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Review Article

The Effect of Different Types of Radiosources on Various Types of Bacteria and DNA

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Abstract

The role of radiation on many types of bacteria such as *Escherichia Coli* (gram –ve), *Staphylococcus Epidermidis* (gram +) particularly on their RNA gene as well as its DNA. The current work is to review the effect of irradiation of gamma on viable bacteria cell precisely on its DNA and how to increase this effect through increasing the radiation dose reaching 12 KiloGray (12 KGy), and evaluate its effect on 16S RNA gene. The reaction of polymerase chain, on real-time was used as a quantitative measurement to study the sequence and the expression (q-RT-PCR). Irradiation the cells of *E. coli* with 0.4 KGy, the gene expression will changed quickly due to Heat Shock Protein (HSP), and at 1.3 KGy the groES, grp, and ibpB were all up-regulated further than 0.4 kGy. Increasing radiation dose may help to repair the pattern of the gene (HSP therapy).

Keywords: Radiation, microorganism, gamma, DNA, protein

Introduction

In December 1895 is the date of X-Ray invention by the German Scientists Wilhem Rontegn (1845-1923) [1], this date open the wide application to the radiation. However radiation can be defined as a type of energy that transferred from its source to the target as particles move in energetic wave. The type and energy of radiation was specified according to its wave, and in sunlight electromagnetic radiation, high wave length has low energy i.e., radio wave (wavelength = 10^3 m) while high energetic radiation has low wavelength i.e., gamma rays (wavelength = 10^{-12} m) [2, 3].

Ionizing radiation, such as X-Rays and Gamma Rays, that has high energies and a short wavelength, which is sufficient to modify atoms through eliminate one electron and generating ion [4]. The absorbance dosage of the irradiated material usually differs from one material to another and depends upon the required ionization energy that can produce ions, this significant parameter, is related to the treatment's consequences [5] which has the following advantages [6]:

- Sterilize at doses over 10 KGy.
- Eliminate pathogen microorganisms in food.
- Extend the shelf-life of perishable.
- Delay the spoilage and ripening.
- Destroy parasites and insects.
- Inhibit sprouting.

Bacteria are gram positive or gram negative, its appearance in different shapes such as bacilli (rod-shaped), cocci (spherical shape), vibrio (curved rod shape) [7-10], Bacteria usually exist in different environments such as oil seep, deep sea, hot, spring, radioactive wastes even in deep earth [11, 12].

Bacterial radiation

Bacteria have a wide range of radiation tolerances, making them the most basic model organisms for researching gene regulation and defense mechanisms. The study of bacterial radiation sensitivity is motivated by fundamental microbiology, microbial ecology, the documentation of UV in water treatment, the astrological biology for potential human space missions, also in industrial applications like makeup are all possibilities. Although space radiations are varies from radiation the cause's ionization like such as ϒ-Rays (gamma rays), UV-Radiation (UVB, UVA), infrared (IR) and visible light, Microorganisms are damaged by sunlight in two ways: directly and indirectly [13].

Effect radiation on Molecular genetic

Radiation-induced cellular damage is largely caused by nucleic acid. The UVB fraction causes pyrimidine bases to dimerize, The pyrimidine (6-4) pyrimidone photoproducts (6-4 PPs) and cyclobutane pyrimidine dimers (CPDs), respectively, give birth to both of them (6-4 PPs and CPDs). There are twelve photoproducts that could be induced, however, it do not occur at the same time at the same frequency, and they differ greatly depending on the prokaryotic genome's GC level. Base alterations and single/double strand breaks were due to ionizing radiation, which damages DNA and RNA [14]. UVA or visible light can either cause harmful oxidative pressure by the production of ROS (Reactive

Oxygen Species) which interact with proteins, DNA and lipids, otherwise they may have a valuable effect through activating photolyase (the light-dependent repair enzyme) which is concerned with the mechanism of photoreactivation [15] .The sugar and base lesions, base-free sites, strand breaks and DNA-protein cross-links are a few of the DNA lesions caused by oxidative stress [16].

