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Chapter

Considering the Antioxidant Properties of Tea to Improve Human Health

Sabila Nelson

Abstract

One of the highly available drinks consumed across the planet is tea. Scientists know tea for its ability to oppose oxidation, cell death, bacterial growth and replication, inflammation, plus restorative effects of bioengineering due to the possession of several ingredients including catechin types, caffeine, minerals, small amounts of vitamins, and sugars. Scientists believe that tea components are responsible for invigorating the cerebrospinal neural network and regulating wellbeing in human beings through the mutualistic backtracking of infirmities, such as aging, due to the interplay of extraneous harm precipitated by external elements, such as prolonged subject to harsh heat from the sun which may lead to dermatoheliosis. This scenario later could cause other worrisome conditions, including erythroderma, early aging, anatomical pathology, edema, heat stroke, progression of nonmalignant, and malignancies in various sites. More so, researchers have linked tea use to a reversal in initiation and development of heterometabolic irregularities existing in paltry quantities in reproductive ducts and systems which impacts procreation by proliferating the functionality deficiencies. This chapter will explore and synthesize the literature to advance possible modalities of activity suggested by scientific enlightenment to enhance a better understanding of possible aspects of tea related to improving human health.

Keywords: tea, antioxidants, catechins, polyphenols, health, disease

1. Introduction

Antioxidant properties in tea, exhibit diuretic, anticarcinogenic, and immunity-support, which suppresses the existence and replication of microbes, and prevent inflammation [1], the properties are instrumental in the inhibition and cure of various disorders, including lymphoproliferative conditions, coronary arterial and cerebrovascular maladies, malignancies, hyperglycemia, elevated vital signals, and other nutrition deficiency ailments. The qualification of tea as a healthful drink is premised by nutritionists on its possession of magnificent properties. Tea is utilized by over 3 billion people in more than 160 countries across the globe and is the second-most consumed drink, water being the leading. There is a mass global production of
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up to three billion kilograms of tea annually, extracted from the leaves, tea buds, or
delicate tea stems of the plants of the genus Camellia [1–9].

Research confirms tea (L.) Kuntze is the most widely used plant tea species, with
the most important consumers being the Europeans, particularly the British (close
to 540 milliliters per day), and a world average of 120 milliliters of tea per day, per
person. Consumers have attributed the utilization of tea as a daily libation and folk
medicine in China and several Asian states since early times to its subsumption of
profuse polyphenols that exert an opposing effect on oxidative tendencies of oxidant
elements by synchronizing the signaling pathway of Nrf2, and also vitalizing NF-kB
and MAPK pathways [2, 10].

Tea is out there in various forms, each of these tea types has different levels of
antioxidants, and analysts have classified them based on the processing methods and
fermentation method and skill, geographical, and climatic conditions. The chemical
composition of tea changes significantly during the fermentation process, resulting in
the production of theaflavins, which add to the usefulness of tea [5, 9, 11]. Consistent
with the available literature, the Chinese were the first human beings to consume
tea as juice or medicine around 2737 BC. Though the first producers of tea were only
China, India, and Kenya, consumption has now spread widely and people from many
countries on all continents of the world now cultivate and tea enjoy [5].

2. History and origin of tea

Scholars believe that Shen Nung, the second emperor of China, first recognized
tea in 2737 BCE. It was a unique coincidence that the Emperor was a cup of hot water,
while resting under a tree shade when a plant leaf blew into the hot water in the cup,
he felt a pleasant flavor and continued using tea [12, 13]. According to a narration
by Serafini et al. [14], nobody knew much about tea until 1560 when a Portuguese
man named Father Jasper de Cruz who was also a Jesuit missionary, encountered and
wrote about it.

By as early as 1657, people from England, particularly in London had already real-
ized the importance of tea as a health drink as it was being sold by a few people in the
coffee house of Garway. Later on, in 1826, the commercial selling of tea began in seals
designed by John Horniman, and later was the introduction of packages in lead-lines.
In 1870, twinnings of England began a uniform blending of tea.

A few years later, in 1904, Richard Blechynden an Englishman created ice tea.
This eventuality preceded the invention of tea bags by Thomas Sullivan in 1908, a
then-renowned New York tea importer who could send tea in small silk bags to his
clients. It was until 1953 that traders finally introduced the world’s first instant tea,
which to date became a primary drink throughout Europe, North America, North
Africa, and Asia.

