ABSTRACT

Green tea has many health benefits, some have been proven and some may just be folklore. Just like black tea, it comes from the *Camellia sinensis* plant. Black tea is fermented and green tea is not (oolong tea is partly fermented). Some of the various chemical compounds in green tea: polyphenols and flavonoids; alkaloids, such as caffeine and theobromine; carbohydrates; tannins; minerals, such as F and Al. Green tea has higher amounts of these chemicals than black tea because the fermentation process alters their composition. Of all the different polyphenols, one seems to stand out above the rest. *Epigallocatechin gallate* is a very powerful antioxidant and is believed to be an important player in the therapeutic qualities of green tea.
Along with the natural fluoride found in tea, polyphenols and catechins are associated with killing bacteria that cause tooth decay, bad breath, and gum disease—the number one cause for tooth loss. Adding sugar, honey, or other sweeteners to tea however, may negate these benefits. Numerous researches have demonstrated that tea is beneficial in preventing cancer including prostate, pancreatic, breast, colorectal, esophageal, bladder, lung, and stomach. The catechins found in tea prevent cell mutation, deactivate certain carcinogens, and reduce the formation and growth of tumors. It’s thought that tea helps diminish bone loss through antioxidant and anti-inflammatory activity. Additionally, tea’s health-promoting properties are thought to suppress the breakdown of bone while increasing the amount and activity of bone building cells. Evidence is still inconclusive in this area, but it’s thought that the catechins found in tea, specifically green tea, create thermogenesis—the production of heat within the body which is related to burning calories. For people who are at-risk for developing cancer, it might be a worthwhile avenue to pursue. The strong antioxidant potential of catechins, and especially EGCG, are widely demonstrated in vitro and in animal studies. In addition, catechins possess antimutagenic, antidiabetic, anti-inflammatory, antibacterial and antiviral properties. Recent human studies suggest that green tea may contribute to reduce the risk of cardiovascular disease and has another beneficial effect on health. Although research of green tea is very promising, future studies considering dietetic, environmental and life style factors, are necessary to fully understand its contribution to human health.

**Keywords:** Polyphenols; Catechins; Antioxidant activity; EGCG; HDL; Cytotoxicity; LDL; Metalloenzymes; Glucose tolerance; Insulin sensitivity; Catechins

**INTRODUCTION**

Tea, a product made up from leaf and bud of the plant *Camellia sinensis*, is the second most consumed beverage in the world, well ahead of coffee, beer, wine and carbonated soft drinks (Rietveld and Wiseman, 2003, McKay and Blumberg, 2002). Originating from China, tea has gained the world’s taste in the past 2000 years. Depending on the manufacturing process, teas are classified into three major types: ‘non-fermented’ green tea (produced by drying and steaming the fresh leaves to inactivate the polyphenol oxidase and thus, non oxidation occurs); ‘semi-fermented’ oolong tea (produced when the fresh leaves are subjected to a partial fermentation stage before drying); and ‘fermented’ black and red (*Pu-Erh*) teas which undergo a post-harvest fermentation stage before drying and steaming, although the fermentation of black tea is due to an oxidation catalyzed by polyphenol oxidase, and that of *Pu-Erh* tea is attained by using microorganisms (Wu and Wei, 2002, Shu et al., 2003).

In vitro and animal studies, and clinical trials employing putative intermediary indicators of disease, particularly biomarkers of oxidative stress status, provide strong evidence that green tea polyphenols (GTP) may play a role in the risk and pathogenesis of several chronic
diseases, especially cardiovascular disease and cancer, and related pathologies. In addition, several studies suggest a beneficial impact of green tea intake on bone density, cognitive function, dental caries and kidney stones, among other effects (Shu et al., 2003 and Fung et al., 2003). Over the last years, numerous epidemiological and clinical studies have revealed several physiological responses to green tea which may be relevant to the promotion of health and the prevention or treatment of some chronic diseases. However, the results from epidemiological and clinical studies of the relationship between green tea consumption and human health are mixed.

For example, conflicting results between human studies may arise in part, from ignoring socioeconomic and lifestyle factors as well as by inadequate methodology to define tea preparation and intake (McKay and Blumberg, 2002, Shu et al., 2003, Vison et al., 1995). Green tea is a type of tea that is harvested and then quickly preserved. Whereas black tealeaves are allowed to oxidize after they are picked, green tealeaves are immediately heated to prevent oxidation. (Oxidation is a natural process. It's the same thing that happens when you slice an apple and it begins to turn brown and taste sweeter as it is exposed to oxygen).