DNA lesions cause the polymerase to stall through DNA transcription and repetition, or the lesion could be due to bypass of misincorporation with DNA, which can lead toward mutations [17]. Also, oxidative damage or strand breakage to non-coding or protein-coding RNAs can lead to protein synthesis mistakes or gene expression dysregulation [18]. Microorganisms adopt a variety of strategies to prevent cell disintegration by reversing, deleting, or protecting themselves. Before tolerate DNA damage [19]. An overall the cell cycle is delayed or stopped in reaction to DNA damage, giving additional time for DNA repair [20], while speedily developing and inhalation cells were exposed to moderately stimuli, the suicide response predicts that their growth will be halted, but their metabolism will continue. This uncoupling of development from metabolism causes a burst of free radical formation and it is this burst of free radicals, not the stress per second, which kills the cells [21].

The steadiness among the rapidity of the damages caused by induced radiation and the cell's ability to defend itself and prevent the damage buildup, in addition to the rate of repairing the damage determines the biological effect of radiation. Some types of damage, such as oxidative proteins and lipid harms, these types were of harms cannot renovate in the cells, and the quantity of protein damage that accumulates is a crucial component in bacterial radioresistance [22].

The majority of ionizing radiation-regulated genes were found to have activities that were either identical to or unknown in former bacteria exposed to hazardous radiation [23]. Also, a recent study of the UVC-induced transcriptome of further radioresistant microbes and bacteria, Deinococcus gobiensis, utilizing elevated resolution technology of RNA-Seq that discovered am essential fraction of undiscovered pathways and genes. The involved genes in (recB) recombination repair and phrB (photo reactivation) were discovered to become activated soon after exposure to UV in D. radiodurans, consequently remain a crucial factor to phenotype resistance [24].

A calculable proteomic pathway with 2D gels was applied to evaluate the proteomes of unirradiated and irradiated and *D. radiodurans* to recognize the approach of its DNA repair and intense radioresistance [25]. Merely 26 spots of peptide were differed considerably between the conditions of two irradiations, and there were 21 proteins that properly recognized via MS (mass spectroscopy). With the exemption of the PprA proteins and single-stranded DNA-binding protein (SSB), most of these proteins have biological activities as a:

I. Inorganic metabolism translation and ion transport.
II. Nucleotide metabolism and transport.
III. Energy conversion and production.
IV. Carbohydrate metabolism and transport.
V. Post-translational modification, chaperones, protein turnover.
VI. Signal transduction.
VII. Transcription.

VIII. Translation.

None of the previously revealed genes were significant for D. radiodurans' radiation resistance as a DNA ligation enhancer were known to be significant to radioresistance [26].

5-1Sensitive *and* Resistant Bacteria

Besides the (SSB) and the PprA proteins, which were formerly revealed, were important for D. radiodurans and resistance to radiation as a DNA ligation enhancer, none of them were previously recognized to be significant to radioresistance [27]. In order to reveal the traits that distinguish radiation-resistant and radiation-sensitive phenotypes, the IR responses of resistant and sensitive bacteria should be compared. For this reason, the radiation sensitive bacteria S. oneidensis is compared to the resistant bacterium D. radiodurans [28].

S. oneidensis was the subject of two transcriptome investigations to better understand its high sensitivity to various types of radiation. Its genome, that was very alike to E. coli's and has all of the essential DNA tolerance/ repair systems, with the SOS response, DNA photolyase, mismatch repair, nucleotide excision repair, mutagenesis repair and recombination repair, could not explain its sensitivity [29].

6-1Response of Bacteria in marine to solar radiation

More than 10^{29} bacteria are believed to exist in the oceans [30], such bacteria were played a essential role in aquatic biogeochemical cycles. In many marine ecosystems, the UVR (solar UV-radiation) wavelength from 280 to 400 nm was found to get to enormous depths, impacting a major portion of the water surface

by which the productions of phytoplankton take a lace [31]. The complete spectrum of solar radiation is exposed to marine bacteria at the ocean's surface, and together UVA and UVB can have significant negative impacts on the activity of the bacteria, photochemical modification and phytoplankton photosynthesis, of the soluble organic matter. The reduction of the stratospheric ozone layer has recently caused environmental change [32] raise the worries regarding the effects of harmful UVR on aquatic microbes. Protein constancy and turnover can be increased or decreased, which can be influenced with the presence of lesions. Proteins are main component that radiation can damage, and its looks that the capability to protect proteins from oxidation differentiates the resistance of radiation resistant from the sensitive bacteria. The changes in the amino acid, the production of the carbonyl group, formation of protein-protein cross-links, fragmentation, and S–S bridges development are all examples of protein degradation caused by oxidative stress caused by solar radiation [33].

