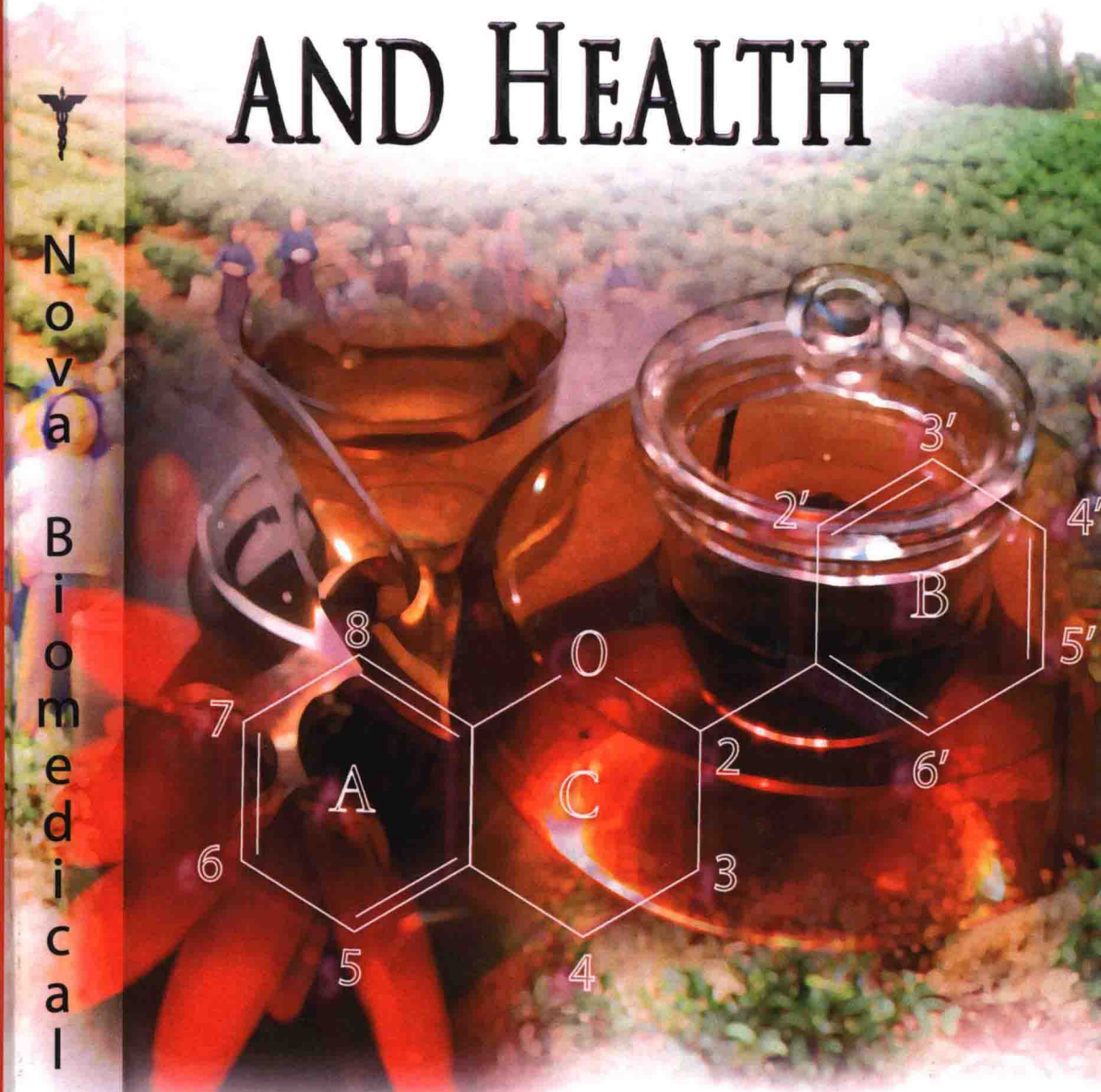
Food and Beverage Consumption and Health

Tea Consumption and Health



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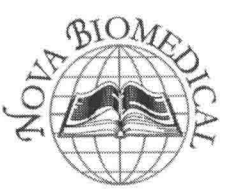

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PREFACE

Tea has been consumed for the the last 3,000 years. Tea, either green or black tea has been consumed as a beverage and its health benefits have been widely explored. Tea is known for its benefits against cardiovascular disease, anti-inflammatory benefits, antimicrobial, as well as skin and oral care agent. In this book, experts in tea explore its health effects in various aspects such as skin, diabetes, cardiovascular disease etc. This book is an excellent collection of literature evidence on health benefits of tea for the global reader.