3. Sources of oxidants in human bodies

In its entirety, metabolic and respiratory processes in the body initiate the creation
of reactive oxygen species (ROS), such as free radicals (O$_2^-$) from superoxide anions,
hydroxyl ions, and peroxides (H$_2$O$_2$), including some, which are highly reactive [10]
and capable of inducing oxidative ruin to fleshy and corpuscle constituents, such as
polypeptides, fats, biomolecules, and nucleic acids, when left unbalanced. Scientists
have demonstrated that oxidative stress exacerbates the likelihood of genesis and development of chronic disease conditions once there is an excessive build-up of large aggregates of ROS.

Production of malondialdehyde (MDA) (a major indicator of lipid oxidation), which is a central ingredient of oxidative stress incriminated in unpleasant health effects explains the negative consequences of the action of oxidants on lipids and fats. In his summary of findings, Rasaei [15] recommends a desperate need for interventions, especially the utilization of green tea to augment the body’s antioxidant response to be able to counteract oxidative stress and MDA production.

Throughout human lives, people suffer equilibrium disruptions, thanks to human lifestyles; the food, drinking water, coupled with the composition of the air inhaled [16–25], intense physical exercise [26–31], and stress predisposes the superfluous formation of reactive oxygen species in human bodies. Consequently, ROS contains free radicals that steer the emergence of oxidative stress, which vandalizes the anatomy of the human organism, thereby causing a disruption in body functional equilibrium, thus precipitating disorders, such as hardening of the arteries, lymphoproliferative, and/or neurodegenerative upsets (Parkinson’s or Alzheimer’s disease), or maybe obesity.

A fundamental hunt for straightforwardly available sources of antioxidants perpetuates the steadiness in the middle of creating and eliminating reactive oxygen species, examples of dominant and massively predominant antioxidants are alpha-tocopherol (vitamin E), retinol (vitamin A and vitamin C), and also polyphenolic compounds. The attachment to numerous health-effects, including antioxidant validity to phenolic chemicals is based on findings from rigorous research and has positioned phenols as a vital part of the human diet. Polyphenols can proficiently trap oxidizing peroxide ions, and exterminate lipid radicals, ROS, and hydroxyl radicals.

Polyphenols extracted from plants contribute significantly to decelerating senescent progression and decreased contingency of neurodegenerative conditions related to age, such as Alzheimer’s disease, Parkinson’s disease, and/or ischemic brain trauma. Some of the natural plant resources, tea, coffee, fruits, vegetables, spices, and herbs are rich sources of antioxidants in the form of flavonoids, which supplement the daily menu, adding up to good health [23].

4. The antioxidant properties of tea

Since the nineteenth century to date, researchers have proclaimed that scientists have competently isolated from tea, more than 500 chemical components, both organic and with different relevancies in maintaining human health [9]. Research findings have further demonstrated and attributed the potential health rewards of drinking tea to the antioxidant nature of tea polyphenols [2]. Over 70 types of tea polyphenols exist (catechins and epicatechin), theaflavins, flavonols and proanthocyanidins, kaempferol, cannabiscetin, and their glycosides [32]. The structural arrangements for the main green tea catechins are shown in Figure 1.

Flavonoids from tea exhibit a stronger property that justifies its ability to neutralize ROS/RNS, and, therefore, the antioxidant activity of tea is directly proportional to the amount of flavonols present; the higher, the better. It is equally worth noting that using tea and its components cannot take over the role of standard chemotherapy rather, the beneficial properties of tea, particularly EGCG may be used to complement
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Figure 1. Structural representation of the main catechins [33].

Figure 2. Showing how Flavonoids alter multiple pathways implicated in brain aging and neurodegenerative diseases [37].

and support the standard anticancer approach [34–36]. Figure 2 shows the multidimensional role of tea flavonoids.

5. Mechanism of action of antioxidants

Although tea has quite an innumerable number of phenolic chemicals that contribute in isolation or in synergy. EGCG being a major antioxidative player, is instrumental in combating, inflammation, proliferation, and thrombogenesis. It also has a positive impacts on endothelial function.