Carbonylation is an oxidative reaction that occurs permanently, different than other reactions such as cysteine disulfide bond production, and methionine sulfoxide, that induced damages due to radiation [34]. As a result, a cell must degrade carbonylated proteins in order to rid itself of them; moreover the fate that referred to the carbonylated proteins that were damaged. Proteins that have been mistranslated or otherwise misfolded (due to the mutation of RNA/DNA and/or deficiencies in chaperone) may be a further susceptible to carbonylation [35].

This carbonylation has been linked to the formation of abnormal protein isoforms, according to proteomics [36]. The fast and mistranslated of carbonylation or else the irregular proteins suggests that carbonylation plays a significant physiological role in the quality of protein controlling. Since the carbonylated proteins have extra sensitivity to the destruction of proteolytic other than non-oxidized proteins [37], an erroneous protein's quick carbonylation can guarantee the routed to the processing of proteolyse. Carbonyl groups in a protein's active core cause it to degrade, according to biochemical study. Because carbonylation is an irreversible/unrepeatable change, it may do an indication to directing the proteins damaging to the pathway of degradation other than the pathway of repairing chaperone. Nevertheless, the extremely carbonylated proteins can occasionally form proteolysis-resistant and the aggregation of high-molecular-weight. Protease function appears to be inhibited by such aggregates [38].

Living organisms face constant challenges in extreme conditions. However, microorganisms from all three fields of life (archaea, bacteria, and eukaryotes) were isolated from extreme settings for instance surface sands, hydrothermal vents, of warm baked deserts that exposed high UV radiation, and temperature and desiccation cycles [39]. Artificial environment like toxic chemical waste dumps, and radiation can afford strong range of pressure to extremophiles occurring. The Deinococcaceae family of bacteria, and Deinococcus radiodurans, are known among these highly stress resistant species for their capacity to tolerate ionizing radiation exposure. It was firstly discovered in the canned beef that was irradiated with a dose of (4,000 Gy) to create sterility [40]. Desiccation, ultraviolet light and ionizing radiation are all toxic to these bacteria

[41]. D. radiodurans can withstand extraordinarily doses of radiation, like (5,000 Gy), which results in breaking 3000 DNA single-strand and 200 DNA double-strand, and more than 1000 damaged nucleotides for each genome, with no viability loses. A 500 J/m^2 dose of UV-light, which creates around 5,000 dimers of pyrimidine in DNA, has little effect on survival, and D. radiodurans has 85% viability subsequent to 2 years in the existence of below 5 percent humidity. D. radiodurans may withstand significant levels of oxidative stress as well. However,Not all Deinococcus species have ionizing radiation resistance. Ionizing radiation sensitivity has been discovered in Deinococcales species for example Deinococcusalpinitundrae, Deinococcusaltitudinis, Deinococcusclaudionis and Deinococcusradiomollis, which were isolated and settings recently from alpine. In addition, a review of bacteria showed 11 phyla containing species that are exceptionally resistant to the fatal consequences of ionizing radiation, which are associated but don't share a common ancestor [42].

7-1Effect of ionizing radiation on the living cells

The creation of electrons and many ions is caused by ionizing radiation, which is created by the affect of radiation of radioactive materials are photons that ionize water molecules and alter numerous molecules in a cell, hydroxyl radicals (ROS), particularly OH, are exceedingly reactive. Directly or indirectly, free radicals caused damages to the products of the DNA, i.e., DNA single-strand, basic changes, and double-strand breaks. It is widely accepted that 80% of the damaged in DNA were caused by ROS (indirect effect), while the 20% is

caused directly by photon interactions with DNA. Bacteria or Archaea that are extremely resist the ionizing radiation does not damage the DNA [43].

8-1Protection against oxidative stress

Antioxidant enzymes protect the biomolecules from the damaged that caused by ROS-mediated which include catalases and superoxide dismutases, these are the first line up of defense to the oxidative stress. The dismutase of superoxide catalyzes the transformation of oxygen to hydrogen peroxide of the superoxide, catalases or peroxidases then convert this to water. Plant redox activities, i.e., the cycles of ascorbate/glutathione, are connected to the latter enzymes [42]. After being exposed to ionizing radiation, D. radiodurans encodes three expected superoxide dismutases and three predicted catalases [45].