Green tea is widely drunk in China, Japan, Korea and Morocco; oolong tea is popular in China and Taiwan (Fung et al., 2003, Xu et al., 2003). In USA, the 80% of tea consumed is black ice tea (Vison et al., 1995). Although health benefits have been attributed to green tea consumption since the beginning of its history, scientific investigations on this beverage and its constituents have been underway for less than three decades (Shu et al., 1995). The economic and social interest of tea is clear and its consumption is part of many people daily routine, as an everyday drink and as a therapeutic aid in many illnesses. Tea is the most consumed drink in the world after water. Green tea is a ‘non-fermented’ tea, and contains more catechins, than black tea or oolong tea. Catechins are in vitro and in vivo strong antioxidants. In addition, its content of certain minerals and vitamins increases the antioxidant potential of this type of tea. Since ancient times, green tea has been considered by the traditional Chinese medicine as a healthful beverage.

Recent human studies suggest that green tea may contribute to a reduction in the risk of cardiovascular disease and some forms of cancer, as well as to the promotion of oral health and other physiological functions such as anti-hypertensive effect, body weight control, antibacterial and antivirasic activity, solar ultraviolet protection, bone mineral density increase, anti-fibrotic properties, and neuroprotective power. Increasing interest in its health benefits has led to the inclusion of green tea in the group of beverages with functional properties. However, although all the evidence from research on green tea is very promising, future studies are necessary to fully understand its contributions to human health, and advise its regular consumption in Western diets, in which green tea consumption is nowadays limited and sporadic. A green tea extract is a herbal derivative
from green tea leaves (*Camellia sinensis*). Containing antioxidant ingredients – mainly green tea catechins (GTC) – green tea and its derivatives are sought-after amongst people who pursue health. In the West, green tea is nowhere near as popular as black tea. However, green tea is the most popular type of tea in Japan and in parts of China, and it is gaining popularity in the West due to its purported health benefits, which include high levels of antioxidants and vitamins. Tea consumption is also associated with a lower risk of heart disease and stroke. Research published by Harvard demonstrates that people who drink at least one cup of tea daily have a 44 % lower risk of heart attack. Some animal studies have demonstrated that tea also lowers cholesterol levels. For human to gain any health benefits, one would need to drink around 3-4 cups every day (without milk and/or sugar). Drinking as many as 4 cups a day may be necessary to reap the anti-cancer benefits. Drinking at least 3 cups a day is recommended to raise the body's metabolic rate. A study published this year by the European Journal of Nutrition found that consumption of one or more cups of green tea a day was significantly associated with decreasing the risk of tooth loss. In one study, participants who drank 4 cups of tea daily had remarkably higher fat oxidation (by 12 %) and burned an average of 67 additional calories a day. Herbs for Health magazine cites a Japanese report stating that men who drank10 cups of green tea per day stayed cancer-free for 3 years longer than men who drank less than 3 cups a day (there are ~240 - 320 mg of polyphenols in 3 cups of green tea). Meanwhile, a study by Cleveland's Western Reserve University (CWRU) concluded that drinking four or more cups of green tea per day could help prevent rheumatoid arthritis, or reduce symptoms in individuals already suffering from the disease. And Japanese scientists at the Saitama Cancer Research Institute (SCRI) discovered that there were fewer recurrences of breast cancer, and the disease spread less quickly, in women with a history of drinking 5 cups or more of green tea daily. Routine tea consumption, especially for > 10 years, has been associated with decreasing the risk of osteoporotic fractures. Foodstuff can be regarded as functional if it is satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond adequate nutritional effects in a way which is relevant to either the state of well-being and health or the reduction of the risk of a disease (Fung et al., 2003, Arts et al., 2000, Wang et al., 2003), so green tea has been proved to have functional properties and at present, its consumption is widely recommended.

Depending on where they were grown, how they were processed, when they were harvested, etc., good green teas can have a range of tastes. Common descriptors for good quality green tea include: sweet, bittersweet, nutty, vegetal, buttery, floral, swampy, fruity and oceanic. Steamed green teas tend to taste bittersweet (especially in the after taste), while other green teas tend to taste sweet. It is safe to drink green tea during pregnancy, as long as you don’t drink too much. That's because green tea contains caffeine. Experts recommend sticking to 200mg of caffeine a day, which is about three to four cups of green tea. Bear in mind that this limit includes all sources of caffeine. So you'll need to count coffee, cola, energy drinks, chocolates and soft drinks. Green tea has been thought to be a health-promoting drink, because it is rich in antioxidants. Antioxidants are chemical compounds that can help to prevent cell damage in our bodies. Research suggests that green tea may help protect you against a number of diseases, including heart disease, high blood pressure and some forms of cancer. Drinking green tea may also be good for your teeth and bones and strengthen your immune system.

However, drinking an extremely large amount of green tea can prevent you from absorbing folic acid properly. Folic acid is an important nutrient, particularly during the first 12 weeks of
your pregnancy. One small study suggests that babies can develop neural tube defects, such as spina bifida caused by the lack of folic acid, if their mums drink lots of green tea around the
time of conception. It’s unlikely you’d want to drink that much green tea every day so enjoy a mug or two if you want.