Experts have surmised tea antioxidants in two ways: in the first place, EGCG breaks the oxidant chain by donating a p-electron on its benzene ring to the available free radical, and by so doing, eliminates the invasive free radicals [12]. In this instance, single electrons tend to the benzene ring, thereby reducing the activity of
the hydrogen-oxygen bond in the phenolic hydroxyl group. The hydrogen in phenolic hydroxyl groups participates in the increase and scavenging of free radicals that compete for active oxygen and also terminate the auto-oxidation reaction of the free radicals [10, 38]. Second, phenols remove ROS/RNS to promote the initiation of antioxidants relevant to quenching the formation of cold product chains. Wherefore, improve and protect the antioxidant defense system, chelate available metal ions, strengthen co-oxidants, and/or regulate gene expressions [12, 39].

Yan et al. [10] in their research found that ROS could function at low levels as molecular signals to regulate cellular activities, such as adaptive cellular responses and possible cell growth. Once there is an imbalance between ROS accumulation and the antioxidant process in the body, oxidative stress and damage to cells and tissues become the result, leading to several health anomalies. Further corroborative evidence from research suggests an association between free radicals and the development of diseases, such as arterial hardening, malignancies, emphysema, and others.

Bernatoniene and Kopustinskiene [39] detail how catechins can inhibit the actions of oxidant supporting enzymes, such as NADPH, or modulate the interaction of ligands with receptors like TNF; they are also capable of repressing many pathways related to oxidative stress that is responsible for the processes of inflammation. Catechins are suspect in modulating important responses to pathogenesis-related oxidative stress by facilitating the activities of redox-sensitive transcription factors, enhancement of activated B cells, and activator proteins. The interactive ability of Catechins is possible due to penetrative ability into the membranes of lipid bilayers via adsorption or penetration, hydrogen bonding to protein proline residues, and power to bind to the enzyme ATP-binding sites. Figure 3 partly explains the role of EGCG in the body.

Figure 3.
EGCG induces the up regulation of antioxidant or detoxifying enzymes by Nrf2-ARE signaling [40].
Researchers have also suggested the similar structures and conformational properties of both catechins and transcriptional factors as possible mechanisms for interactions. Figure 4 illustrates the oxidation mechanism of catechins.

Oz et al. [1] further elucidate how an assortment of reviews has communicated the importance of tea polyphenols as formidable antioxidants in the inactivation of several signaling trails involved in inflammation; down-regulation of Cox-2 and Bcl-2 activities, up-regulation of protective and programmed apoptotic trajectories, and NF-κB mediated pathways of IKK.

6. Health importance of tea antioxidant properties

In this write-up, I will highlight the oxidative impact of tea polyphenols on cancer, cardiovascular conditions, neurodegenerative disorders, diabetes, and their role in boosting fertility in human beings.

6.1 Cancer

The role of EGCG, as an active compound of green tea, is to deter and ameliorate disease courtesy of its antioxidant and anti-inflammatory properties, in conformity the with a validated myriad of study findings. Scientists have proven the effectiveness of this green tea compound in the inhibition of carcinogenesis processes in many types of cancer, though it is still under investigation for effectiveness in other types. Furthermore, catechins are effective in modulating the complexity of chemical processes in the mitochondrion and act in synergy with chemotherapeutic agents to reduce toxicities and anti-carcinogenic outcomes [12, 35, 39, 41]. Figure 5 shows the spectrum of EGCG action on numerous cancer sites.

Besides hampering the accumulation of ROS in human bodies to prevent cancer, EGCG also blocks the DNA synthesis of cancer cells without interfering with the
division of normal body cells [10]. In an experiment aimed at establishing the role of EGCG in stimulating hepatocytes in goats, findings revealed efficacy in promoting cell proliferation, improving the integrity of cell membranes, and cell endurance and function under stress from oxidation, [10, 35].

More findings by Niedzwiecki et al. [42] from several other experiments agreed that tea polyphenols, in combination act synergistically to inhibit tumor growth and metastasis, thus efficacious if used against multiple targets and levels of cancer development and progression, and thus, could be a safe and efficacious approach in cancer prevention and therapy.

Given the numerous findings, scientists recommend that medics could use the synergistic competence of tea catechins with anticancer medications to support therapy as well as cancer prevention [43]. Almatroodi et al. [41] further contend that the combined therapy helps to enhance more anti-cancerous activity and reduction of toxicities by the mitigation of the after-effects sometimes witnessed during single chemotherapy use, which though efficacious in the treatment of cancer, and causes adverse side effects, including malaise, hair loss, infection, nausea, and vomiting, appetite complications, mood swings, and changes in physiologic and biochemical processes Tang et al. [44]. See Figure 6 for illustration.