Chapter 1 - Tea, the dried leaves of the *Camellia sinensis* species of the Theaceae family, is a popular beverage with an annual production of three billion kilograms worldwide. Tea, brewed from the plant *Camellia sinensis* is consumed in different parts of the world as green, black or Oolong tea. Research findings suggest that the polyphenolic compounds, (−)-epigallocatechin-3-gallate found primarily in green tea, and theaflavin-3,3′-digallate, a major component of black tea, are the two most effective anti-cancer factors found in tea. The possible beneficial health effects of tea are being extensively investigated and have received a great deal of attention in recent times. Research conducted in many laboratory were indicate that tea can improve resistance against cancer, prevent cardiovascular diseases, promote digestive functions, stimulate the immune system, reduce inflammatory problems, and can have many other benefits. Tea catechins an important antioxidant that can be exploited as dietary supplement in foods and beverages or as pharmaceutical/cosmetic use. However, the use of tea as a cancer chemopreventive or for other health benefits has been confounded by the low oral bioavailability of its active polyphenolic catechins, particularly epigallocatechin-3-gallate (EGCG), the most active catechin. The utilization of encapsulated polyphenols, instead of free compounds, can effectively alleviate these deficiencies. One approach to achieve this goal is the encapsulation of polyphenol with protein milk. It was found that use of thermally modified β-lactoglobulin conferred considerable protection to EGCG against oxidative degradation. Protein milk can increase the bioavailability of polyphenol also polyphenol can protected milk protein against oxidation. An addition of *Camellia sinensis* green tea extract before irradiation of caseins cow milk proteins was examined. We founded that the presence of *Camellia sinensis* green tea extract during irradiation in the presence of oxygen prevented the protein aggregation even at doses higher than 10 kGy, probably by scavenging oxygen radicals produced by irradiation. In this paper, we examine the available scientific information concerning tea, its polyphenol and human health. Also we report on studies that shed more light on the novel methods to increase the bioavailability of polyphenol and novel use of tea.

Chapter 2 - The origins of tea (*Camellia sinensis* (L.) O. Kuntze) are almost lost in time, with narratives that mix reality with many legends. For centuries, green tea has been widely used as food and medicine, since it provides, not only essential nutrients required for human life, but also other bioactive compounds for health promotion and disease prevention. In fact, some of these phytochemicals have served as sources of inspiration for generations of medicinal chemists, pharmacists, and nutritionists and will continue to provide humankind with valuable agents of potential use in research, prevention, and treatment of a number of chronic pathologies.

The chemistry of green tea is very complex, with thousands of phytochemicals, namely phenolic compounds, methylxanthines, organic acids, fibers, free amino acids, volatiles, between other classes of compounds. The potential bioactivities ascribed to this beverage include antioxidant, antimutagenic, anticarcinogenic, antimicrobial, anti-inflammatory, hypocholesterolemic, hypoglicemic and other clinically relevant activities.

Several scientific studies indicate that green tea is an excellent and inexpensive natural source of polyphenols, especially of catechins (flavan-3-ols). These compounds are well known for their strong antioxidant properties and are considered by many researchers as the main responsible for the beneficial health effects of this beverage and its derivatives (extracts).

In this chapter, I pretend to emphasize the virtues of this ancient drink in the light of the modern science. Thus, I will discuss briefly the aspects of its origin, cultivation and manufacturing process and will be focused in those related to its chemical composition and bioactivities, especially antioxidant and antitumor activities.

Chapter 3 - Tea is a popular beverage consumed worldwide that has been shown to have many health benefits. Its major polyphenols constituents, tea catechins, are the main components responsible for the medicinal effects of this beverage. Catechins exert vascular protective effects through multiple mechanisms, including antioxidative, anti-hypertensive, anti-inflammatory, anti-proliferative, anti-thrombogenic, and lipid lowering effects. Epigallocatechin-3-gallate (EGCG) is the most abundant catechin in green tea and presents potent anti-inflammatory effects by inhibiting enzyme activities and signal transduction pathways that play important roles in inflammation. After oral consumption, EGCG becomes bioavailable and several studies suggest that EGCG may directly interact with a large set of protein targets and alter the physiological response of the cells. This chapter highlights current developments about the effects of EGCG as an anti-inflammatory compound and its molecular targets that directly affect inflammation. These data support the use of EGCG as a possible chemopreventive agent with a potential to inhibit the development of multiple diseases, such as cardiovascular and neurodegenerative diseases and cancer.

