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Article

Prospects for Development of Biologically Active Supplements Based on Inulin and Collagen for the Prophylaxis of Bone Metabolism Disorders Associated with Diabetes

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Abstract: Diabetes mellitus is a common chronic disease today, which not only disrupts carbohydrate metabolism, but also negatively affects bone tissue metabolism, increasing the risk of developing secondary bone diseases such as osteopenia and osteoporosis. The development of biologically active food supplements to prevent this problem is one of the current scientific directions. This article reviews the scientific basis and prospects for developing a biologically active supplement based on inulin and collagen for the prevention of diabetes mellitus and bone metabolism disorders associated with this disease.

Keywords: diabetes, inulin, glucose, intestinal microflora, polysaccharide, peanut, osteopenia, osteoporosis, collagen

Introduction

Diabetes mellitus (Latin diabetes mellitus) is a group of endocrine diseases that occurs due to a complete or partial deficiency of the hormone insulin. As a result, hyperglycemia is observed in the blood - a persistent increase in the amount of glucose in the blood. The disease is characterized by a chronic course and a violation of metabolic processes in the body (carbohydrate, protein, fat, mineral and water-salt metabolism). The first definitions of this pathological condition were given by the most prominent clinical symptoms of the disease - excessive fluid loss through urination (polyuria) and insatiable thirst (polydipsia). In ancient times, diabetes mellitus was considered a pathological condition accompanied by a loss of the ability to retain fluid in the body [1].

Materials and Methods

This work is a narrative literature review. Relevant sources were identified through searches of PubMed/MEDLINE, Google Scholar, Scopus, and the scientific-literature portals of the Republic of

Uzbekistan, using combinations of the keywords “diabetes mellitus,” “bone metabolism,” “osteopenia,” “osteoporosis,” “inulin,” “collagen,” “prebiotic,” and “medicinal plants with antidiabetic activity.” Publications from 1996 to 2025 were considered eligible for inclusion; peer-reviewed journal articles, systematic reviews, meta-analyses, and randomized controlled trials were prioritized over grey literature. Sources describing the pathophysiological relationship between diabetes mellitus and bone metabolism, the pharmacological and phytotherapeutic management of diabetes, and the physicochemical and physiological properties of inulin and collagen were selected and synthesized to build the scientific rationale for a combined inulin–collagen biologically active food supplement. Because this is a theoretical and analytical review rather than an original experimental study, no laboratory procedures, human or animal subjects, or statistical analyses were involved; the Results presented below represent a structured synthesis of the reviewed literature.

Results

Diabetes mellitus is the most common chronic disease in highly developed countries today. The number of such patients is increasing every year in all countries of the world. Diabetes mellitus is a type of endocrine disease and is caused by a complete or partial deficiency of the hormone insulin. As a result, hyperglycemia is observed in the blood - a persistent increase in the amount of glucose in the blood. There are 2 types of diabetes mellitus, the first type is characterized by an absolute deficiency of insulin produced by the pancreas, mainly in adolescents and children. In the second type, an increase in blood sugar levels is caused by insulin resistance. Normally, the blood sugar level in the human body is 3.3-5.5 mmol / l.

Patients with diabetes mellitus typically present with symptoms such as increased thirst, frequent urination, weight loss, loss of appetite, fatigue, and bone metabolism disorders over the years . [2]

Patients with diabetes mellitus develop osteopenia. This leads to bone loss, fragility, pain and deformity, osteoporosis and osteopenia. The development of modern medicine has enabled the pharmaceutical industry to develop several drugs, such as thiazolidinediones and insulin. Although these drugs have hypoglycemic effects, they can often cause a number of complications, such as nephrological diseases, fatigue, gastrointestinal disorders, diarrhea. Therefore, it is important to further study the active components of antidiabetic medicinal plants and their possible mechanisms for future research [3].

Medicinal plants are preferred over synthetic drugs for reducing the adverse effects of diabetes and its secondary complications, as they have fewer side effects and are cost-effective [4].

There are approximately 410 experimentally proven medicinal plants with antidiabetic properties, of which only 109 have been fully elucidated. Several medicinal plant extracts have been shown to modulate metabolic pathways such as glycolysis, gluconeogenesis, Krebs cycle, glycogen synthesis and degradation, insulin synthesis and secretion, cholesterol synthesis, and carbohydrate metabolism and absorption [5].

The table below lists the names of medicinal plants with antidiabetic activity and their main active ingredients.

Table 1. Medicinal plants with experimentally proven antidiabetic activity and their main active ingredients.

