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Research Article

Major Applications of Antioxidant Enzymes in Cancer Treatments: A Review

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Abstract –

The Major Applications of Antioxidant Enzymes in Cancer Treatments were investigated in the present study. Throughout human cells, reactive oxygen species (ROS) perform an important function. High production of ROS destroys essential macromolecules like nucleic acids, which can start and progress the carcinogenesis cycle. Antioxidant enzymes are vital in the identification of neoplastic illnesses like non-small cell ovarian cancer, bladder cancer, lung cancer, & colon cancer. Reduced CAT & SOD activities, as well as elevated glutathione GST occurrence, are common features of non-small cell cancer related to lungs. Cancer related to bladder is associated with decreased SOD, CAT, as well as GPx activities. With ovarian cancer patients, the activities of catalase (CAT), superoxide dismutases (SOD), & glutathione peroxidases (GPx) are reduced. MnSOD activity (in vitro research) as well as SOD activity are elevated in colorectal cancer, but CAT, GPx, & GR are lowered (in vivo research). In different cancers, SOD, CAT, & XOR are good predictive indicators. Glutathione reductases, thioredoxin, glutathione S-transferases, GPx, Catalase, SOD, heme oxygenase-1, as well as quinone oxidoreductases are among the cytoprotective or stress-responsive enzymes that are activated by Nrf2. Changes inside the Nrf2 and Keap1 genes, unexpectedly, cause variations in the activation of a large variety of oxidant or antioxidant genes which support both cancer development and therapy. Antioxidants can aid to keep both damaged and healthy cells throughout anti-cancer treatments, limiting the treatment's effectiveness. As a result, several doctors are hesitant to prescribe antioxidants, particularly vitamins as well as supplements, throughout chemo/radiation treatments.

KEYWORD: Applications, Antioxidant Enzymes, Cancer Treatments, chemo/radio therapies

I. INTRODUCTION

In a state of balance, human body cells generate minimal amounts of ROS. ROS has a part in a range of biological processes through boosting signaling pathways which are important for cell growth and also multiplication. Excessive formation of reactive oxygen species (ROS) can harm essential macromolecules such proteins, nucleic acids, as well as lipids. Cells, on the other hand, include a variety of chemicals which can eliminate the molecules those are doing the damages. Antioxidant enzymes, such as GPx, xanthine oxidoreductase (XOR), SOD, and CAT are the most significant of such compounds. Despite the fact that

antioxidants exist in a number of structural patterns and intracellular & extracellular locations, their work results in a unified antioxidant defense mechanism.

Due to the generation of DNA damages as well as its consequences upon intracellular signal transduction pathways, oxidative stress performs a crucial part throughout carcinogenesis [1]. Base alterations, base-free (apyrimidinic & apurinic) locations, strand breakdown, as well as DNA-protein cross-links are all caused by ROS, however the particular spectra of products relies upon the reactive species engaged. Such mutations have been found in genes whose malfunction is linked to cancer initiation [2]. ROS also may perform a function in the growth of cancer through generating and sustaining oncogenic phenotypes [3]. Enhanced lipid peroxidation could explain the substantial association between fat and oil intake and fatality rates because of leukemia with cancerous neoplasia of rectum, breast, & ovaries in persons over 55 years old [4].

Oxidative stress has been considered as a crucial component in carcinogenesis in latest days. Damage evaluation in diverse biological contexts, including cells and tissues, is important for understanding carcinogenesis processes and, as a result, developing intervention techniques. The analysis of genetic polymorphisms, as well as the gains or losses of activity of numerous antioxidant enzymes including GST, SOD, GPx, CAT, and GR has become an essential tool to best explain cancer progression as well as treatments [5]. We considered malignant disorders including ovarian cancer, bladder cancer, lung cancer, as well as colon cancer for this research.