Chapter 4 - Green tea catechins are known to have many biological functions, including anti-inflammatory, anti-oxidative and anti-carcinogenic effects. These effects are induced by the suppression of several inflammatory factors including nuclear factor-kappa B (NF-κB), a multipotential promoter of matrix metalloproteinase (MMP), cytokines, and adhesion molecules. While these characteristics of green tea catechins have been well documented, the effects on inflammatory cardiovascular diseases have not yet been well investigated. In this article, we reviewed recent clinical and experimental data to reveal the anti-inflammatory effects of green tea catechins in cardiovascular diseases. We performed oral administration of green tea catechins into murine and rat models of cardiac transplantation, myocarditis and myocardial ischemia to clarify the effects on the inflammation-induced ventricular and

arterial remodeling. From our results and other investigations, catechins are potent agents for the treatment and prevention of inflammatory cardiovascular diseases because they are critically involved in the suppression of proinflammatory signaling pathways.

Chapter 5 - Black tea and green tea are the commonly known varieties of tea, used in different parts of the world. However, a third and lesser known variety, oolong tea is also available. Black tea is fully fermented; oolong tea is partially fermented, while green tea is not fermented at all. These differences in the processing techniques render these teas with distinctive chemical constitutions. Yet, various researchers have shown a positive role of each type of tea in ameliorating the knotty situation of diabetes. It has been published that consumption of tea, in any form, improves insulin resistance as well as glycemic control. Epidemiological studies have evaluated tea and its components and have shown a definite advantage of tea consumption in lowering the risks associated with diabetes. Moreover, the anti-hyperglycemic activity of tea has also been studied in vitro using the intestinal glucose uptake model. The role of tea polyphenols and catechins has been emphasized to a great extent in this regard. Apart from caffeine, catechins and polyphenols are found in tea in higher concentrations which are considered to be responsible for the anti-diabetic effects. Green tea was found to tender the renal complications of diabetes. Black tea was reported to reduce the risk of type 2 diabetes in Asian population. Oolong tea was found to augment the lowering of plasma glucose levels in combination with oral hypoglycemic agents. All these findings provide insights to the potential role of different varieties of teas in managing the difficult situation of diabetes.

Chapter 6 - Some prospective cohort and case-control studies suggest that long-term consumption of tea is associated with a reduced risk of mortality from ischemic stroke. Habitual tea consumption is also associated with a reduced risk of developing hypertension (an important cardiovascular risk factor for ischemic stroke). In stroke-prone spontaneously hypertensive rats, green tea consumption attenuated increases in blood pressure which corroborated with human observational studies. Tea flavonols enhance endothelial function by increasing cerebral blood flow and protecting against oxidative stress-induced ischemia. Green tea extract and its putative flavonol, epigallocatechin gallate (EGCG), significantly reduce infarct size in surgically-induced ischemic stroke in animal models. In vivo experiments show that EGCG, a potent free radical scavenger, activates endogenous antioxidant systems which reduce oxidative stress and ameliorate the sequel of events which lead to cerebral ischemia. EGCG reduces neuronal damage caused by chemically-induced oxidative stress, thus providing protection against ischemic stroke in in vitro models. Other studies have suggested that EGCG activates Nrf2 (a transcription factor which stimulates intracellular antioxidant signalling pathways) and increases the activity of heme oxygenase-I (a potent antioxidant enzyme). These mechanisms may explain, in part, the neuroprotective role of green tea against ischemic stroke. At the molecular level, components of green tea may provide neuroprotection by regulating various receptors, including $GABA_A$, and modulating intracellular signalling pathways, including STAT-1. The evidence from both pre-clinical and clinical studies suggests that tea may prevent ischemic stroke.