Further findings from clinical trials as discussed by Musial et al. [35] produced interesting results which portrayed a positive response when Polyphenon E was administered as a supplement, consisting of thriving catechins: EC, EGC, ECG, and EGCG to patients with carcinoma effectiveness. Each capsule contained a decaf EGCG mixture with 200 mg content. During the first phase of the experiment to determine the required dose of EGCG, investigators established a limit of 1200 mg EGCG as a thresh hold for future safety. They also discovered that effective prevention against colorectal adenocarcinoma required consuming ten cups of tea of 150 milliliters each per day.

Other findings from reviews of in vivo and in vitro studies by Tang et al. [44] recommended the consumption of five cups of tea per day for four weeks to achieve anticancer effectiveness. Also, oral bacteria that could be a causative agent in oral
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Figure 6.
The most molecular target of tea on targeting cancer [44].

cancer would be neutralized by drinking five cups of infusion tea extracted from two grams of tea daily for six months; this practice also applies to reducing oxidative stress and stopping the initiation of prostate cancer. However, a warning based on findings from an isolated study indicated an increased risk of developing bladder cancer when one consumed five to nine cups of tea per day [35].

6.2 Neurodegenerative diseases

Maher explains neurodegeneration as “any pathological condition which primarily affects neurons,” and terms neurodegenerative diseases as an outsized and heterogeneous group of neurological disorders that significantly affect distinct subsets of neurons in specific anatomical locations. Of a wider variety of known neurodegenerative disorders, four are of serious attention, thus Alzheimer’s disease (AD), Parkinson’s disease (PD), Huntington’s disease (HD), and amyotrophic lateral sclerosis.

Researchers believe in an increased likelihood of neurodegenerative conditions due to suspected elevated quantities of ROS in the brain [39, 45], this lowers antioxidant activity in the human brain vis-à-vis other body organs. Accelerated senescence and neurodegeneration are caused by mitochondrial oxidative insults and impaired electron transfer, which often weaken and affect the central nervous system.

Also noted is that oxidative products clog neurons during the aging process. This event calls for the consumption of antioxidant compounds, precisely, catechins that are suspects in the delay and/or stoppage of neurodegenerative processes, and declining brain function [39].

Furthermore, scientific evidence has it that polyphenols can lower the morbidity due to PD and AD by reducing oxidative stress and regulating signaling pathways and metal chelation. Hence, scholars believe that theanine inhibits the glutamate receptors and regulates the extracellular concentration of glutamine, presenting the much-desired neuroprotective effects.

Another possible way that the neuroprotective mode of action by which caffeine and theaflavins contribute is the ability to use their antioxidant properties in antagonizing the adenosine receptor A2AR, respectively. Besides, the element of aroma is a crucial factor affecting tea’s sensory quality, with over 600 volatilities identified from the aroma of tea.
Moreover, the legitimately generated tea volatilities from chemical reactions could lessen brain signal dissemination, soothe stress, and experience tranquilizing effects, but the mechanisms have not been well elucidated by experts [3]. From more findings, EGCG suppresses TNF-α, interleukin-1β, interleukin-6, and iNOS, in Aβ energized EOC 13.31, invigorates the extracellular antioxidants certain to nuclear factor 2, as well as the oxygenase1 (HO-1). Ultimately, EGCG also subdues nuclear factor-kB (NF-κB), and prompts the actuation of ROS by the Aβ remedy, as shown in Figure 7.

Another central nervous system progressive disorder that has no cure known as paralysis agitans derives its genesis from the destruction of brain cells that produce dopamine. Its impact can be minimized with green tea use as a foremost recommendation by several researchers. The reason for green tea predisposition is the fact that it protects neurons, hence prevents PD, cushions dopamine neurons, provides a shielding effect from ROS, intercepts apoptosis in the brain and CNS, and thus prevents PD [12].

Findings by Vishnoi et al. [12] from an in vitro study substantiated the ability of tea to restrain the human acetylcholinesterase with an IC value of 0.03 mg/ml and restrained β-secretase at a test concentration of 0.03 mg/ml by 38%. The study further hypothesized that tea infusion constituted biologically functional truths, conceivably acting in an interactive manner. Physicians could prefer this idea to retard the progression of disease with the presumption that these principles reach the brain.

Scientists think the appliance of EGCG decreases the production of beta-amyloid, a protein that shapes the plaque that obstructs the brains of Alzheimer’s casualties and aggravates disease symptoms. Impeding the actions of the enzyme acetylcholinesterase and β-amyloidosis should be the first aspiration for the therapy for Alzheimer’s disease [12].