Green tea can also prevent your body from absorbing iron. So it is best not to drink tea with your meals.

<table>
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<th>Is any other food or drink reported to have as many health benefits as green tea? The Chinese have known about the medicinal benefits of green tea since ancient times, using it to treat everything from headaches to depression. In her book Green Tea: The Natural Secret for a Healthier Life, Nadine Taylor states that green tea has been used as a medicine in China for at least 4,000 years. Today, scientific research in both Asia and the west is providing hard evidence for the health benefits long associated with drinking green tea. For example, in 1994 the Journal of the National Cancer Institute published the results of an epidemiological study indicating that drinking green tea reduced the risk of esophageal cancer in Chinese men and women by nearly sixty %. University of Purdue researchers recently concluded that a compound in green tea inhibits the growth of cancer cells. There is also research indicating that drinking green tea lowers total cholesterol levels, as well as improving the ratio of good (HDL) cholesterol to bad (LDL) cholesterol.</th>
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**Green Tea and Human Health**

Green tea has been considered a medicine and a healthful beverage since ancient times. The traditional Chinese medicine has recommended this plant for headaches, body aches and pains, digestion, depression, detoxification, as an energizer and, in general, to prolong life. Green tea leaves contain three main components which act upon human health: xanthic bases (caffeine and theophylline), essential oils and especially, polyphenolic compounds. Caffeine acts mainly upon the central nervous system, stimulating wakefulness, facilitating ideas association and decreasing the sensation of fatigue (Henning et al., 2003). Some of the effects caused by caffeine are influenced by theophylline tea content. Theophylline induces psychoactive activity, it also has a slightly inotrope and vasodilator effect, and a much higher diuretic effect than caffeine. However, its most interesting effects can be seen at the broncho pulmonary and respiratory level. Theophylline causes a non-specific relaxation on the bronchial smooth muscle, and respiratory stimulation is also observed. Essential oils are in a great extent volatile and they evaporate from the beverage after some time, thus it is not very convenient to overextend the brewing time. Among their properties, the one of facilitating digestion must be highlighted (Fung et al., 2003, Hoshiyama et al., 2004). Green tea is the type of tea with the higher percentage of essential oils (Manach et al., 2004 Okushio et al., 2004). However, green tea has received a great deal of attention especially due to its content of polyphenols, which are strong antioxidants and present important biological properties. Numerous studies have also demonstrated that the aqueous extract of GTP possesses antimitogenic, antidiabetic, antibacterial, anti-inflammatory, and hypcholesterolemic properties (Kim et al., 2000, Higdon and Frei, 2003, Chow et al., 2001). Beneficial effects in oral diseases such as protection against dental caries, periodontal disease, and tooth loss (which may significantly affect a person’s overall health) have been also described. Among all GTP, catechins and gallic acid have been especially considered to be the main players in the beneficial effects on human health next detailed (Frei and Higdon, 2003, Klauing et al., 1999, Lambert and Yang, 2003, Yamamoto et al., 2003, Laurie et al., 2005, Siddiqui et al., 2004, D’Alessandro et al., 2003Yamamoto et al., 2004).
What Makes Green Tea So Special?

The secret of green tea lies in the fact it is rich in catechin polyphenols, particularly EGCG. Which is a powerful anti-oxidant: besides inhibiting the growth of cancer cells, it kills cancer cells without harming healthy tissue. It has also been effective in lowering LDL cholesterol levels, and inhibiting the abnormal formation of blood clots. The latter takes on added importance when you consider that thrombosis (the formation of abnormal blood clots) is the leading cause of heart attacks and stroke. Links are being made between the effects of drinking green tea and the "French Paradox." For years, researchers were puzzled by the fact that, despite consuming a diet rich in fat, the French have a lower incidence of heart disease than Americans. The answer was found to lie in red wine, which contains resveratrol, a polyphenol that limits the negative effects of smoking and a fatty diet. In a 1997 study, researchers from the University of Kansas determined that EGCG is twice as powerful as resveratrol, which may explain why the rate of heart disease among Japanese men is quite low, even though approximately seventy-five % are smokers. Why don't other Chinese teas have similar health-giving properties? Green, oolong, and black teas all come from the leaves of the *Camellia sinensis* plant. What sets green tea apart is the way it is processed. Green tea leaves are steamed, which prevents the EGCG compound from being oxidized. By contrast, black and oolong tea leaves are made from fermented leaves, which results in the EGCG being converted into other compounds that are not nearly as effective in preventing and fighting various diseases.

If you want to cut those extra inches around your tummy, switching to green tea could be a simpler way.

