Global Journal of
Pharmacy & Pharmaceutical Sciences
ISSN: 2573-2250

Juniper Publishers
key to the Researchers

Mini Review
Volume 9 Issue 5 - June 2022
DOI: 10.19080/GJPPS.2022.09.555773

Glob J Pharmaceu Sci

Deinococcus Radiodurans as Extraordinary DNA Fixers

Nida Tabassum Khan*

Department of Biotechnology, Balochistan University of Information Technology, Engineering and Management Sciences, Pakistan

Submission: June 02, 2022; **Published:** June 23, 2022

***Corresponding author:** Nida Tabassum Khan, Department of Biotechnology, Balochistan University of Information Technology, Engineering and Management Sciences, Pakistan

Abstract

Deinococcus radiodurans is known for its exceptional tolerance potential against ionizing radiation, an unusual trait not found in any other bacterium. Radiation induced DNA damage in *Deinococcus radiodurans* seems, by all accounts, to be repaired through the involvement of enzymatic components i.e., RecA that cleaves and splice together the overlapping chromosomal fragments through homologues recombination. This swift mechanism of DNA repairing in these bacterium's accounts for their survival under extreme conditions and also their utilization in bioremediation of heavy metals such as *Deinococcus radiodurans* assisted biofilms involved in the bioremediation of nickel and cobalt metals.

Keywords: RecA; Dehydration; Radiations; Cleavage; DNA repair

Introduction

Deinococcus radiodurans is an extremophilic bacterium and one of the most radiation-tolerant life forms known [1,2]. It can survive under extreme conditions such as low temperatures, dehydration, vacuum, and corrosive environment, and subsequently is known as a polyextremophile [3]. Deinococcus, initially recognized as Micrococcus, are coccoid or rod-shaped nonsporulating microbes known for their highly resistant nature towards external stimuli [4]. In addition, their enhanced ability to fix DNA damage contrasted with other known bacterial species [5]. *Deinococcus radiodurans* can endure several thousand times the portion of radiation that would kill any other species [6]. *Deinococcus radiodurans* strain R1 was the first isolated bacterium in 1956 from X beam irradiated canned meat [7]. Above 60 unique species have been isolated from exceptionally different conditions, for example, air dust, activated sludge, enacted slime, desert soils, arsenic contaminated water, underground aquifers or biofilms, radioactive locales etc [8,9]. These species develop at temperatures going from 4 to 55°C and have been refocused in an unmistakable eubacterial phylogenetic heredity connected with the genus Thermus [10]. The neighboring Deinococcus relatives are non-pathogenic Trueperaceae, Thermus, Oceanithermus and Vulcanithermus [11,12].

However, this has perplexed researcher for a really long time, as no organic entity might have been presented to such extreme radiation under regular conditions. Yet *Deinococcus radiodurans* displayed high resistance from radiation is more than likely a result of its way to cope with dehydration [13,14]. With regards to tolerating elevated degrees of radiation, the five known members from the family Deinococcaceae have no adversaries [15]. Every bacterium carries several duplicates of its single circular chromosome [16]. Whenever presented to somewhere in the range of 10 and 15kilo grays of radiation more than a few hours, each duplicate supports around 120 breaks that slice through the two strands of its DNA [17]. Contrasted to the fact that other microbe's demise if their chromosomes experience only a few such breaks, yet *Deinococcus radiodurans* can fix its broken chromosomes [18].

DNA Repair in *Deinococcus radiodurans*

Deinococcus radiodurans phenomenal DNA fixing framework probably developed to mend DNA damages caused by extreme stresses [19]. As most bacteria produces spores to prevent DNA damages or in most cases their genomes are irreversibly broken underneath steady circumstances while *Deinococcus radiodurans* possess specialized DNA repair system for reconstruction [20].

Repairing Mechanism

After dehydration, the bacterium needs to remake a duplicate of its chromosome from several fragments for which it requires

the assistance of RecA enzyme [21] which cleaves and splices together overlapping sections of DNA with partially matching sequences, thus can reconstruct a chromosome from irregular random fragments] through homologous recombination [22,23].

Role of RecA enzyme in repairing mechanism

Resistance from radiation in *Deinococcus radiodurans* is due to the presence of RecA gene [24]. Deleting it or even replacing it with the equivalent gene from a bacterium called Shigella flexneri did not restore *Deinococcus radiodurans* ability to fix its DNA [25]. Radiation-induced damaged chromosome should be held in their precise order for quick repair thus DNA is accumulated into bundles, as though the duplicates of its chromosome are piled up [26]. The damaged DNA end is recessed in an exceeding 5′-3′orientation, freeing single abandoned 3′ overhangs which, through RecA and RadA interceded strand invasion, prime DNA amalgamation on overlapping fragments [27]. DNA synthesis is started by politico III and prolonged by politico I and hence the newly combined single strands standardize to correlative single abandoned expansions framing long twofold abandoned DNA intermediates that are constructed into circular chromosomes by RecA enzyme mediated homologous recombination [28,29].

