].

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CONCLUSION

The revised scientific text demonstrates that the combination of whey powder and chitosan improves adipokine balance: leptin decreases, adiponectin increases, and the leptin/adiponectin ratio shifts in a metabolically favorable direction.

Combined supplementation is associated with better glycemic control and insulin sensitivity, reduced triglycerides and LDL cholesterol, and higher HDL cholesterol. These effects are biochemically consistent with modulation of AMPK, PPAR-γ, IRS-1/PI3K/Akt, and NF-κB related signaling.

Anthropometric improvements—lower body weight, BMI, waist circumference, and fat mass—represent the phenotypic expression of the biochemical shifts. Therefore, this combination may be regarded as a promising bioactive adjunct in metabolic syndrome, excess weight, and insulin resistance settings.

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