II. CONCEPT OF ANTIOXIDANT ENZYMES AND ITS TYPES

Free radicals can be stabilized or deactivated by antioxidant enzymes until they harm biological elements. They work by lowering the energy of free radicals or sacrificing part of its electron for their usage, allowing them to be stabilized. Antioxidants are substances that suppress the oxidation of every molecule when available in very small concentrations. [6] Antioxidants defend the organism from the destructive impacts by FR (free radicals) produced during metabolism. [7] Free radicals are highly reactive molecules which either contribute or take electrons from molecules in which they interact. [8] Free radicals are neutralized by an antioxidant defense mechanism in aerobic organisms. This mechanism contains enzymes as well as nonenzymatic antioxidants which help to scavenge such free radicals. Antioxidants within cells protect cells from the harmful effects of oxidative stress. SOD, CAT, Glutathione, Vitamin E, Vitamin A, as well as other peroxidases are examples of antioxidants.

Superoxide Dismutase (SOD)

Superoxide dismutase enzymes are distributed all over the body as well as catalyze the dismutation of superoxide. When used as by-product of this process, hydrogen peroxide is generated, that aids in the spreading of free radical damage. Hydrogen peroxide, superoxide, as well as hydroxyl radicals are only a few of the reactive oxidizing agents produced by the individual body. The hydroxyl radical is by far the most damaging to tissue, triggering the death of nearby cells. SOD is a three-variant enzymes. The cytoplasm contains the majority of copper-zinc-comprising enzymes, whereas manganese SOD is present in the mitochondria. Extracellularly, a 3rd form that exists. [7]

Glutathione (GSH)

The glutamine, amino acids cysteine, as well as glycine make up a key antioxidant defense mechanism found in all cellular components. It is one of the most important antioxidants since it is involved in the production of nucleic acids, proteins, and the detoxification of xenobiotics [20]. GSH is primarily produced by the liver and subsequently transformed into oxidative glutathione by the enzymes GPx and glutathione reductase. It is found in the cytoplasm among all metabolically active cells.

GPx and glutathione reductase (GRx) are antioxidant enzymes. Glutathione in its diluted state has a protective function. The oxidized form does not offer any protection. The oxidized form is not protective. Reduced glutathione aids in the neutralization of H_2O_2 generated within the cell. These enzymes are important in preventing oxidative stress from increasing. [10] Glutathione is a free radical scavenger due to its frequent oxidation and reduction. [11]

Catalase

Catalase refers to an antioxidant enzymes which converts H_2O_2 to water and oxygen. It counteracts the effects of H_2O_2 found within cells. Since many catalase is destroyed by tissue manipulations, the exact number of catalase available inside the cytoplasm can't be determined. [12] A mismatch among ROS and antioxidant activity causes oxidative stress. A lot of disorders have oxidative stress as an etiologic or exacerbating component.

Heme Oxygenase

Heme oxygenase-1 is a protein which breaks down heme to bilirubin, biliverdin, CO (carbon monoxide), as well as free iron. This is in charge of physiologically active cells' adaptive mechanisms to changes in cellular oxidative stress. Different signaling pathways, transcriptional elements, along with the metabolic disorder of sick as well as normal cells all affect the activity as well as expression of heme oxygenase.

Peroxiredoxins

These are a group of 6 isoenzymes that serve as antioxidants against H_2O_2 (hydrogen peroxide), ROOH (alkyl hydroperoxides), as well as ONOO (peroxynitrite). After experiencing oxidation of respective active-site cysteines, mitochondrial as well as cytosolic peroxiredoxins may detox H_2O_2 into water.

Thioredoxins

Both the cytoplasm and the nucleus include Thioredoxin-1. Thioredoxin-2 can be found throughout the mitochondria. Such antioxidants have 2 cysteine effective surface areas that serve as hydrogen donors for thioredoxin-dependent peroxide reductases, aiding in oxidative protein removal & survival of cell.

III. ROLE AND IMPACT OF ANTIOXIDANT ENZYMES AGAINST CANCER

Antioxidant enzymes have a well-known involvement in cancer prevention by preventing oxidative DNA damage. Moreover, there are several freshly discovered processes. Overexpression of CAT has been demonstrated to delay the transition from G0/G1 to S-phase in mice aortic endothelial cells during cell cycles management [13]. During anti-CD3 activation, $CD4^+$ T cells with CAT transduction are less susceptible to H_2O_2 driven loss of functionality. . Co-culture with activated granulocytes as well as oxidized

lipids (4-hydroxynonenal or H_2O_2) improved oxidant stress cell losses resilience. When cells were exposed to H_2O_2, CAT expression in cytomegalovirus (CMV)-specific $CD8^+$ T lymphocytes prevented cell loss and enhanced their ability to identify CMV peptide-loaded targeted cells. T cells transduced by CAT is more successful in immunotherapy for patients with early cancer as well as acute viral infections, according to this study [14].

