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BIOCHEMICAL EFFECT OF PEPTIDES FORMED FROM WHEY POWDER AND CHITOSAN ON ENZYMATIC ACTIVITY

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ABSTRACT: The article analyzes the effects of peptides formed from whey proteins and the biopolymer chitosan on enzymatic activity, their biochemical mechanisms of action, and their modulatory role in cellular processes. Based on scientific literature, the formation of ACE-inhibitory, antioxidant, immunomodulatory, antimicrobial, and metabolism-enhancing peptide complexes as a result of the proteolytic hydrolysis of whey proteins is highlighted. The study also examines the synergistic effects of chitosan and bioactive peptides, as well as molecular mechanisms involving PI3K/Akt, MAPK, and Nrf2 pathways, which lead to the activation of enzymatic systems and the enhancement of antioxidant enzymes including SOD, GPx, and catalase. The results demonstrate the practical significance of these bioactive components in the development of health-promoting dietary supplements.

Keywords: whey, chitosan, bioactive peptides, enzymatic hydrolysis, ACE-inhibitor, antioxidant enzymes, immunomodulator, metalloproteinases, PI3K/Akt, Nrf2, MAPK, enzymatic activity, functional foods.

INTRODUCTION. Whey, a secondary product of dairy processing, is internationally recognized as a valuable raw material due to its high biological value. β-Lactoglobulin, α-lactalbumin, lactoferrin, immunoglobulins, and glycomacropeptides in whey undergo proteolytic cleavage under the action of proteases, resulting in the formation of various biologically active peptides [1; 3; 7]. Chitosan, a deacetylated chitin-derived natural polymer, is widely used as a carrier of biologically active compounds due to its metabolic, immunological, and adsorption properties [10; 14].

International research has confirmed the antihypertensive (ACE-inhibitory), antioxidant, antimicrobial, and immunomodulatory properties of whey-derived peptides [2; 6; 12]. In Russia, Belarus, and Kazakhstan, scientific developments have been made to produce bioactive supplements based on whey [18; 20]. In Uzbekistan, the number of studies related to whey and chitosan has increased in recent years, including laboratory experiments by Rakhmonov F.X. evaluating their physiological effects on broiler chickens [4; 5; 9; 22].

METHODOLOGY. Analytical methods included systematic review of scientific literature, comparative biochemical analysis of reactions, and molecular-biological interpretation of enzymatic processes.

Sources: publications indexed in PubMed, Scopus, eLIBRARY, Google Scholar; CIS-region scientific journals; and open-source publications related to laboratory research by Rakhmonov F.X.

Biochemical basis: proteolytic hydrolysis of whey proteins mediated by proteases (pepsin, trypsin, chymotrypsin), papain, and bromelain; effects of peptides on cellular enzymatic pathways.

MAIN PART. Hydrolysis of whey proteins and generation of bioactive peptides. Under the action of proteolytic enzymes, β-lactoglobulin and α-lactalbumin are cleaved into di-, tri-, and oligopeptides (Val-Pro-Pro, Ile-Pro-Pro). These peptides inhibit ACE and are capable of reducing arterial blood pressure, as confirmed in laboratory studies [11; 16].

1. Synergistic biological action of chitosan and peptides.

Chitosan, possessing cationic chemical properties, can act as a carrier for signaling molecules and enhance the bioavailability of peptides when consumed [13; 21].

2. Mechanisms of enzymatic activity enhancement.

Whey-derived peptides interact with intracellular enzymatic systems by:
– inhibiting angiotensin-converting enzyme (ACE) [2];
– increasing the activity of antioxidant enzymes SOD, GPx, catalase [8; 17];
– activating digestive enzymes such as trypsin, chymotrypsin, lipase, amylase [6; 14];– reducing activity of metalloproteinases (MMP-2, MMP-9), thereby enhancing tissue regeneration [19].

3. Signal transduction pathways.

The molecular influence of peptides occurs via:
– PI3K/Akt – increasing cellular energy metabolism and viability;
– MAPK – modulating cellular proliferation and inflammation;
– Nrf2 – enhancing antioxidant gene expression [7; 18].

ANALYSIS. Experiments conducted by Rakhmonov F.X. and colleagues on broiler chickens demonstrated that supplementation with whey-chitosan mixtures improved blood biochemical indicators such as glucose, triglycerides, and total protein [4; 5; 9]. These findings confirm the enzymatic and immuno-metabolic effects of whey peptides at the organism level.

RESULTS. Whey peptides and chitosan:
– accelerate enzymatic processes;
– provide cardioprotective action via ACE inhibition;
– reduce oxidative stress and enhance antioxidant defenses;
– exhibit antimicrobial activity by disrupting microbial cell membranes;
– modulate cytokine secretion within the immune system.

These results confirm their applicability in functional food production and development of bioactive dietary supplements.

CONCLUSION. The synergistic interaction between peptides formed through whey protein hydrolysis and the biopolymer chitosan possesses significant scientific and practical potential in activating enzymatic systems and modulating metabolism. Molecular-level justification of their effects suggests perspectives for application in pharmaceuticals, sports medicine, and veterinary science.

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