A new study shows that green tea extract increases the rate of calorie burning by the body. It reduces blood fat, cholesterol, bloatedness, detoxifies the body and suppresses untimely food cravings. Enabled with diuretic properties, it also eliminates excess water and thereby reduces excess weight. So the best way to get rid of that paunch is to have green tea along with the right amount of bodily exercise. Boosts exercise endurance: Antioxidants present in green tea extracts increase body's ability to burn fat as fuel which accounts for improved muscle endurance. It also enhances energy levels and boosts your metabolism. Reduces the risk of heart attack: Drinking green tea rapidly improves the health of body cells lining the blood vessels and also helps in lowering one’s risk for heart disease. The flavonoids present in this tea protect the heart by relaxing the blood vessels so blood can flow more easily. So, protect your heart and have green tea on a regular basis.

Fights against various cancers: The antioxidants in tea helps protect against a shipload of cancers, including breast, colon, colorectal, skin, lung, esophagus, stomach, small intestine, pancreas, liver, ovarian, prostate and oral cancers. Green tea extract is reported to induce cancer cell death and starve tumors by curbing the growth of new blood vessels that feed them. Hydration benefits: If you love drinking green tea then there is good news for you.
Contrary to common belief that tea dehydrates, green tea provides hydration benefits similar to water. Tea not only rehydrates as well as water does, it also has many other health benefits. Protection from harmful ultraviolet rays: The sun’s UV rays in summer act as a constant threat. Green tea is rich in antioxidants that scavenge harmful free radicals in the body according to researches. Also using green tea extracts along with your sunscreen could afford you the greatest level of sun protection. Green tea can do wonders to a person suffering from diabetes. Green tea apparently helps regulate glucose levels slowing the rise of blood sugar. It also triggers and stimulates insulin production and activates the functioning of pancreas to some extent. Blood sugar level in the body is also normalized and regularized by the use of green tea.

Polyphenols in green tea may help maintain the parts of brain that regulate learning and memory. So, regular consumption of green tea could help in prevention of degenerative and neurological diseases like Alzheimer’s and Parkinson’s. Antioxidants found in green tea fight free radicals thereby keeping a check on ageing and promoting longevity. Because it contains high levels of oligomeric proanthocyanidins one of the most powerful antioxidants, Green Tea is thought to help slow down the premature ageing process. Polyphenols and Flavonoids present in green tea boost the immune system to make the human body stronger in fighting various infections. Also, Vitamin C present in green tea keeps cold and flu away. New evidence is emerging that green tea can even help dieters. In November, 1999, the American Journal of Clinical Nutrition published the results of a study at the University of Geneva (UOG) in Switzerland. Researchers found that men who were given a combination of caffeine and green tea extract burned more calories than those given only caffeine or a placebo. Green tea can even help prevent tooth decay! Just as its bacteria-destroying abilities can help prevent food poisoning, it can also kill the bacteria that cause dental plaque.

Chemical and Biochemical Characteristics

Constituents
The cardinal antioxidative ingredient in the green tea extract is green tea catechins (GTC), which comprise four major epicatechin derivatives; namely, epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), and EGCG. Other components include three kinds of flavonoids, known as kaempferol, quercetin, and myricetin. A remarkably higher content of myricetin is detected in tea and its extracts than in many other plants, and this high concentration of myricetin may have some implications with the bioactivity of tea and its extracts. Caffeine may be excluded in green tea extracts in order to avoid side-effects; caffeine-free green tea extract supplements are now available.

Chemical properties
Green tea extract is 20x more antioxidant-active than Vitamin C. The main attribution is supposed to be EGCG. In alkaline solutions (pH > 8), GTC is rather unstable; in acidic solutions (pH < 4), however, GTC shows excellent stability. The stability in alkaline solutions varies between 4 components of GTC in green tea extracts. Recent study demonstrates that EGCG and EGC is more unstable than EC and ECG in a basic solution, giving an explanation to the fact that EGCG and EGC don’t circulate in the basic sodium phosphate buffer fluid of human body. In a high temperature environment, GTC is not stable: an epimerization change is likely to occur, because heating results in the conversion from EGCG to GCG. Thus it is considered inappropriate to infuse green tea or its extracts with overheated water (Lin et al., 2003 and Fernandez et al., 2002).
Biochemical properties