Investigators have made far more efforts to identify treatments for cancer. Several efforts have included antioxidant therapy, some of which have shown to be effective against cancer. Gene treatment using either GPx or Mn-SOD alone decreased cancer development with 51 percent and 54 percent in an animal model research, respectively, whereas combining the 2 reduced cancer development to 81 percent and improved animal survival [15]. Resveratrol has recently been shown to protect mice against colorectal cancer through reducing oxidative stress. The antioxidant condition of enzymes (GST, SOD, GPx, GR, & CAT) along with non-enzymatic (lowered vitamin E, vitamin C, glutathione, & beta-carotene) antioxidants was substantially enhanced in diets supplemented with resveratrol (entire-period) therapies routine. As a result, the level of lipid peroxidation markers has decreased. Taurine stimulates the expression of SOD, GPx, as well as CAT genes, making it helpful in melanoma [16]. Taurine stimulates the expression of GPx, SOD, as well as CAT genes, making it beneficial against melanoma [16]. Ginkgo biloba extraction is anticancer because it boosts antioxidant enzymes including SOD & CAT [17].

Role and Impact of Antioxidant enzymes on Mucosal or Oral Cancer

When the function of this enzymes in people with cancer was investigated, it was shown that majority cancerous cells lacked manganese superoxides. [5] The antioxidant manganese SOD has been discovered to be a cancer suppressor. [18] As a result, SOD activity can be considered as an oxidant biomarker against tumor. [19] It was discovered that carcinogenesis of the rat buccal pouch caused a change in glutathione content. Gamma-glutamyl transpeptidase is indeed an enzyme which acts as a catalyst the degradation of glutathione and reduces the detrimental impact of carcinogens. The concentrations of glutathione gradually increased, eventually doubling in the testing pouch contrasted with the control. The preneoplastic pouches epithelium were discovered to be resilient to the carcinogen's detrimental consequences. This could be because diminished glutathione as well as gamma-glutamyl transpeptidase levels have increased. [20] The activities of erythrocyte catalase was lower among oral cancer patients related to precancer patients. This could be due to the rise in superoxide anion generation or a reduction in the enzyme's antioxidants scavenging capacity. [21] The SOD activities of erythrocytes in individuals with oral submucous fibrosis was contrasted to the phase of the infection. It was not revealing because there was no shift in concentrations. [22] According to previous research, there is a steady decrease in SOD levels, which has a positive relationship with diagnostic grading for oral submucous fibrosis. [23] The mean hemolysate concentrations both of SOD as well as GPX were lowered in individuals with oral submucous fibrosis contrasted with healthy controls. [24]

Role and Impact of Antioxidant enzymes on Lung cancer

A century ago, lung cancer was the most commonly diagnosed cancer, affecting approximately 1.5 million annual deaths. Epithelial cells are the most common cause of lung cancer. Lung cancer can be classified into three types: Non-small cell lung cancer and small-cell lung cancer, respectively, accounted for 87 percent and 15 percent of lung cancer cases. Multiple signaling molecules (for example, mitogen-activated

