Chapter 10

Radioprotective Effects of Chitosan Polysaccharides and Biomedical Applications

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ABSTRACT

Ionizing radiation (IR) plays a central role in the biomedical field, both for diagnosis and for the treatment of pathologies such as cancer. However, exposure to IR can cause significant cellular damage, affecting both tumor cells and neighbouring healthy tissue. In this context, the use of effective radioprotective agents is a necessity. Chitosan (CS), a natural biopolymer derived from chitin, stands out for its antioxidant, anti-inflammatory and reparative properties, as well as its biocompatibility and biodegradability. These characteristics make it a promising candidate for radiation protection. This chapter examines the radioprotective mechanisms of chitosan, in particular its ability to trap reactive oxygen species and enhance the activity of antioxidant enzymes. It also highlights its many biomedical applications, particularly in tissue engineering and controlled drug release. Finally, the limits to its clinical use and recent advances aimed at improving its physico-chemical properties are discussed, paving the way for new therapeutic strategies in radiation protection.

INTRODUCTION

Ionizing radiation (IR) is widely used in the biomedical field, both for diagnostic purposes, such as medical imaging, and for therapeutic purposes, such as radiotherapy for the treatment of cancer. However, such exposure can cause significant cellular damage, affecting not only tumor cells but also surrounding healthy tissue. In this context, radioprotectors play a crucial role in helping to limit the side effects of radiation while preserving therapeutic efficacy.

Among the natural compounds studied for their radioprotective potential, chitosan (CS), a biopolymer derived from the deacetylation of chitin, is attracting growing interest. Its antioxidant, anti-inflammatory and reparative properties make it a promising biocompatible alternative to traditional synthetic agents. Because of its biocompatibility, biodegradability and unique bioactive characteristics, chitosan is now emerging as a prime candidate for protecting cells and tissues against the deleterious effects of IR. Its integration into innovative biomedical strategies opens the way to new approaches to protection against radiation-induced damage, both in patients and exposed healthcare professionals (Omer., 2021; Frolova et al., 2020).

CS's radioprotective effects have been ascribed to its potent antioxidant activity, scavenging ROS and reducing oxidative damage to cellular components such as DNA, proteins and lipids (Frolova et al. 2020). Moreover, its cationic nature allowed it to interact with negatively charged cellular structures, stabilizing membranes and shielding against radiation-induced fragmentation. CS has been shown to enhance the body's natural defense mechanisms by stimulating the activity of key antioxidant enzymes such as superoxide dismutase (SOD) and catalase (CAT). This dual action not only mitigates immediate radiation damage, but also supports long-term cellular repair processes (Wang et al. 2024).

Alongside its radioprotective properties, CS has been extensively used in the biomedical field. In drug delivery field, nanoparticles, hydrogels and films have enabled targeted, controlled release of therapeutic agents. These systems improve drug bioavailability and stability while minimizing side effects, making them ideal for a wide range of treatments, including those requiring preside release into damaged or diseased tissue (Tao et al. 2020). In tissue engineering, CS scaffolds and membranes mimic the extra-cellular matrix, promoting cell adhesion, proliferation and differentiation (Georgopoulou et al. 2018).