Chapter 7 - Tea is one of the most popular drinks in the world, second only to water in terms of per capita consumption. Green tea is an extract of the leaves of the plant *Camellia sinensis* and it has been considered as a potential health beverage from ancient times in the system of medicine. Polyphenols are structurally diverse group of compound, ubiquitous in all plant kingdoms. As a result they form an integral part of human diet. Polyphenols are

being widely used in the recent time as they possess antioxidant and free radical scavenging activities. Most of the polyphenols in green tea are flavanols, commonly known as catechins. The primary catechins in green tea are (-) epicatechin (EC), (-) epicatechin-3-gallate (ECG), (-) epigallocatechin (EGC), and (-) epigallocatechin-3-gallate (EGCG). In addition, caffeine, theobromine, theophylline and phenolic acids are also present as minor constituents. Epidemiological studies suggest that green tea and its catechins show varying health benefits in the prevention of cancer, diabetes, CNS disorders etc. The beneficial effects of green tea and its polyphenols in the prevention of cardiovascular disorders and their current status are reviewed in this chapter.

Chapter 8 - Tea is a well known beverage in the world due to its health benefits. A lot of studies indicated that tea contains more than 500 components that display several activities. Catechins are the most important component in a tea leaf. They present a great deal of antioxidant activity. Several reports revealed that catechins particularly epigallocatechin gallate (EGCG) are promising ingredients for protecting and nourishing skin. Catechins can scavenge free radicals and retard extracellular matrix degradation induced by UV radiation and pollution. Furthermore, catechins also directly affect the skin by activating collagen synthesis and inhibiting matrix metalloproteinase enzyme synthesis.

Based on the results in *in vitro* study, the benefits of tea looked promising. However, the results of the in vivo study have not been satisfactory. A few studies reported that tea and tea catechins significantly improved skin elasticity and increased dermis's thickness, therefore, skin wrinkle relief was obtained. The skin inflammation induced by UV radiation was decreased substantially when pre-treating the skin with tea catechins. On the contrary, a few studies revealed that topical formulation of tea catechins did not significantly improve skin health. The discrepancy in results with the in vivo study was due to the limitation of catechins's properties. Instability, less skin permeation and cutaneous metabolism were the crucial parameters in effectiveness of tea catechins. The health benefit from tea seems to be limited in real life, the appropriate preparations of tea application and delivery technology are the solution.

Chapter 9 - Scarring and adhesions remain a major problem in medicine and surgery, causing unsightly repairs on the skin, disability if the scarring affects limbs or fingers and even death if scarring occurs in organs such as liver, kidneys or lungs. *Camellia sinensis* (green tea) is known to contain a rich source of poylphenols known as catechins. The major polyphenol in green tea is epigallocatechin-3-gallate (EGCG) which has been shown to have a wide biological activity. EGCG has been shown in *in vitro* and *in vivo* studies to reduce fibrosis and the contraction often associated with scarring. This review will summarise current scientific evidence of the role that EGCG plays in reducing scarring in a number of models. It will also review the potential biological processes that are altered with the administration of EGCG and its future potential as an anti-fibrotic therapy.

Chapter 10 - Human immunodeficiency virus-1 (HIV-1) infection ultimately results in impaired specific immune function subsequent to the initial binding of the HIV-1-gp120, to the CD4 receptor. HIV-1 eludes the immune system and leads to the onset of acquired immunodeficiency syndrome (AIDS). Ever since the discovery of the virus as the causative agent, there has been an intense effort to develop therapeutic methods to inhibit or prevent infection. The current impact of the global AIDS epidemic is staggering with over 60 million people infected with HIV. Antiretroviral (ARV) therapy has decreased the number of AIDS cases dramatically. However, ARV therapy is not able to eradicate HIV-1 from patients

completely. Furthermore, the toxicity of current available anti-HIV drugs makes it difficult to maintain patients' adherence to ARV therapy. The inevitable emergence of drug-resistant mutants, especially multi-drug resistant mutants, in response to ARV therapies will reduce the rates of success of ARV. There is an urgent need to expand the range of interventions to prevent HIV transmission and acquisition and development of novel anti-HIV agents is necessary.

One such candidate is the green tea catechin, epigallocathecin gallate (EGCG). In HIV-1 infection, EGCG is responsible for the reported antiviral effects of green tea. EGCG inhibits HIV-1 replication in human peripheral blood mononuclear cells (PBMC) in vitro with resultant decrease in HIV-1 p24 antigen concentration and reverse transcriptase.

The translational research of this natural product from bench to bedside is chronicled here with evidence that the green tea component, EGCG, at physiologically relevant concentrantions inhibits the binding of HIV-1-gp120 to CD4 over a broad spectrum of virus strains leading to the implementation of a Phase I/IIa clinical trial in HIV-1-infected individuals of a FDA-IND approved decaffeinated supplemental preparation of tea catechin, Polyphenon E, developed at NIH.