Additional evidence from various studies conducted in Asia and Europe, involving over 290 participants concluded that the outset of PD and AD could amazingly be procrastinated by up to 7.7 years when subjects take between two and three cups of tea on a daily basis [8]. Additional studies have shown the significant roles of tea polyphenols in the treatment of neurodegenerative diseases by protecting the systema nervosum through improvement of learning and memory as in (AD), improvement of nerve redox disparity, and mitochondrial affliction by balancing biological time as in (PD), and lowering of neural vandalism after the cerebral ischemia at an EGCG recommended dose of fifty mg/kg.

Moreover, analysts have reported that consuming an average of 400 mg/kg of green tea polyphenols could lead to an increase in the perceptual-cognitive capacity of patients recovering from chronic cerebral hypoperfusion by scavenging oxygen free radicals, limitation of the creation of lipid peroxides, and mitigating the effect of oxidized DNA, thereby enforcing a neuroprotective function [9].
6.3 Cardiovascular disease

Cardiovascular disease (CVD) is an aggregation of ailments entailing numerous aspects. Amongst those factors are inflammation, cumulative damage done by free radicals, thrombolytic aggregation, and metabolic processes [12]. Other previous studies have highlighted that habitual consumers of green tea were less likely to suffer from diseases of the heart and cardiovascular accidents. Research published by Harvard University further confirms a link between taking tea and wellness; drinking at least one cup of tea daily reduced heart attacks by up to 44%.

Green tea also dramatically raises the antioxidant capacity of the blood, which in effect shields the LDL cholesterol particles from being oxidized, limiting one part of the heart disease pathways. Research findings further entrench that women dying from cardiovascular disease and stroke were lower than 31% for those who consumed five or more cups of tea every day [12].

Oxidative stress has been incriminated as a victim in the progression of various cardiovascular infirmities, including high blood pressure, endothelial dysfunction and hardening of arteries, ischemic heart diseases, cardiomyopathy, cardiac hypertrophy, and congestive heart failure [39].

A summary of findings from over 150 human interventions and animal studies involving more than 35,000 subjects between 1992 and 2017 from across the world by Li et al. Ref. [4] has postulated that tea relaxes muscles facilitating smooth contraction, enhancing endothelial nitric oxide synthase activity, reducing vascular inflammation, inhibiting renin activity, and anti-vascular oxidative stress, thus confirmed that both tea and tea metabolites have anti-hypertensive effects in ex vivo tissue and in vitro cell culture studies, although some controversial reports existed [39].

Correspondingly, wrap-up evidence from a plethora of studies by Serafini et al. [14] deduced that taking a capsule containing theaflavin-enriched GTE (375 mg) daily with two cups of GT, containing about 250 mg of total catechins could provide tea flavan-3-ols enough to control CVDs by up to 10 mg/dL [0.25 mmol/L] of LDL.

6.4 Diabetes

Diabetes is a serious global, long-term condition with a major impact on the lives and well-being of individuals, families, and societies worldwide [46, 47]. Diabetes is an amalgam of metabolic conditions that cause high blood sugar and could be a result of autoimmune and hereditary defects. High blood glucose is either because of impaired insulin production, low cellular sensitivity to insulin, or a combination of the two factors [48].

Diabetes is one of the top 10 causes of death among grownups, causing an estimated four million deaths globally in 2017. During the same year, 2017, global health expenditure on diabetes soared to a high USD 727 billion [49]. Diabetes is into three categories; T1D, T2D, and GDM [48].

It may not be feasible to prevent T1D but is treatable by health professionals with insulin supplementation, whereas T2D can both be averted, and/or reversed by altering diet and management of lifestyle factors [46]. T2D is a heterogeneous disorder, characterized by the resistance of glucose and lipid metabolism in peripheral tissues to the biological activity of insulin, and inadequate secretion of insulin by pancreatic β cells [12], the loss of functional β-cell mass plays a central role in the deterioration of blood glucose control [50], inherited and/or acquired deficiencies in insulin secretion and/or by decreased responsiveness of the organs to secrete insulin also called
insulin resistance culminates into increased blood glucose, this in turn can damage many of the body's systems, including blood vessels and nerves [51].

