Chapter 11

Chitosan Polysaccharides for Osteoporosis Therapy in Postmenopausal Women

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ABSTRACT

Osteoporosis is a common degenerative disease in postmenopausal women, characterized by a loss of bone density and skeletal fragility, increasing fracture risk. This chapter examines the use of chitosan, a natural biopolymer derived from chitin, as a therapeutic agent in osteoporosis treatment. Chitosan's unique properties, such as biocompatibility, biodegradability, and the ability to form three-dimensional

DOI: 10.4018/979-8-3373-0055-9.ch011

structures, make it a promising candidate for bone therapies. The chapter also analyzes chemical and functional modifications to chitosan that enhance its bioactive effects and drug delivery capabilities, offering promising perspectives for non-hormonal osteoporosis treatments.

I. INTRODUCTION

Bone disorders encompass any disease affecting human bones, leading to abnormalities in the skeletal system. Osteoporosis, a skeletal disorder, is characterized by an increased risk of fractures, resulting in significant morbidity and mortality (Santhosh et al., 2019). Several factors contribute to this condition, including aging, insufficient calcium intake, reduced androgen levels, and genetic predisposition (Satarug et al., 2003). Alongside conventional therapies (such as parathyroid hormone and its analogs) and/or anti-resorptive treatments (bisphosphonates, hormone replacement therapy, selective estrogen receptor modulators, and calcitonin), a challenge lies in identifying biomaterials that can simultaneously provide detoxification against heavy metals and promote bone regeneration. Currently available bone biomaterials on the market do not fully satisfy these requirements and often involve substantial production costs.

Natural-origin polymers are gaining increasing attention for various biomedical and biological applications, including drug delivery systems, tissue engineering, wound dressings, and food packaging (Juncos Bombin et al., 2020). Among the most extensively studied polymers in the biomedical field are collagen, gelatin, alginate, chitosan, silk, hyaluronic acid, elastin, glycosaminoglycans (GAGs), and peptides. These materials play a vital role in numerous biological processes, such as cell differentiation, proliferation, and adhesion, as well as in inflammatory and immune responses (Gim et al., 2019). Their diversity in molecular weight, size, and charge, combined with their stability and low in vivo toxicity, makes them promising candidates for a range of applications. The presence of functional groups such as hydroxyl, carboxylic acid, and amine groups in the structure of polysaccharides provides several in vivo advantages, including prolonged half-life in the body, the ability to support cell growth, and the formation of hydrogels, while minimizing inflammatory or immune responses (Ferreira et al., 2015).

In this context, the novelty of this research lies in its innovative approach to investigating chitosan not only as a regenerative biomaterial but also as a therapeutic agent for postmenopausal bone disorders, specifically osteoporosis, by targeting both bone repair and heavy metal detoxification simultaneously (Khan & Ahmad, 2013). This dual-function role of chitosan remains largely underexplored in current literature. Thus, the objective of this chapter is to investigate the therapeutic potential of chitosan in treating postmenopausal disorders, with a particular focus on osteoporosis.

II. PATHOPHYSIOLOGY OF OSTEOPOROSIS IN POSTMENOPAUSAL WOMEN

Bone is a living tissue, and therefore, it is constantly renewed. This renewal process is called **bone remodeling**. During this biological action, two types of cells intervene successively, first the osteoclasts to destroy the old bone, and the osteoblasts which will rebuild the new bone. When there is an imbalance in this balance of bone remodeling, where bone resorption mediated by osteoclasts exceeds bone formation mediated by osteoblasts, this case is called osteoporosis (H. Li et al., 2021). It is a pathophysiology that results in the loss of bone mass, which often leads to bone fragility as well as fractures (H. Li et al., 2021), in fact, more than 8.9 million fractures are caused by osteoporosis each year (Noh et al., 2020).