A major drawback of present conventional antiretroviral drugs is their high cost and unavailability in the Third World. A cheap, readily available, and safe treatment, such as could be provided by this complementary and alternative medicine, green tea catechin, would have an enormous impact on public health.

Chapter 11 - Herbal tea preparations have been traditionally used to remedy sleep disturbance for many years. Herbal plants such as valerian (*Valeriana officinalis*), kava kava (*Piper methysticum*), chamomile (*Matricaria recuita*), and passionflower (*Passiflora incarnata*), have long been used in sedative herbal teas. Although these herbs are widely added to commercial products with the prime purpose of remedying sleep, there is little or no scientific evidence for their efficacy. While such herbs are sold as teas, extracts and tablets, it is not clear whether herbal tea preparations contain any bioactive constituents that are effective beyond the relaxing effects of a warm beverage. This chapter describes the prevalence of mild sleep disturbance in the population, the lack of effective treatments that are readily available, and the therapeutic application of herbal medicines as alternatives or complements to pharmacological and psychological treatments. A review of the evidence regarding the effectiveness and potential side effects of sedative herbs, with an emphasis on *Passiflora incarnata* herbal tea, is then provided. Recent research suggests that *Passiflora incarnata* tea can promote better subjective sleep quality. Therefore, it seems that both widespread popular use and initial research evidence suggest that there is efficacy in the use of *Passiflora incarnata* herbal tea for treating mild fluctuations in sleep quality. Further scientific studies are needed to confirm recent findings, and to better understand the potential efficacy of *Passiflora incarnata* tea on the different aspects of sleep.

Chapter 12 - Urinary incontinence (UI) is a distressing condition and costly problem in middle-aged and older people. A recent study suggested an inverse association between UI and habitual green tea consumption in middle-aged and older women. To investigate whether a similar relationship holds for male UI, seven hundred men aged 40-75 years were recruited from the community in middle and southern Japan. A validated food frequency questionnaire was administered face-to-face to obtain information on dietary intake and habitual tea consumption. UI status was ascertained using the International Consultation on Incontinence Questionnaire-Short Form. Among the 683 eligible participants, 49 men (7.2%) experienced

urine leakage for the past 2.6 (SD 1.9) years. Their daily green tea intake (281 ml) was lower than others without the condition (311 ml), even though the prevalence of green tea drinking (88%) was similar between the two groups. Relative to non-drinkers, the adjusted odds ratios of UI were 0.93 (95% confidence interval 0.36 to 2.42) for drinking more than 700 ml and 0.75 (95% confidence interval 0.27 to 2.04) for drinking four or more cups daily. The corresponding dose-response relationships for these quantity and frequency of intake were not significant. The findings suggested no association between UI and habitual green tea consumption in middle-aged and older Japanese men.

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Chapter 1

TEA POLYPHENOLS: HEALTH, BIOAVAILABILITY AND NOVEL USE

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ABSTRACT

Tea, the dried leaves of the *Camellia sinensis* species of the Theaceae family, is a popular beverage with an annual production of three billion kilograms worldwide. Tea, brewed from the plant *Camellia sinensis* is consumed in different parts of the world as green, black or Oolong tea. Research findings suggest that the polyphenolic compounds, (−)-epigallocatechin-3-gallate found primarily in green tea, and theaflavin-3,3′-digallate, a major component of black tea, are the two most effective anti-cancer factors found in tea. The possible beneficial health effects of tea are being extensively investigated and have received a great deal of attention in recent times. Research conducted in many laboratory were indicate that tea can improve resistance against cancer, prevent cardiovascular diseases, promote digestive functions, stimulate the immune system, reduce inflammatory problems, and can have many other benefits. Tea catechins an important antioxidant that can be exploited as dietary supplement in foods and beverages

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or as pharmaceutical/cosmetic use. However, the use of tea as a cancer chemopreventive or for other health benefits has been confounded by the low oral bioavailability of its active polyphenolic catechins, particularly epigallocatechin-3-gallate (EGCG), the most active catechin. The utilization of encapsulated polyphenols, instead of free compounds, can effectively alleviate these deficiencies. One approach to achieve this goal is the encapsulation of polyphenol with protein milk. It was found that use of thermally modified β-lactoglobulin conferred considerable protection to EGCG against oxidative degradation. Protein milk can increase the bioavailability of polyphenol also polyphenol can protected milk protein against oxidation. An addition of *Camellia sinensis* green tea extract before irradiation of caseins cow milk proteins was examined. We founded that the presence of *Camellia sinensis* green tea extract during irradiation in the presence of oxygen prevented the protein aggregation even at doses higher than 10 kGy, probably by scavenging oxygen radicals produced by irradiation. In this paper, we examine the available scientific information concerning tea, its polyphenol and human health. Also we report on studies that shed more light on the novel methods to increase the bioavailability of polyphenol and novel use of tea.