9-1Effect radiation on DNA

The repairmen in the breaks of the double-strand DNA are effective 4.1. the kinetics of breaking repair to Double-Strand DNA. The majority of damaging and the difficulty to repair the lesions of DNA are double-strand breaks. On the other hand T. gammatoleransarchaea and D. radiodurans bacteria, can withstand doses of -irradiation that cause many breaks in the genome of the DNA double-strand. Culturing the cells in post-irradiation media, the repairing kinetic to 6,800 Gy exposures was remarkably quick (within 2 to 3 hours) [46].

10-1 Induced response to γ-irradiation

A transcriptome analysis of D. radiodurans' transcriptome indicates a new collection of up-regulated genes that are response to ionizing radiation or desiccation. Culturing D. radiodurans can recover it from desiccation; the

expression of 33 of the 72 genes elevated in the 1st hour followed by a sub lethal dose of ionizing radiation is likewise high. Among these genes, there are just little repairs in DNA genes. Notably pprA, ddrD, ddrC, ddrB, DdrA, and recA are the five genes whose expression is most strongly elevated in response to each stress. These genes have only been discovered in Deinococcusgeothermalis and D. deserti, and not in any other Deinococcus species. In D. radioduransradioresistance, three of them were discovered to be important [47]. DdrA prevent degradation of the ends of single-stranded DNA [48] and is also protect the DNA substrates form recombinogenic, while the binding of DdrB to PprA and single-strand DNA can protect them from degradation via NHEJ pathway. It's also worth noting that ionizing radiation induces the three expected dismutases of the superoxide and 3 expected catalases, that protect the bimolecular damaging from ROS-mediated [49].

11-1Radiology on bacteria

Radiobiologists have long employed target theory principles when aware of the problem of radiation-induced the cell fatal, which is typically described as the defeat of the capability to reproduce for an indefinite period. Because bacteria are more complex than viruses, the assumption that DNA is the only and most important target, which arose naturally from molecular biology's basic dogma, must be scrutinized more closely. Lepton Fluxes in the Atmosphere: 600 GeV to 60 TeV Because of the characteristics of the ionization radiation, the early lesions of the radiochemical are probably to be scattered via the cell at random, without any class of molecules being disproportionately affected. Aside from molecular damage, the collapse of the "cytoskeletal" framework, which is

critical for preserving the cell's internal order, must be taken into account. The dose-response statistics that helped determine the critical target size by size.

In the case of bacterial death, however, it is significantly less certain. For example, amongst bacteria that has same quantity of DNA and analytically impossible to differentiate its basic makeup, the quantity of essential to causer cell fatal is varies notably. Such findings imply that their dose response slopes are biological more essential than physical, or that DNA isn't the related target. Another study found that the response of a collection of bacteria agree with the contents of their guanine-cytosine, implying that the response data to the dose have a molecular foundation. This is yet a theory precept, more recently; we've learned that radiation-induced lesions can be repaired in strain-dependent ways. Also known for a long time is that the relationship to the dose-response for a known bacteria strain that differe upon the physiological condition of the specimens that were irradiated [(50)] and their treatment before, during, and after irradiation [(51)]. Finally, the meaning is that it is survival or caused arbitrarily death. According to the radiobiologists who deal with the cells of mammals in particular are perceptive to this difficulty [(52)]. The association between reproductive death and the initial punch events provides as a parameters connected with any survival to bacterial curve which are important theory for help [(53)].

12-1Radiology effects on bacterial DNA and phage

Considering DNA as a main cell target is an individual significant source to determine the affect of radiation on the cells of bacteria. It was noted that there

is a significant correlation between sensitivity to X-ray and the contents of guanine-cytosine of bacterial species as depicted by [52].

2-Results and Discussion

1-2 Effect of irradiation with gamma on the DNA of bacteria and its viability

Although irradiation with gamma is usually intended for sterilizing, nothing is known about its influence on the eradication of amplifiable DNA, which is important for molecular diagnostic techniques.