protein kinases), transcriptional regulators (hypoxia-inducible factor-1, activator protein-1, Bach-1, NF-E2-related factor-2), and 2 additive areas in the ho-1 5' regulatory area are all involved in the regulation of the ho-1 gene, as per Ryte et al., [25]. The development of the HO-1 proteins in the lung may happen in relation to oxidative stress caused by infections, changing oxygen pressure, or inflammatory disorders. HO-1 is still thought to defend from oxidative cell injury [25]. Sayin et al. [26] show that augmenting the meal using antioxidants N-acetylcysteine (NAC) and vitamin E enhances tumor growth and lowers survivorship in rats with B-RAF and K-RAS-induced lung cancer. NAC as well as vitamin E, that are chemically dissimilar, generate well synchronized alterations in cancer transcriptome patterns that are driven by lower activity of endogenous antioxidant genes, according to RNA sequencing. Vitamin E & NAC promote cancer cell proliferation in rat & humans lung tumor cells through lowering ROS, damage to DNA, & p53 activation. Inactivating p53 promotes tumor development and reverses the antioxidant benefit. ROS-p53 axis accelerates tumor development. Antioxidants may promote the development of early cancers or precancerous tumors in high demographics including users and individuals having chronic obstructive pulmonary illness who use NAC to alleviate mucus production [26]. Gong et al. [27] looked into this. Although targeted treatments and immunotherapy have revolutionized lung treatment for cancer, the total life expectancy among lung cancer patients remains poor. Exploiting the tremendous promise of molecularly tailored medicines is critical. Exploiting the tremendous potential of molecularly focused medicines is critical. During lung squamous cell carcinoma, extremely high somatic alterations in KEAP1/NRF2 (27.9 percent) have been discovered. We looked at whether a nuclear factor erythroid 2-related factor 2 (NRF2) inhibitors may be used to treat lung cancer caused by KEAP1/NRF2 mutations [27].

Role and Impact of Antioxidant enzymes on Bladder cancer

One of the most prevalent cancerous growth of urinary system is bladder cancer. It has a high level of aggressiveness and a dismal prognosis. Non-muscle invasive (NMI) (pTa or pT1) and invasive (pT2, pT3, or pT4) transient urothelial bladder cancers have a poor prognosis. Arsenic, a trivalent inorganic, suppresses cellular enzyme through attaching to the dihydrolipoamide sulfhydryl compounds, hence decreasing cellular ATP synthesis. Shibata et al., [28] examined genetic modification in Keap1, a negative activator of Nrf2, in BTC comprising cancers derived by gallbladder as well as extra- & intrahepatic bile ducts. The significance of the cancer-related mutation Keap1 with Nrf2 control was investigated, as well as the link between Nrf2 activation as well as 5-fluorouracil resistance. Keap1 gene changes were found in BTC on a recurrent basis (in 1/11 cell lines along with 6/53 primary cancers) and were particularly common (4/13, 30.7 percent) in GBC (gallbladder cancer). Such changes resulted in a significant lack of Nrf2 repression function, constitutive Nrf2 activation, as well as cell growth. Nrf2 activity suppression via Keap1 complementation or Nrf2 short interfering RNA improved 5-FU sensitivity in Keap1-altered BTC cells. Keap1 mutations are typically observed in GBC. These are some of the molecular pathways for chemotherapy resistance in GBC is abnormal Nrf2 activation induced by Keap1 mutations, which will be a new treatment focus as an enhancers for sensitivity to 5-FU-based therapies.

Role and Impact of Antioxidant enzymes on Ovarian Cancer

Ovarian cancers have the greatest fatality rate. It has multiple histological kinds, each with a unique survivability characteristic. Ovarian cancer affects six out of every 100,000 women globally, with a 4 out of 100,000 fatality rate. The average European overall survival is around 40 percent, and it varies by stage

of the disease. Epithelial ovarian cancer (EOC) sufferers are resilient to platinum-based therapy, as per Konstantinopoulos et al. Platinum substances produce electrophilic intermediates which facilitate DNA cross-linking as well as double DNA breakage. We noted the existence of Kelch-like ECH related protein 1 (Keap1) mutations & NF-E2 connected component 2 (Nrf2) pathway stimulation in EOC and linked with these research results to platinum resistance or therapeutic strategies since this Keap1-Nrf2 pathway facilitates the cellular reaction to electrophilic xenobiotics. In far more than 50% of the EOC patients samples studied, Nrf2 immunohistochemistry revealed nuclear localization (a surrogate for pathway activation), with a higher incidence in the clear cell EOC subtypes. In cancers having nuclear Nrf2 positivity, quantitative real-time PCR demonstrated that Nrf2 target genes were elevated. Clear cell EOCs have higher levels of Nrf2 target genes than other EOC subtypes, according to microarray study. Keap1 sequencing study revealed abnormalities in 29percent of clear cell specimens as well as 8 percent of non-clear cell malignancies. In vitro, RNAi-mediated Keap1 knockdown was linked to Nrf2 pathway activation as well as carboplatin resistance. Persons with Nrf2 pathway stimulation showed poor therapeutic reactions to platinum-based medications, were more likely to develop platinum resistance, and had a shorter median survival chances. These observations demonstrate the presence of Keap1 mutations in EOC and reveal a completely undiscovered role for the Keap1-Nrf2 pathway in chemotherapeutic response regulation in this disease.