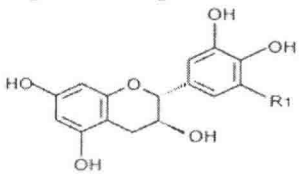
INTRODUCTION

Tea, the dried leaves of the *Camellia sinensis* species of the Theaceae family, is a popular beverage with an annual production of three billion kilograms worldwide. Tea, brewed from the plant *Camellia sinensis* is consumed in different parts of the world as green, black or Oolong tea. For green tea is prepared from the young shoots of tea plant *Camellia sinensis*. The fresh tea leaves from the plant *Camellia sinensis* are steamed and dried to inactivate the polyphenol oxidase enzyme, a process that essentially maintains the polyphenols in their monomeric forms. Black tea, on the other hand, is produced by extended fermentation of tea leaves which results in the polymeric compounds, thearubigins and theaflavins. Oolong tea is a partially fermented product and contains a mixture of the monomeric polyphenols and higher molecular weight theaflavins [1]. All three varieties of tea contain significant amounts of caffeine (3–6%) which is unaffected by the different processing methods [2]. Historically, green tea has been consumed by the Japanese and Chinese populations for centuries, and is probably the most consumed beverage besides water, in Asian society. Green tea has attracted significant attention recently, both in the scientific and in consumer communities. Scientific evidences to support the health benefits of green tea consumption begin to appear. Those benefits include improving blood flow, preventing cardiovascular disease, eliminating various toxins and improving resistance to various diseases [3]. Also it can prevent a variety of cancer and atherosclerosis in humans [4, 5]. This publicity has led to the increased consumption of green tea by the general and patient population, and to the inclusion of green tea extract as a featured ingredient in several nutritional supplements, including multivitamin supplements. Its low toxicity, low cost, and natural abundance thus make it an attractive substance to investigate [6]. Owing to the health benefits, green tea consumption is increasing, which is reflected by its annual growth rate of ca. 4.5% [7]. Graham (1992) affirmed that the major nutraceutical compounds in green tea are tea catechins, which are flavonols, which make up 30% of the dry weight of green tea leaves [1]. Flavanols are a class of flavonoids which are polyphenols, which are of interest to human health [8]. These catechins are present in higher quantities in green tea than in black or oolong tea, because of differences in the processing of tea leaves after harvest. Biological activity of green tea has been extensively studied, but 80%

of the approximately 2.5 million metric tons of manufactured dried tea is black tea [9]. Therefore, in recent years, black tea is extensively investigated mainly regarding its influence on human health [10].Tea catechins have the most effective antioxidant activity compared to other tea polyphenols. The major green tea catechins are (−)-epigallocatechin gallate (EGCG), (−)-epicatechin gallate (ECG), (−)-epigallocatechin (EGC) and (−)-epicatechin (EC). These epicatechins can change to their epimers that are non epicatechins, i.e. (−)-gallocatechin gallate (GCG), (−)-catechin gallate (CG), (−)-gallocatechin (GC) and (±)-catechin (C) (Figs. 1 and 2). EGCG is the most abundant and active catechin and it is usually used as a quality indicator [11, 12, 13]. Other studies confirmed that green tea contains other polyphenols such as gallic acid, quercetin, kaempferol, myricetin and their glycosides, but at lower concentration than EGCG [8, 14]. Numerous scientists have reported that the cancer preventive activities of EGCG: growth inhibition of human cancer cell lines in cultures, induction of apoptosis, inhibition of tumor promotion and carcinogenesis in animal experiments, antimutagenic and anti-oxidant activities, inhibition of tumor necrosis factor-a (TNF-a) release from cells induced by a tumor promoter, and modulation of gene expression [15, 16, 17].