The biochemical properties of green tea extracts can be generally divided into four aspects—antioxidant, anticarcinogen, anti-inflammatory, and anti-radiation. Green tea extracts exhibit stronger antioxidant protection for human body than vitamin C and vitamin E. Scavenging effect of lipid free-radicals (one antioxidant property) of polyphenols in green tea extracts can be clearly observed in experiments. The ability of GTP in green tea extracts to eliminate lipid-derived free radicals is noticeably stronger (almost 50x) than that of ginkgo biloba extracts. Further investigations indicate that the boosting level of superoxide dismutase (SOD) and glutathione dismutase (GSHPx) may account for the inhibitory effect of GTC against lipid oxidation (rancidification). It should be mentioned that from the antioxidant perspective, green tea extracts are, generally speaking, more effective than black tea extracts due to the better preservation of catechins. Moreover, the anticarcinogenic property make the green tea extracts a hotspot in recent scientific researches. In many experiments, green tea extracts show inhibitory effects on cancer cells. In vitro assays, catechin and caffeine, which are main components in green tea extracts, block the cell cycle of cancer cells (cytotoxicity) and induce programmed cell death; in vivo, green tea extracts also inhibit prostatic carcinoma transplanted in nude mice. In addition, green tea extracts also contain a wide-ranged anti-inflammatory characteristics, so it may be helpful in treating chronic inflammatory states. The bactericidal activity against S. mutans is conspicuous in Japanese green tea extracts, and the maltose level in mouth is consistently lower after drinking tea. Therefore, green tea extracts may be effective in oral hygiene maintenance. Green tea extracts show anti-radiation properties on white rats in radioactive isotope experiments. Green tea extracts can enhance the effect of penicillin G against B. subtilis.

Green Tea and its Nutritional Value

Green tea consumption contributes to the overall daily fluid intake, and if sugar is not added, the calories intake is insignificant; besides, the caffeine intake is lower than in coffee, black tea or cola soft-drinks. In addition, green tea contribution to the dietary intake of antioxidant compounds (catechins and other phytochemical substances, certain vitamins as vitamin C, and minerals as Mn, Cr, Se, Zn) is very interesting to promote human health and well being, and more relevant than that other non-alcoholic beverages widely consumed. The Mn content is high, and tea is considered a rich source of this essential element. Manganese is a constituent of three metalloenzymes (i.e., arginase, pyruvate carboxylase, and Mn-superoxide dismutase) and it activates a large number of enzymes, such as glycosyl transferases, involved in mucopolysaccharide synthesis. Manganese deficiency can cause abnormalities in the metabolism of carbohydrates, glycosaminoglycans, and cholesterol. Chromium (Cr), selenium (Se) and zinc (Zn) play also an important role in human metabolism, and interest in these elements is increasing since there are reports relating trace element status and oxidative diseases. Chromium is involved in carbohydrate and lipid metabolism; the most frequent sign of Cr deficiency is altered glucose tolerance; this nutrient has been associated with diabetes and cardiovascular diseases. Beneficial effects of dietary Cr supplementation, particularly in groups in which deficiencies are frequent, have been reported. Selenium functions through selenoproteins, several of which are oxidant defense enzymes; Se acts as enzymatic cofactor of glutathione peroxidase in the elimination of peroxide radicals from the organism. Epidemiological studies have shown the possible effects of Se in the prevention and regression of cancer. Most Se is ingested in food, but food derived from vegetables has a variable Se content depending on the zone where they
have been cultivated. Zinc enzymes participate in a wide variety of metabolic processes including carbohydrate, lipid, and protein synthesis or degradation. This element is required for deoxyribonucleic and ribonucleic acid synthesis; it may also play a role in stabilizing plasma membranes. Zinc has been recognized as a cofactor of the superoxide dismutase enzyme, which is involved in protection against oxidative processes. Recently there has been a development of terminology and change in conceptual approaches towards setting nutrient recommendations from adequate to optimum nutrition. Regarding antioxidant minerals, the US Food and Nutrition Board (USFNB) has set an Adequate Intake for Mn at 2.3 and 1.8 mg/day for adult men and women, respectively, and a Tolerable Upper Intake Level (TUIL) at 11 mg/day for adults. Chromium Adequate Intake (CAI) values are 35 and 25 μg/day for young men and women, respectively. The Recommended Dietary Allowance for Zn is 8 and 11 mg/day for adult men and women, respectively; the TUIL for adults is 40 mg/day. The selenium Recommended Dietary Allowance (RDA) and TUIL for adults is 55 and 400 μg/day, respectively. In addition, green tea contains more vitamin C than black and oolong teas; the total content of vitamin C in tea leaves decreased during the manufacturing process of fermented teas however bibliographical data on vitamin C content in green tea are scarce. Due to the fact that green tea consumption in the occidental diets (except Morocco) is scarce and occasional, its contribution to the total antioxidant dietary intake is low. For example, it’s evaluated the contribution of the most consumed beverages to the antioxidant intake in the Spanish diet; the intake is estimated at 1623 mg of vitamin E and 598 mg of vitamin C by the ferric reducing ability of plasma (FRAP) procedure.