Role and Impact of Antioxidant enzymes on Colorectal Cancer

Generally, colorectal cancer is lethal. In both men and women, colorectal cancer is the third most frequent cancer. It is caused by uncontrolled cell proliferation throughout the colon & rectum. Colorectal cancer is thought to be increased by variables including poor diet, overweight, smoking, as well as excessive alcohol consumption. RAC1 is a crucial driver of carcinogenesis after APC loss, according to Myant et al. [30]. The amplification of LGR5 intestinal stem cell (ISC) hallmark, progenitor hyperproliferation, as well as conversion all need RAC1. These mechanisms are mediated mechanistically by ROS generated by RAC1 and NF-B activation. Such findings implicate RAC1-induced ROS generation and NF-B activation in CRC development.

IV. REDOX POTENTIAL OF ANTIOXIDANTS AND ITS METABOLIC IMPACT

Oxidative stress occurs if the amount of FR produced surpasses the antioxidants' capacity to control and eliminate them. O_2 is more sensitive to the generation of free radicals through sequential electron addition due to the presence of 2 unpaired electrons inside different electronic orbitals. In living cells, such oxygen radicals perform a major part during oxidative stress as well as damages [31]. Consequently, the generation of oxygen radicals, that generate ROS, causes free radical-induced cellular harmful consequences. There are multiple essential contributors of free radical generation in the cell, including endoplasmic reticulum oxidation, mitochondrial ETC, radiation, chemotherapy, as well as a broad range of enzymatic activity. Whenever free radicals oxidize and destroy the biological elements, they can cause pathogenic diseases [32,33]. As a result, the degree of oxidation of numerous biomolecules as well as cellular components would rise, resulting in illness. In people with recurrent aphthous stomatitis, antioxidants are linked to a lower level of SOD in their erythrocytes. Another 2 enzymes, GPX as well as catalase, did not change significantly from controls. Glutathione S-transferases, CAT, GPx, glutathione reductases, SOD, heme oxygenase-1, quinone oxidoreductases, and thioredoxin are all cytoprotective or stress-responsive enzymes

that are activated by Nrf2. Mutations throughout the Nrf2 & Keap1 genes change the expression of many antioxidant or oxidant genes, promoting cancer development or treatments.

Antioxidants and Enzymes' Metabolic Factors

In even a normoxic settings, the deposition of ROS as well as Kreb's cycle metabolites stimulates Hif-1. Hif-1 activation under hypoxic settings is able to activate metabolic genes that aid cancer development [34]. The word 'oncometabolites' refers to the particular metabolites produced in neoplastic cells resulting of reprogrammed or changed metabolic pathways. 2-hydroxybutarate (2-HG), maleate, fumerate, and succinate are frequent oncometabolites detected in cancerous cells. They can contribute to metabolic reprogramming as well as alter mitochondrial dynamics, resulting in diseases. These comprise a rise in EMT, cancerous cells metastasis, as well as modifications in the inflammation, epigenetic, as well as paracrine signaling features of cancerous cells [35,36].