The impact of irradiation with gamma was studied on the vitality of Escherichia coli and Staphylococcus epidermidis (as calculated by the cultures) and their DNA (as calculated via 16S rRNA gene PCR). For E. coli and S. epidermidis, the viability was abolished at both 2.8 & 3.6 KGy respectively. The dosage of the radiation is essential to decrease the viable bacterium which was 0.31 and 0.35 kGy, correspondingly. S. had D10 values of 2.58 and 3.09 kGy for amplifiable DNA isolated from bacteria. The values of *D10* to DNA were considerably upper for the extracted DNA from irradiated bacterial cells (52.6 and 22.9 KGy for E. coli, and S. epidermidis respectively $P<0.001$),

The current study found that in viable bacterial cells, their irradiated DNA, is not capable to remove the amplifiable genes of 16S rRNA at 12 kGy dose, and therefore it cannot be used to eliminate the contaminated DNA from the components of PCR reaction. This disclosure has sensible consequences for microbiologists who used this technique (molecular diagnostic) [55].

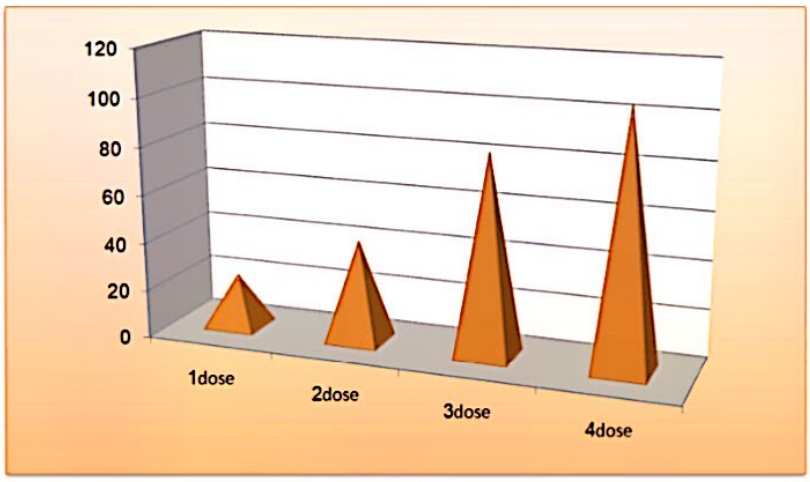

Figure 1: Effect of irradiation with gamma on the DNA of bacteria using quantitative *16S rRNA* gene of *E. coli* and *S. epidermidis*.

2-2 Effect of irradiation with gamma on gene expression on *E. coli O157:H7* pathogen

In gamma-irradiated E. O157:H7, the levels of expression of 7 genes that produce HSP (heat shock proteins) (dnaK, clpB, grpE, groES, htpG, ibpB, and htpX) were examined. At a dose that killed the bacteria, the impact of timing to previously irradiated RNA on the expression the 7 genes was also inspected using 0.4 kGy dose. Figure 2 shows the effect of irradiation with 1.3 and 0.4 kGy.

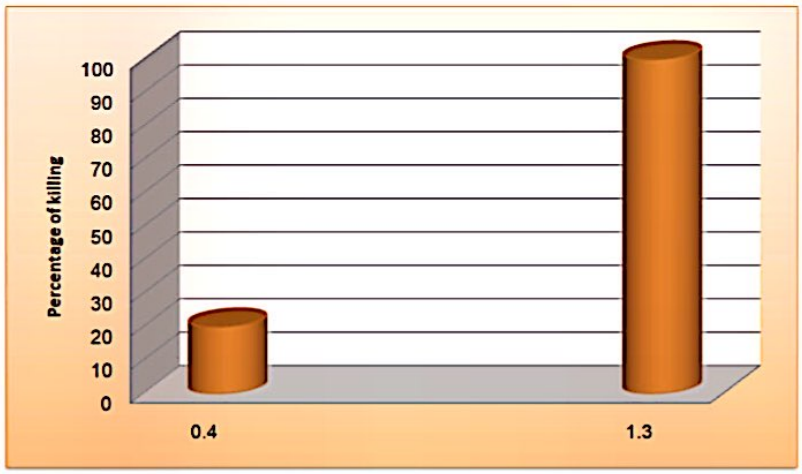

Figure 2: Effect of irradiation with gamma on the expression of gene of heat shock proteins HSP (7 genes)

RNA was extracted at 0, 15, 30, 60, 90, and 120 minutes after irradiation with doses, that killed the cells. The expression of gene was quantified using q-RT-PCR method. (Quantitative Real Time Polymerase Chain Reaction) + When E. coli cells were irradiated with 0.4 kGy, the genes expressing HSP that evolved quickly. At 1.3 kGy, ibpB, grpE, and groES were all upregulated above at 0.4 kGy. There were extra proteins that damaged throughout irradiation at a killing dose for the seven genes investigated, and this dose promotes higher expression of HSP, that aids in repairing repair. In E. coli treated with -irradiation, the pattern of the genes expression producing HSP differ from those treated with heat shock [(56)].