Tea only contributes to 3–5% of the total, whereas coffee and red wine are the main contributors. However, all the above mentioned properties of green tea, demonstrate that it can be considered an alternative to other widely consumed drinks, which have a higher content of energy and/or caffeine, and are richer in sugars, alcohol, CO₂, etc. Besides, drinking tea is an optimum way of fighting thirst due to its refreshing properties, its slightly bitter taste, its low binding effect and its fruity and agreeable smell. Its preparation is easy, uncomplicated and varied (lemon, mint, cinnamon, … can be added to it (Chow et al., 2001, Scalabert and Williamson, 2000, Leenen et al., 2000, Van et al., 1999, Hollman et al., 2001, Langley, 2000).

**Green Tea and its Composition**
Green tea chemical composition is complex: proteins (15–20% dry weight) whose enzymes constitute an important fraction; aminoacids (1–4% dry weight) such as teanine or 5-N-ethylglutamine, glutamic acid, tryptophan, glycine, serine, aspartic acid, tyrosine, valine,
leucine, threonine, arginine, lysine; carbohydrates (5–7% dry weight) such as cellulose, pectins, glucose, fructose, sucrose; lipids as linoleic and α-linolenic acids; sterols as stigmasterol; vitamins (B, C, E); xanthic bases such as caffeine and theophylline; pigments as chlorophyll and carotenoids; volatile compounds as aldehydes, alcohols, esters, lactones, hydrocarbons, etc.; minerals and trace elements (5% dry weight) such as Ca, Mg, Cr, Mn, Fe, Cu, Zn, Mo, Se, Na, P, Co, Sr, Ni, K, F and Al. Due to the great importance of the mineral presence in tea, many studies have been carried out to determine their levels in green tea leaves and their infusions. For example, Large variations of the mineral content have been observed (Al, Ca, Mg and Mn) in green tea from different origins. Fernández-Cáceres et al. determined the content of Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, Sr, Ti, and Zn in 46 tea samples, and no clear differences were found between mineral content of green and black teas. Shu et al. observed the great variations among different tea varieties in accumulating fluoride and aluminum. Fung et al. indicated that black tea had higher Al and F concentrations than green tea. Xu et al. reported that the content of Se in green teas was greatly increased by foliar application of Se-enriched fertilizers; moreover, the selenium-enriched green tea exhibited significantly higher antioxidant activity than regular green tea (Xu et al., 2004, Amanta et al., 2002, Embola et al., 2002, Pan et al., 2003, Kim et al., 2003, Skrzydlewsja et al., 2002a).

Polyphenols constitute the most interesting group of green tea leaf components, and in consequence, green tea can be considered an important dietary source of polyphenols, particularly flavonoids. Flavonoids are phenol derivatives synthesized in substantial amounts (0.5–1.5%) and variety (< 4000 identified), and widely distributed among plants. The United States Department of Agriculture (USDA) has recently published a Database for the Flavonoid Content of Selected Foods (FSDSF). The main flavonoids present in green tea include catechins (flavan-3-ols). The four major catechins are (−)-epigallocatechin-3-gallate (EGCG), that represents approximately 59% of the total of catechins; (−)-epigallocatechin (EGC) (19% approximately); (−)-epicatechin-3-gallate (ECG) (13.6% ~); and (−)-epicatechin (EC) (6.4% approximately). Green tea also contains gallic acid (GA) and other phenolic acids such as chlorogenic acid and caffeic acid, and flavonols such as kaempferol, myricetin and quercetin Lin et al., 2003. In black tea the polymerized catechins such as theaflavins and thearubigins predominate. Black and green teas both contain similar amount of flavonoids, however they differ in their chemical structure; green tea contains more catechins (simple flavonoids), while the oxidation undergone by the leaves in order to make black tea, converts these simple flavonoids into theaflavins and thearubigins (Fernandez et al., 2002).

The relative catechin content of green tea depends on how the leaves are processed before drying (a certain grade of fermentation and heating of tea leaves during the manufacturing process can result in polymerization of monophenolic compounds such as the catechins, leading to conformational changes and thus modifying its properties. Other factors influencing catechin content are the geographical location and growing conditions (soil, climate, agricultural practices, fertilizers), the type of green tea (e.g., blended, decaffeinated, instant), and the preparation of the infusion (e.g., amount of the product used, brew time, temperature). McKay and Blumberg reported that decaffeinating reduces slightly the tea catechin content; also, instant preparations and iced and ready-to drink teas present less content of catequins. The production of bottled green tea beverage has encountered a browning problem mainly caused by the oxidation of catechins (Cabrera et al., 2003).
Antioxidant Commotion

Green tea is considered a dietary source of antioxidant nutrients: green tea is rich in polyphenols (catechins and gallic acid, particularly), but it also contains carotenoids, tocopherols, ascorbic acid (vitamin C), minerals such as Cr, Mn, Se or Zn, and certain phytochemical compounds. These compounds could increase the GTP antioxidant potential. GTP present antioxidant activity \textit{in vitro} by scavenging reactive oxygen and nitrogen species and chelating redox-active transition metal ions; GTP can chelate metal ions like iron and copper to prevent their participation in Fenton and Haber-Weiss reactions (Singh et al, 2002, Nakachi et al., 2000, Ishikawa et al., 1997, Gomikawa and Ishikawa, 2002, Trevisanato and Kim, 2000, Yokozawa et al., 2002, Sesso et al., 1999, Peters et al., 2001McAnlis et al., 1998). They may also function indirectly as antioxidants through 1) inhibition of the redox-sensitive transcription factors; 2) inhibition of ‘pro-oxidant’ enzymes, such as inducible nitric oxide synthase, lipoxygenases, cyclooxygenases and xanthine oxidase; and 3) induction of antioxidant enzymes, such as glutathione-S-transferases and superoxide dismutases.