Heavy metals-bioremediation by *Deinococcus radiodurans* biofilms

Throughout the recent years, atomic energy plants decontamination methods likewise generate high quantity of radioactive waste thereby raising environmental concerns [30]. *Deinococcus radiodurans* biofilms is accounted for the treatment of low active waste material based on the fact that biofilm-mediated bioremediation is more effective when contrasted with processes interceded by their planktonic partners [31,32]. However, little is documented regarding *Deinococcus radiodurans* biofilm creating capacity [33].it was reported that recombinant *Deinococcus radiodurans* holding a plasmid containing gfp and kan"R gene induces biofilm forming characteristics to the bacterium [34,35]. *Deinococcus radiodurans* biofilms comprises basically of proteins and sugars with modest quantity of extracellular DNA (eDNA) [36]. Further their biofilm formation was enhanced at higher concentrations of calcium ions [37] and was capable of removing metals like Co and Ni from the waste [38]. The presence of Ca ions fundamentally improved exopolysaccharide and eDNA (both adversely charged) generation in the biofilm framework [39]. This demonstrated adsorption could be the significant system behind upgraded biofilm interceded expulsion of heavy metals [40].

Conclusion

Thus, *Deinococcus radiodurans* possess an effective DNA repair enzymatic mechanism which accounts for their resistance against ionizing radiations.

References

1. Cox MM, Battista JR (2005) *Deinococcus radiodurans* the consummate survivor. Nature Reviews Microbiology 3(11): 882-892.
2. Blasius M, Hübscher U, Sommer S (2008) *Deinococcus radiodurans*: what belongs to the survival kit? Critical reviews in biochemistry and molecular biology 43(3): 221-238.
3. Daly MJ (2009) A new perspective on radiation resistance based on *Deinococcus radiodurans*. Nature Reviews Microbiology 7(3): 237-245.
4. Minton KW (1994) DNA repair in the extremely radioresistant bacterium *Deinococcus radiodurans*. Molecular microbiology 13(1): 9-15.
5. Krisko A, Radman M (2013) Biology of extreme radiation resistance: the way of *Deinococcus radiodurans*. Cold Spring Harbor perspectives in biology 5(7): a012765.
6. Slade D, Radman M (2011) Oxidative stress resistance in *Deinococcus radiodurans*. Microbiology and molecular biology reviews 75(1): 133-191.
7. Bruckbauer ST, Cox MM (2021) Experimental evolution of extremophile resistance to ionizing radiation. Trends Genet 37(9): 830-845.
8. Misra HS, Rajpurohit YS, Kota S (2013) Physiological and molecular basis of extreme radioresistance in *Deinococcus radiodurans*. Current Science (Bangalore) 104(2): 194-205.
9. Mattimore V, Battista JR (1996) Radioresistance of *Deinococcus radiodurans*: functions necessary to survive ionizing radiation are also necessary to survive prolonged desiccation. J bacteriol 178(3): 633-637.
10. Moseley BE (1983) Photobiology and radiobiology of Micrococcus (Deinococcus) radiodurans. In: Photochemical and Photobiological Reviews. Springer, Boston, USA, pp. 223-274.
11. Nishida H, Abe R, Nagayama T, Yano K (2012) Genome signature difference between *Deinococcus radiodurans* and Thermus thermophilus. Int J Evol Biol 2012: 205274.
12. Omelchenko MV, Wolf YI, Gaidamakova EK, Matrosova VY, Vasilenko, et al. (2005) Comparative genomics of Thermus thermophilus and *Deinococcus radiodurans*: divergent routes of adaptation to thermophily and radiation resistance. BMC Evol biol 5(1): 57.
13. Venkateswaran A, McFarlan SC, Ghosal D, Minton KW, Vasilenko A, et al. (2000) Physiologic determinants of radiation resistance in *Deinococcus radiodurans*. Appl environ microbiol 66(6): 2620-2626.
14. Minton KW (1996) Repair of ionizing-radiation damage in the radiation resistant bacterium *Deinococcus radiodurans*. Mutat Res 363(1): 1-7.
15. Battista JR, Earl AM, Park MJ (1999) Why is *Deinococcus radiodurans* so resistant to ionizing radiation? Trends microbiol 7(9): 362-365.
16. Mattimore V, Battista JR (1996) Radioresistance of *Deinococcus radiodurans*: functions necessary to survive ionizing radiation are also necessary to survive prolonged desiccation. Journal of bacteriology 178(3): 633-637.
17. Long H, Kucukyildirim S, Sung W, Williams E, Lee H, et al. (2015) Background mutational features of the radiation-resistant bacterium *Deinococcus radiodurans*. Mol Biol Evol 32(9): 2383-2392.
18. Battista JR (2000) Radiation resistance: the fragments that remain. Curr Biol 10(5): R204-R205.
19. Slade D, Lindner AB, Paul G, Radman M (2009) Recombination and replication in DNA repair of heavily irradiated *Deinococcus radiodurans*. Cell 136(6): 1044-1055.
20. Cox MM, Keck JL, Battista JR (2010) Rising from the Ashes: DNA Repair in *Deinococcus radiodurans*. Plos genetics 6(1): e1000815.
21. Timmins J, Moe E (2016) A decade of biochemical and structural studies of the DNA repair machinery of *Deinococcus radiodurans*: major findings, functional and mechanistic insight and challenges. Comput Struct Biotechnol J 14: 168-176.