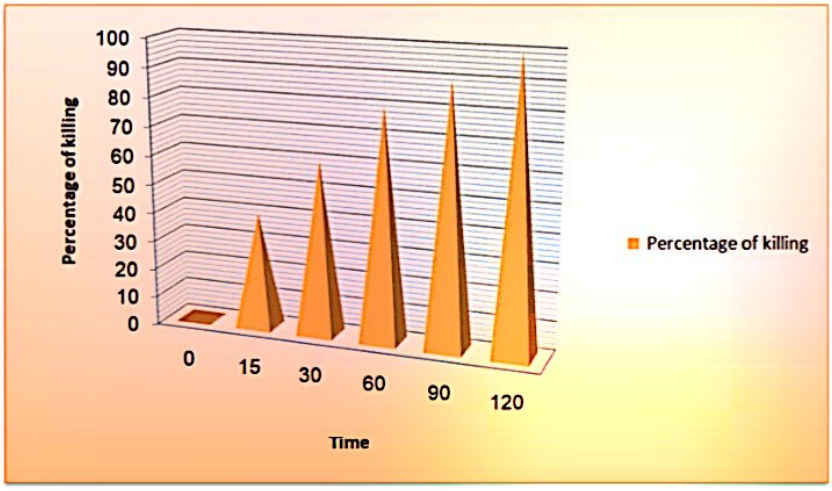

Figure 3: Effect of γ-irradiation on *Escherichia coli O157:H7*.

3-2 Vaccine Confers irritated with X-Ray (A defense from Pneumonia that cause by *P. aeruginosa)*

P. aeruginosa is a gram-negative bacterium that is one of the most common causes of nosocomial infection in hospitals around the world; yet, there is presently no effective vaccination available. The bacteria's multiplication ability was limited but antigenic expression was preserved after it was inactivated using X-ray irradiation, allowing it to be employed as a possible vaccine, according to the researchers. Mice inoculated with this vaccine were challenged in an acute pneumonia paradigm by the parental strain, heterologous strain PAO-6 (O6), and homologous O-antigen strain PAO-1 (O2/O5). The vaccine's protective effect, the innate host and the responses of the cellular immunity, were all assessed, and it was determined that inoculated mice were able to protect from both strains. Particularly, the antiserum was merely efficient towards alike bacteria, but the lymphocytes transfer of effectively prevented the

extend of the virulent heterologous serogroup PAO-6 infection, and, not CD8 antibody, abolished the protective effect. Additionally, the vaccinated mice could quickly recruit neutrophils early to the airways subsequent to challenges of the intranasal via PAO-6 and the vaccine that was irradiated showed to be protective through the generated cells of Th17, IL-17, CD4, the metabolically of the active microbes considered to be a promising approach to a safe vaccination against *P. aeruginosa* [57, 58].

4-2 Radiation action on DNA and effect of Oxygen

Ionizing radiation causes DNA degradation in Escherichia coli cells, resulting in about half of the total amount of DNA that was previously insoluble in trichloroacetic acid being degraded. Synthesis has also been reduced. The decomposition process is inhibited by oxygen by a factor of four, whereas the synthesis process is inhibited by a ratio of about 1.5. Radiation effect on bacteria is thus most likely mediated through DNA at relatively low dosages [59, 60].

5-2 Free Radical and DNA damaging

A huge segment of the damaging in DNA is produced by ionizing radiation, which is because of the formation of the free radicals that usually generated during the radiolysis in water because of indirect effects. The formation of hydroxyl radical's species considered as a hazardous, mutagenic and cytotoxic process. The repairing process involved 3 to 4 enzyme stages upon the primary lesion to repair the damage in DNA that caused by the induction of the free radical [61].

Acknowledgment about author

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