Oncometabolites are produced by mutations in the genes that create the cycle of Kreb enzyme isocitrate dehydrogenase 1, 2, 3 (IDH1/2/3), fumarate hydratase, and succinate dehydrogenase. In human cells, the homodimeric IDH1/2 employ $NADP^+$ for the reversible conversion of isocitrate to -ketoglutarate (-KG), while IDH3 uses NAD^+ for the irreversible conversion of the same compounds [37]. The metabolite 2-HG has 2 enantiomers: D-2-hydroxyglutarate (D2HG) and L-2-hydroxyglutarate (L2HG). The oncometabolite D-2-hydroxyglutarate (D2HG), which would be a reduced form of alpha-ketoglutarate, is increased when Isocitrate dehydrogenase 1 or 2 (IDH1/2) is mutated. The cytoplasmic pool of alpha-ketoglutarate, a cosubstrate for dioxygenases, is depleted as a result. The end outcome is epigenetic alterations that contribute to the emergence of neoplasms [38,39]. Because of the overexpression of mutants IDH1 with elevated amounts of Hif-1, oncometabolites are able to cause a 'pseudohypoxic' condition for increasing tumor growth throughout human tumor cell lines [40]. Enhanced Hif-1 expression improves the function of glucose transporters and hexokinase-2, leading to increase in glucose flow throughout glycolysis. Furthermore, with enantiomers of 2-HG, D2HG as well as L2HG, the effect of such alterations on tumor size and angiogenesis is different [41,42]. Substantial volumes of fumerate as well as succinate leaking into the cytoplasm can also induce Hif-1 and cause a 'pseudohypoxic' response, identical with 2-HG [43]. A rise in fumerate may lead to inactivation of fumarate hydratase, resulting in oxidative stress because of NADPH reduction as well as succination of glutathione resulting in the creation of succinic-GSH (a covalent adduct of fumarate and glutathione) [44,45]. Furthermore, when engaging in the electron transfer throughout the mitochondrial respiratory chain, succinate dehydrogenase will modify the cellular redox potential, encouraging carcinogenesis [46]. As a result, cancer cells can produce more NADP, which allows them to withstand higher levels of oxidative stress at the time of increased metabolic activity To create these reductive intermediates NADH & NADPH, serine hydroxymethyltransferase must first swap carbon to tetrahydrofolate, then to methylene-tetrahydrofolate in the metabolism of folate (an essential vitamin) [47-49]. Target-specific antioxidant inhibitor targeting NADPH or NADP could potentially increase oxidative stress and slow cancer development. Animal models must be used in pre-clinical testing to help explain the adverse effects of these antioxidant inhibitors.

GSH is among the most significant antioxidants for preventing oxidative stress in normal cells & sustaining cellular redox balance. They are used in anti-cancer treatment since GSH is essential for cell survivability in neoplasms following hypoxia & nutritional insufficiency. Excess glutathione, on the other hand, may enhance cancer growth through detoxifying xenobiotics, giving treatment resistance and fostering

metastasis [50, 51]. The lack of activity of cancer suppressor genes, and also the stimulation of oncogenes for signalling and metabolic pathways, results in a significant level of ROS in cancerous cells. Cancerous cells exploit the additional oxygen and glucose available to produce NADPH, which aids them persist in an oxidative stress environment. ROS levels rise in hypoxic as well as low-glucose environments, activating antioxidant mechanisms once more by modifying central carbon metabolism. Disruption of matrix attachment will also result in cell loss or cancer mass spread to distant regions in these kind of circumstances [39]. Antioxidants that target mitochondrial inhibitors & FR of oxidative stress enzymes may be able to diminish Hif-1 activation caused by hypoxia. Assessing cancer growth & metastasis is required to determine the treatment implications of this study.

V. IMPACT OF ANTIOXIDANTS IN CHEMOTHERAPY AND PHOTODYNAMIC THERAPY (PDT)

Anti-cancer drugs are frequently cytotoxic, meaning they alter the cellular oxidative level and induce a range of side effects. Chemotherapeutic drugs commonly induce DNA damage by generating FR which interrupt the cell cycle & result in cell loss by necrosis or apoptosis. [52] The majority of such chemotherapeutic drugs target fast-dividing cells, such as bone marrow as well as epithelial cells, as well as a number of tissues and organs, including the lungs, cardiomyocytes, hepatocytes, and also the kidneys. They can trigger severe difficulties and affect multiple organs by interacting with rapidly cell divisions. Antioxidants could be combined with tumor treatment to increase cellular oxidative stress. As a result, in the therapy of cancer, many antioxidants & prooxidants have benefits and drawbacks (Table 1).