Diabetes has high morbidity and mortality, attributed to its complications, such as diabetic nephropathy, diabetic cardiovascular complications, diabetic neuropathy, and diabetic hepatopathy [52]. An aggregate of findings by Imran et al. [53] from several experiments using rats to determine the effects of theaflavins and thearugibin drink on blood glucose levels indicated a reduction in cholesterol, LDL, and triglyceride levels of experimental rats in all studies with a significant increase in HDL. In this context, theaflavins-based drink imparted maximum reduction in cholesterol, the highest glucose decline, and maximum insulin increase in all studies as compared to other nutraceutical drinks.

Functional drinks can be useful for combating lifestyle-related maladies with special reference to hypercholesterolemia and hyperglycemia. What's more, Li et al. [4] reported consequential therapeutic qualities of tea on hypertensive diabetic patients where diabetics who took green tea infusions after meals, three times daily for a period of four weeks, had their blood pressure reduced significantly. In a short time of 15 days, both the SBP and DBP had reduced significantly by 4.6 mmHg and 3.6 mmHg, respectively.

A similar case-control study meant to determine the effects of green tea extracts involved diabetic Japanese adults and a control group who were healthy and revealed a noticeable drop in sugar levels with the continued use of the tea extract.

In consensus with earlier studies, further evidence was generated with findings from more clinical trials communicating the effectiveness of tea intervention on diabetics and patients with related complications [54], and the important biologic activities of green tea in anti-diabetic makeup [9]. See Figure 8.

Contemporaneous studies have also imputed the anti-diabetic effect of green tea mainly in the following mechanisms; the potential to reduce insulin resistance by

Figure 8. The molecular mechanisms of EGCG against diabetes mellitus and its complications. The effects of ECG against T2D show by improving IR, against diabetic cardiovascular disease by reducing TG and [Ca2+]i, against diabetic nephropathy by reducing ROS, and against diabetic neuropathy by increasing Nrf2. Black lines indicate up regulation, red dotted lines indicate down regulation.
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increasing the absorption of glucose by adipocytes and their ability to bind to insulin [51, 54], the power to enhance glucose metabolism by triggering an increase in glycogen content in the liver, change of the activity of key enzymes in glucose metabolism [43, 46], ameliorating insulin secretion, and amortizing diabetic complications [9].

In another study, investigators administered 500 mg/kg of green tea polyphenols to normal rats during an experiment. By the lapse of sixty minutes, the glucose tolerance had raised notably. A significant reduction in blood sugar in alloxan diabetic rats at specified doses, and for a given period of time justified the significance role that tea plays in improving glycolysis and lipogenesis [12].

Carotenoids in green tea play both a functional role as pro-vitamin A in the visual pathway and a structural role as macular pigments further upholding the antioxidant potency of tea in the prevention and treatment of T2DM [55]. Meanwhile, transpiring corroboration portrays the capacity of phenols to aid the secretion of intestinal L-cells and could be useful in the improvement of glycolysis and homeostasis [49].

Quercetin, another strong antioxidant component in tea has the potential to reduce insulin resistance and decrease inflammation by improving the expression of glucose transporters GLUT4 [8].

Tang et al. [44] tabled findings from several clinical trials with optimism in managing T2DM, in relation to ameliorating insulin resistance and hyperglycemia in humans. The findings advance a postulation that drinking black tea could significantly reduce the glycated hemoglobin levels (HbA1c) and ameliorated the likelihood of ailment due to T2D. Moreover, the same findings confirm that T2D aggravated by diets rich in high fat could as well be contained by regularly taking green tea.

6.5 Infertility

Human infertility is a global concern and already affects one in six couples worldwide [56], research approximates that between 15 and 30% of couples are struggling to conceive [33]. Male factors contribute to 20–50% of the cases, making infertility a controversial problem across the globe, some of the factors point to several anatomical discrepancies, including but not limited to obstructions in seminal tubes, neurological anomalies, aging, and urinary tract infections, these affect spermatogenesis and weakening the sperm function.

It is also worth noting that an interplay of several environmental factors exist that reduce semen quality, hence, infertility, such as tobacco use, excessive consumption of alcohol, exposure of testis to higher temperatures, dietary inadequacies, oxidative stress, and exposure to industrial chemicals, pesticides, and radiation. An understanding of cell biology correlates with the assumption that increased levels of ROS lead to a lower antioxidant response, which is not healthy for sperm production and quality [33, 56, 57] as shown in Figure 9.