How to cite this article: Nida T K. Deinococcus Radiodurans as Extraordinary DNA Fixers. Glob J Pharmaceu Sci. 2022; 9(5): 555773.
DOI: 10.19080/GJPPS.2022.09.555773

22. Basu B, Apte SK (2012) Gamma radiation-induced proteome of *Deinococcus radiodurans* primarily targets DNA repair and oxidative stress alleviation. Mol Cell Proteomics 11(1): M111.011734.

23. Zahradka K, Slade D, Bailone A, Sommer S, Averbeck D, et al. (2006) Reassembly of shattered chromosomes in *Deinococcus radiodurans*. Nature 443(7111): 569-573.

24. Xu G, Lu H, Wang L, Chen H, Xu Z, et al. (2010) DdrB stimulates single-stranded DNA annealing and facilitates RecA-independent DNA repair in *Deinococcus radiodurans*. DNA repair 9(7): 805-812.

25. Repar J, Cvjetan S, Slade D, Radman M, Zahradka D, et al. (2010) RecA protein assures fidelity of DNA repair and genome stability in *Deinococcus radiodurans*. DNA repair 9(11): 1151-1161.

26. Jolivet E, Lecointe F, Coste G, Satoh K, Narumi I, et al. (2006) Limited concentration of RecA delays DNA double-strand break repair in *Deinococcus radiodurans* R1. Mol Microbiol 59(1): 338-349.

27. Misra HS, Khairnar NP, Kota S, Shrivastava S, Joshi VP, et al. (2006) An exonuclease I-sensitive DNA repair pathway in *Deinococcus radiodurans*: a major determinant of radiation resistance. Mol Microbiol 59(4): 1308-1316.

28. Kota S, Misra HS (2008) Identification of a DNA processing complex from *Deinococcus radiodurans*. Bioche Cell Biol 86(5): 448-458.

29. Minton KW, Daly MJ (1995) A model for repair of radiation-induced DNA double-strand breaks in the extreme radiophile *Deinococcus radiodurans*. Bioessays 17(5): 457-464.

30. Shukla SK, Rao TS (2017) The first recorded incidence of *Deinococcus radiodurans* R1 biofilm formation and its implications in heavy metals bioremediation. BioRxiv.

31. Verma S, Kuila A (2019) Bioremediation of heavy metals by microbial process. Environmental Technology & Innovation 14: 100369.

32. Barkay T, Schaefer J (2001) Metal and radionuclide bioremediation: issues, considerations, and potentials. Current opinion in microbiology 4(3): 318-323.

33. Potnis AA, Raghavan PS, Rajaram H (2021) Overview on cyanobacterial exopolysaccharides and biofilms: role in bioremediation. Reviews in Environmental Science and Bio/Technology 20(3): 781-794.

34. Shukla SK, Manobala T, Rao TS (2022) The role of S-layer Protein (SlpA) in biofilm-formation of *Deinococcus radiodurans*. Journal of Applied Microbiology.

35. Kalia VC (2013) Quorum sensing inhibitors: an overview. Biotechnology advances 31(2): 224-245.

36. Shukla SK, Subba Rao T (2015) Heavy metals-bioremediation by highly radioresistant *Deinococcus radiodurans* biofilm prospective use in nuclear reactor decontamination. In Proceedings of the symposium on water chemistry and corrosion in nuclear power plants in Asia.

37. Shukla SK, Khan A, Rao TS (2021) Biofilm extracellular polymeric substances-based bioremediation of radionuclides. In Microbial and Natural Macromolecules, Academic Press, pp. 751-773.

38. Mahto KU, Kumari S, Das S (2021) Unraveling the complex regulatory networks in biofilm formation in bacteria and relevance of biofilms in environmental remediation. Crit Rev Biochem Mol Biol 57(3): 305-332.

39. Shukla SK, Manobala T, Rao TS (2021) Biofilms: Naturally Immobilized Microbial Cell Factories. In Immobilization Strategies, Springer, Singapore, pp. 535-555.

40. Potnis AA, Raghavan PS, Rajaram H (2021) Overview on cyanobacterial exopolysaccharides and biofilms: role in bioremediation. Reviews in Environmental Science and Bio/Technology 20(3): 781-794.

DOI: 10.19080/GJPPS.2022.09.555773