The antioxidant capacity of GTP has been assessed by several methods. For example, oxygen radical absorbance capacity (ORAC) assay found that green tea has a much higher antioxidant activity against peroxyl radicals than vegetables such as garlic, kale, spinach and Brussels sprouts. Using FRAP assay. It has been found that the total antioxidant capacity of green tea is more potent than that of black tea. Investigation of the antioxidant capacity of EGCG using erythrocyte membrane-bound, has been carried out. ATPases as a model, and the results indicated that EGCG is a powerful antioxidant that is capable of protecting erythrocyte membrane-bound ATPases against oxidative stress. Several studies have shown that EGCG can act \textit{in vitro} as an antioxidant by trapping proxyl radicals and inhibiting lipid peroxidation However, the antioxidant capacity of catechins determined \textit{in vitro} is dependent upon the type of assay employed and it does not reflect factors such as bioavailability and metabolism. The fact that catechins are rapidly and extensively metabolized emphasizes the importance of demonstrating their antioxidant activity \textit{in vivo} to better represent the physiological impact of green tea consumption. It has been reported that in order to determine whether or not GTP act as effective antioxidants \textit{in vivo}, future studies in animals and humans should employ sensitive and specific biomarkers of oxidative damage of lipids, proteins and DNA (Singh et al, 2002, Nakachi et al., 2000, Ishikawa et al., 1997, Gomikawa and Ishikawa, 2002, Trevisanato and Kim, 2000, Yokozawa et al., 2002, Sesso et al., 1999).

Nevertheless, a substantial number of human intervention studies with green tea demonstrate a significant increase in plasma antioxidant capacity in humans after consumption of moderate amounts (1–6 cups/day); there are also initial indications which show that the enhanced blood antioxidant potential leads to a reduced oxidative damage in macromolecules such as DNA and lipids (Peter et al., 2001). However, measurement of oxidative damage through biomarkers needs to be further established. It’s reported that the repeated consumption of green tea and encapsulated green tea extracts for one to four weeks has been demonstrated to decrease biomarkers of oxidative status. Furthermore, Klaunig et al.\textsuperscript{36} observed in a study with 40 male smokers in China and 27 men and women (smokers and non-smokers) in the United States, that oxidative DNA damage, lipid peroxidation, and free radical generation were reduced after consuming ~6 cups/day of green tea for seven days. Therefore, GTP may contribute to defenses against oxidative damages It’s suggested that the ability of green tea, consumed within a balanced controlled
diet, to improve overall the antioxidative status and to protect against oxidative damage in humans.

**Antimutagenic and Anticarcinogenic Potential**

Lifestyle-related diseases, including cancer, are also characterized as aging-related diseases, where aging may be the most potent causal factor. Therefore, prevention of lifestyle-related diseases will depend on slowing the aging process and avoiding the clinical appearance the disease. Dietary components that are capable of retarding cellular aging and inhibiting the growth of cancer cells without affecting the growth of normal cells are receiving considerable attention for the development of novel cancer-preventive approaches (Mitscher et al., 1997, Linke and LeGeros, 2003, Zhang and Kashket, 1998, Simpson et al., 2001). The role of green tea in protection against cancer has been supported by ample evidence from studies in cell culture and animal models. Animal studies have shown that green tea inhibit carcinogenesis of the skin, lung, oral cavity, esophagus, stomach, liver, kidney, prostate and other organs. In some studies, the inhibition correlated with an increase in tumor cell apoptosis and a decrease in cell proliferation. Today, green tea is accepted as a cancer preventive on the basis of numerous *in vitro*, *in vivo* and epidemiological studies. The Chemoprevention Branch of the National Cancer Institute (CBNCI) has initiated a plan for developing tea compounds as cancer-chemopreventive agents in human trials. The chemopreventive effects of green tea depend on:

(i) its antioxidant action;
(ii) the specific induction of detoxifying enzymes;
(iii) its molecular regulatory functions on cellular growth, development and apoptosis; and
(iv) a selective improvement in the function of the intestinal bacteria flora.