A synopsis of evidence by Zhang et al. [40] suggests that the secondary metabolite in green tea (EGCG) portrays diverse physiologic activities, including antioxidant, antitumor, and antiviral activities, single or a conglomerate of which could be a recipe for infertility. Further to this, investigators found that fertility in human beings is supported by EGCG through the mitigation of the impacts of excessive ROS on sperm and oocyte cells, cell death, hyperactivation of enzymes on the ERK, and signal regulating proteins operating outside cells.

According to Rahman et al. [33, 45], the high presence of antioxidants in EGCG, can reduce ROS and improve gamete quality in both males and females, at low concentrations, and that supplementation with EGCG in males can considerably increase
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sperm concentration, motility, fertility rate, morphology, and viability, and reduce DNA damage. It is also capable of enhancing the quality of oocytes and embryos, hence, increasing the rates of fertilization and clinical pregnancy in female beings. Consistently, using green tea has an inverse relationship with the risk of ovarian cancer, which is a factor in female infertility; a further illustration is shown in Figure 10.

7. Conclusion

Over the years, there has been global consumption of tea, both for recreational and medicinal purposes. This has been attributed to the demonstrated health benefits, mainly, its antioxidant properties are instrumental in suppressing the initiation, onset, and progression of metabolic disorders, different types of malignancies, degenerative diseases, infertility complications dermatological problems, respiratory infections insulin resistance, and osteoporosis. Although some studies have provided
controversial results about the safety of tea and its products in excess, scientists could not provide an independent confirmation but may be a subject for future research, in comparison with the overwhelming evidence from numerous studies on the benefits and safety of tea and its constituent components. Areas of further exploration should interest in the sustainable bioavailability of tea and its products for intended purposes, more findings on the mechanism of action by tea and its products in the improvement of health, and further need to study the interactive capabilities with other medications and supplements. By and large, the consumption of tea for recreational and medicinal reasons hitherto remains safe and recommended.

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Conflict of interest

The author declares no conflict of interest.

Acronyms

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<tr>
<td>ACC</td>
<td>acetyl-CoA carboxylase</td>
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<tr>
<td>AMD</td>
<td>adjusted mean difference</td>
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<td>BMI</td>
<td>body mass index</td>
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<td>Inhibitory Kappa B Kinase complex</td>
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<td>NF_B</td>
<td>nuclear factor kappa-light-chain-enhancer of activated B cells</td>
</tr>
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<td>NF-kB</td>
<td>nuclear factor kappa light chain enhancer of activated B cells</td>
</tr>
<tr>
<td>Nrf2</td>
<td>nuclear factor erythroid-2 related factor</td>
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<tr>
<td>Ors</td>
<td>odds ratios</td>
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<tr>
<td>PGC-1α</td>
<td>peroxisome proliferator-activated receptor-γ coactivator-1α</td>
</tr>
<tr>
<td>PPAR</td>
<td>peroxisome proliferation-activated receptor</td>
</tr>
<tr>
<td>RCT</td>
<td>randomized controlled trial</td>
</tr>
<tr>
<td>ROS</td>
<td>reactive oxygen species</td>
</tr>
<tr>
<td>SBP</td>
<td>systolic blood pressure</td>
</tr>
<tr>
<td>SCD</td>
<td>stearoyl-CoA desaturase</td>
</tr>
<tr>
<td>SIRT</td>
<td>sirtuin</td>
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<tr>
<td>SOD</td>
<td>superoxide dismutase</td>
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<tr>
<td>SREBP</td>
<td>sterol regulatory element-binding proteins</td>
</tr>
<tr>
<td>TC</td>
<td>total cholesterol</td>
</tr>
<tr>
<td>Tcf7l2</td>
<td>transcription factor 7-like 2</td>
</tr>
<tr>
<td>TFA</td>
<td>total abdominal fat area</td>
</tr>
<tr>
<td>TGs</td>
<td>triglycerides</td>
</tr>
<tr>
<td>TNF</td>
<td>tumor necrosis factor</td>
</tr>
<tr>
<td>UA</td>
<td>uric acid</td>
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<tr>
<td>VEGF</td>
<td>vascular endothelial growth factor</td>
</tr>
<tr>
<td>VFA</td>
<td>visceral fat area</td>
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<tr>
<td>WC</td>
<td>waist circumference</td>
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<tr>
<td>WMD</td>
<td>weighted mean difference</td>
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Author details

Sabila Nelson
Independent Scientist, Mbale, Uganda

‘Address all correspondence to: sabila840@gmail.com

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