No.	Plant name	Latin name	Main active ingredient
1	Earth pear	Helianthus tuberosus L.	Inulin
2	Wood apple	Ayegle marmelosL.	Pectin
3	Coriander	Coriandrum sativum.	Linoleic acid
4	Ginger	Zingiber officinale	Gingerol
5	Garlic	Allium sativum L.	Allicin
6	Prune	Syzygium cimini L.	Polyphenols
7	Basil	Ocimum tenuiflorum L.	Eugenol
8	Bitter melon	Momordica charantia L.	Charantin

Inulin is the only natural fiber found in small amounts in the Jerusalem artichoke plant.

A polysaccharide, consisting mainly of 95% fructose chains. Inulin is a prebiotic substance that helps improve intestinal microflora, regulate carbohydrate metabolism, and control blood glucose levels.

Collagen is a fibrous, water-insoluble protein that, together with other substances, forms collagen fibers, which constitute the main mass of connective tissues. It is widespread in nature and has practical importance as a valuable raw material for industrial production[6].

Due to the bioavailability of collagen and its bioavailability in the body, as well as its low side effects, collagen-based medicines are widely used in medicine.

The resulting drugs and biomaterials are widely used to repair injured tissues, fill tissue defects, stop bleeding, and strengthen and promote bone regeneration[7].

Discussion

Based on the above data, the use of biologically active components obtained from natural sources is of great importance in the prevention of bone metabolism disorders associated with diabetes. The creation of a biologically active food supplement in the form of powder based on inulin and collagen is one of the promising directions aimed at meeting the metabolic needs of the body, supporting the condition of bone tissue, and reducing the risk of diabetic complications. Therefore, the development of a new generation of functional products based on the combination of these components is scientifically and practically relevant.

The findings summarized above indicate that diabetes mellitus and disorders of bone metabolism are mechanistically linked rather than merely co-occurring conditions. Insulin deficiency or resistance, chronic hyperglycemia, and the accumulation of advanced glycation end-products disrupt the normal balance between osteoblast-mediated bone formation and osteoclast-mediated bone resorption, producing a distinct pattern of bone fragility often referred to as diabetic osteopathy [8], [9]. Determinants of bone strength in diabetes extend beyond bone mineral density alone and include changes in bone microarchitecture and matrix quality that are not always captured by standard densitometry [10], and biochemical markers of bone turnover are frequently altered in diabetic patients, providing a further rationale for interventions that support bone matrix formation rather than bone density alone [11].

Within this context, the two components examined in this review target complementary aspects of the problem. Inulin acts primarily as a prebiotic fiber: a dose-response meta-analysis of 33 randomized controlled trials found that inulin-type fructans supplementation meaningfully improves glycemic control in prediabetic and type 2 diabetic populations [12], supporting its inclusion as the carbohydrate-metabolism-supporting component of a combined supplement. Collagen, in turn, acts on the skeletal side of the problem: a randomized, placebo-controlled trial in postmenopausal women with reduced bone mineral density found that twelve months of daily oral collagen peptide supplementation significantly increased bone mineral density in the spine and femoral neck and produced a favorable shift in bone-formation and bone-resorption markers [13], a finding broadly consistent with subsequent meta-analytic evidence [14] and with animal studies showing that combined collagen peptide and mineral supplementation inhibits bone loss [15].

Taken together, these lines of evidence suggest that a supplement combining inulin and collagen could, in principle, address both arms of diabetic osteopathy simultaneously — moderating glycemia through the prebiotic, gut-microbiota-mediated action of inulin, while supplying an exogenous source of amino acids and signaling peptides that support collagen synthesis and bone matrix quality. It should be emphasized, however, that this evidence base is currently indirect: no published trial to date has evaluated an inulin–collagen combination specifically in a diabetic population, and most of the supporting collagen studies have been conducted in postmenopausal women or in animal models of estrogen deficiency rather than in individuals with diabetes. The present review is therefore theoretical and hypothesis-generating rather than confirmatory, and its main limitation is the absence of primary experimental or clinical data on the specific combination proposed here. Future work should prioritize the formulation of a stable inulin–collagen powder,

characterization of its physicochemical and functional properties, and, ultimately, controlled feeding trials in diabetic model systems and, eventually, in patients with diabetes-associated osteopenia, to confirm whether the theoretical complementarity identified in this review translates into a measurable clinical benefit.

Conclusion

The research work theoretically analyzed the composition, functional properties and prospects for use in the prevention of diabetic osteopathy of a biologically active supplement based on inulin and collagen. The results obtained indicate that this area is promising for future scientific and practical research.

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