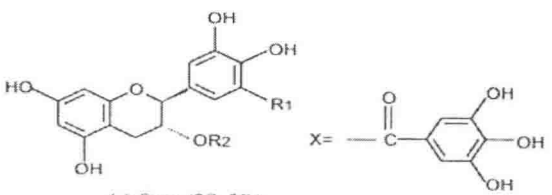
Others studies have suggested that this catechin could influence tumor formation through an inhibition of various cellular processes involved in cell replication and DNA synthesis, by interfering with cell-to-cell adhesion [18], or by inhibiting some of the intracellular communication pathways required for cell division [19, 20]. Also, EGCG was found to inhibit the tyrosine phosphorylation of EGF receptor in human lung cancer cell line A431 cells treated with EGF [16]. Green tea may be a promising tool for the prevention of prostate cancer [21]. Oxidative stress results from an imbalance between pro-oxidant and antioxidant is discussed to be an important mechanism in the development of both cardiovascular diseases [22, 23] and cancer [24]. Higdon and Frei, (2003) reported that tea catechins are an efficient free radical scavenger due to their one electron reduction potential. Antioxidant activity as hydrogen or electron donors is determined by this reduction potential of free radicals and a lower reduction potential has a tendency to lose electron or hydrogen [25]. The rate of reaction with free radicals and the stability of the resulting antioxidant radicals contribute to the reactivity of antioxidant. Guo et al. (1999) reported that the scavenging ability of tea catechins on superoxide anions ($O_2^{\bullet-}$), singlet oxygen ($^1O_2$), the free radicals generated from 2,2P-azobis(2-amidinopropane) hydrochloride (AAPH) and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals [26]. They suggested that the scavenging ability of EGCG and GCG was higher than that of EGC, GC, EC and C due to their gallate group at 3 position of C ring. While abilities to scavenge free radicals for EGC and GC were stronger than EC and C because of a hydroxyl group at the 5′ position of B ring. GCG was more stable than EGCG because it has smaller steric hindrances. In addition, the stability of GC and C was better than EGC and EC. Since tea has an antimicrobial activity against a large spectrum of pathogenic bacteria [27, 28, 29, 30]. Tea polyphenols inhibited the development and growth of bacterial spores and reduced the heat resistance of thermophilic spores [31]. In addition, many reports [28, 29] have presented data regarding the antimicrobial activity of different types of tea extracts on various pathogenic microorganisms. Recently, there has been an increasing interest in the use of natural food additives and incorporation of health-promoting substances into the diet [32]. Using natural green plant extracts or their derived products in various food and beverage applications are an increasing trend in the food industry. Selection of these plant extracts and their application depends on their functional properties,

availability, cost effectiveness, consumer awareness and their effect on the sensory attributes of the final product. Application of polyphenols, in the functional foods, nutraceutical and pharmaceutical industries, depends on preserving the stability, bioactivity and bioavailability of the active ingredients. Try to make the review of knowledge acquired about Tea polyphenol: health, novel methods to increase their availability and novel applications establish one of the aims of this present chapter.



(+)-form (2R, 3S)

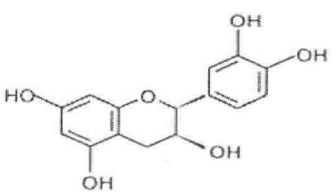
(+)-Catechin: R1=H
(+)-Gallocatechin: R1=OH



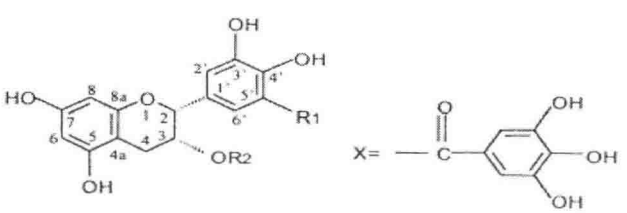
(-)-form (2S, 3R)

(-)-Catechin: R1=R2=H
(-)-Gallocatechin: R1=OH, R2=H
(-)-Catechin gallate: R1=H, R2=X
(-)-Gallocatechin gallate: R1=OH, R2=X

Figure 1. Chemical Structures of tea catechins.



(+)-Epi-form (2S, 3S)



(-)-Epi-form (2R, 3R)

(-)-Epicatechin: R1=R2=H
(-)-Epigallocatechin: R1=OH, R2=H
(-)-Epicatechin gallate: R1=H, R2=X
(-)-Epigallocatechin gallate: R1=OH, R2=X

Figure 2. Chemical Structures of epimers of tea catechins.

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