Table 1: Anti-oxidant and pro-oxidant therapy in cancer: Benefits and Drawbacks

Anti- & Pro-oxidant treatments	**Benefits**	**Drawbacks**
Antioxidants	Excess free radicals within healthy cells must be combated.	Antioxidants may potentially be beneficial to cancer patients.
	Antitumor immunity in the host is improved.	Antioxidants may be more effective at preventing cancer than at curing it.
	It can be found in a vast range of	Delivery to cancer mass or inner

	fruits and veggies.	organs is challenging.
	Biomolecules that oxidize quickly and have a short life span.	Impacts on DNA, resulting in mutations and an increase in tumor rates.
Prooxidants	Increased oxidative stress slows the progression of cancer.	Healthy tissues, particularly interior organs, are damaged.
	Several anti-cancer medications work together to have a synergistic effect.	Throughout radiotherapy, there is a rise in cytotoxicity.

Anti-cancer antioxidant treatments, like any other sort of medical supplements, are separated into 2 groups (1) the prophylactic dosage is a smaller dose that protects both normal and malignant cells, and (2) a prescribed dosages is a larger dose that inhibits cancer cell development while not interacting with normal cell development. Because of the differences in types of cancer, research designs, therapy regimens, and data analysis between research, making significant contrasts is challenging. Furthermore, there is sufficient data to infer that antioxidants boost the cytotoxic activity with chemotherapy through enhancing anti-cancer medication treatment advantages and survival rates. Antioxidants' positive impact can be linked to their ability to reduce the negative consequences of excessive free radical generation yet sustaining the essential cellular oxidative stress throughout anti-cancer chemotherapy regimens. Chemotherapy, in fact, lowers level of serum of antioxidant minerals and vitamins because of lipid peroxidation, leading to increase in oxidative stress. Antioxidants as well as vitamins C and E intake has been shown to lessen the incidence of breast cancer recurrence [53]. Vitamin C enters cells via glucose transporters and has antioxidant actions, maintaining oxidative stress to a minimum. One solution could be to mix antioxidants with cancer chemotherapy that causes cellular oxidative stress.

Photodynamic therapy (PDT)

Photodynamic treatment (PDT) uses non-ionizing radiation to cause growth arrest & cell loss by causing a light-sensitive substance (photosensitizer) to interact to molecular O_2 and generate excess free radicals,

particularly H_2O_2 as well as superoxide radicals. Radiation treatment using ionizing radiations, on the other hand, causes the generation of oxygen radicals within live cells as a result of radiation interaction using water, a technique is called radiolysis [55]. Patients undergoing radiation treatment benefit from a mixture of both natural as well as synthetic antioxidants. Antioxidants including vitamin E (alpha-tocopherol), melatonin, as well as retinol palmitate have been proven to help with mucositis inducing radiation, brain cancer, as well as proctopathy inducing radiation [56]. PDT can be used to generate oxide FR, which can boost cell signaling & result in antitumor immunity, cancer mass reductions, apoptosis, as well as necrosis [57]. Unlike the impact of ionizing radiations on live organisms that contributes to the emergence of enormous quantities of oxide radicals by untargeted radiations, PDT induces a controllable production of oxidative stress with the use of specific drug(s) and a directed reaction. The antioxidant properties in photodynamic reactions, on the other hand, diminishes the effectiveness of PDT, while some of them, such as ascorbic acid, alpha-tocopherol, and butyl-4-hydroxyanisole, may perhaps improve the photodynamic impact in cancer cells [58]. Furthermore, further research into the specific causes for the varied nature of such antioxidants' effects on cancer is required.

CONCLUSION

Recent research on genetic polymorphisms as well as expression levels of different antioxidative enzymes will offer up new opportunities for understanding cancer pathogenesis and therapeutics. Cancer is among the most challenging diseases, and its pathogenic mechanisms are complex. Enzymes like SOD & CAT in bladder cancer; CAT, SOD, & GST in lung cancer; CAT, XOR, & SOD in ovarian cancer; as well as GPx, CAT, SOD, & GR in colorectal cancer are all important in diagnosis and prognosis. Such results inspire researchers to pursue more studies into antioxidant enzyme treatment and associated cancer investigations in the long term. Furthermore, both researchers and practitioners believe that taking antioxidants at the same time reduces the number of free radicals in the body, allowing for healthy cell / tissue regeneration. During the course of the condition, it may be more appropriate to stick to specific antioxidants as a nutritional supplement.

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