D’Alessandro et al. also indicated that an important aspect of cancer risk is related to inflammatory response; currently, anti-inflammatory agents are used in chemopreventive strategies. The inflammatory response involves the production of cytokines and proinflammatory oxidants such as hypochlorous acid and peroxynitrite produced by neutrophils and macrophages, respectively. These oxidants react with phenolic tyrosine residues on proteins to form chloro- and nitrotyrosine. Green tea catechins and soy isoflavones have also been shown to be chemopreventive; the aromatic nature of polyphenols makes them potential targets of hypochlorous acid and peroxynitrite, and these reactions may create novel pharmacophores at the site of inflammation. In addition, a major mechanism of the anticarcinogenic activity of green tea in animals is the impairment of the interaction of carcinogens with DNA leading to mutations. Nevertheless, the antimutagenic activity of green tea as well as its underlying mechanisms must be reviewed, and the role of GTP, the postulated bioactive components, and caffeine must be critically evaluated. EGCG from green tea especially imparts a growth inhibitory effect on cancer cells. EGCG possesses promising anticancer potential due to its antioxidant, antimutagenic and chemopreventive properties.

It has been indicated that the green tea catechins reduce the proliferation of breast cancer cells *in vitro* and decrease breast tumor growth in rodents. Furthermore, *in vitro* studies have demonstrated that the combination of EGCG and tamoxifen is synergistically cytotoxic to breast cancer cells; these results suggest that the catechins have significant potential in the treatment of breast cancer. It has been reported that the treatment with EGCG decreased cell viability at different stages studied (approx. 80% inhibition) in human breast carcinoma MCF-7 cells, but had no adverse effect on the growth of normal mammary cells. These authors found that this treatment inhibited telomerase activity (40–55%); telomerase
is elevated in >90% of breast carcinomas and therefore has received much attention as a target for breast cancer therapy and cancer diagnostic research. According to Wu et al. green tea drinkers showed a significantly reduced risk of breast cancer; compared to women who did not drink green tea regularly (i.e., less than once a month). Furthermore, there was a significant trend of decreasing risk with increasing amount of green tea intake. Two studies in Japanese women diagnosed with breast cancer indicate that green tea consumption is inversely associated with the rate of recurrence, especially in the early stages of breast cancer. It has also been reported that breast cancer is significantly less prevalent among Asian women, whose diets contain high intake of soy products and green tea. These authors suggested that dietary soy phytochemical concentrate plus green tea may be used as a potential effective dietary regimen for inhibiting (Lee, et al., 2004, Elmets et al., 2001, Katiyar, 2003, Dullo et al., 1999, Zheng et al., 2004, Dullo et al., 2000, Kovacs et al., 2004, Andreson et al., 2002, Yee, et al., 2002).

**Ultraviolet Safeguard**

Epidemiological, clinical and biological studies have shown that solar ultraviolet (UV) light is a complete carcinogen and repeated exposure can lead to the development of various skin disorders including melanoma and non-melanoma skin cancers. EGCG is considered to be a topic protector agent against some types of radiation, since it prevents skin disease, photoaging and potential cancer problems due to prolonged exposure. It seems that the rest of catechins also favour this action. Katiyar, 2003 indicated that topical treatment or oral consumption of GTP inhibits chemical carcinogen or UV radiation-induced skin carcinogenesis in different laboratory animal models. Topical treatment of GTP or ECGG and oral consumption of GTP resulted in prevention of UVB-induced inflammatory responses, immunosuppression and oxidative stress, which are the biomarkers of several skin disease conditions. Topical application of GTP and EGCG prior to exposure of UVB protects against UVB-induced local as well as systemic immune suppression in laboratory animals. This fact was associated with the inhibition of UVB-induced infiltration of inflammatory leukocytes. The in vitro and in vivo animal and human studies have suggested that GTP are photoprotective in nature, and can be used as pharmacological agents for the prevention of solar UVB light-induced skin disorders including photoaging, melanoma and non-melanoma skin cancers (Toda et al., 1989 Yam et al., 1997, Weber et al., 2003, Hirasawa et al., 2004).

**Credence be in Command of**

Obesity has increased at an alarming rate in recent years and is now a worldwide health problem. Current interest in the role of functional foods in weight control has focused on plant ingredients capable of interfering with the sympathoadrenal systems. The effects of long-term feeding with tea catechins have been widely studied, and some investigators suggest a potential role of green tea in body weight control. In addition, caffeine and theanine have been found to strengthen polyphenol effects on body weight control and fat accumulation in mice. In vitro studies with green tea extracts containing 25% of catechins have shown its capacity (in conditions similar to physiological ones) to significantly inhibit the gastric lipase, and in a lower extent also the pancreatic lipase. Thus, the lipolysis of long-chain triglycerides is reduced in a 37%. In vitro studies have also shown that green tea extracts interfere in the fat emulsification process, which occurs before enzymes act, and is indispensable for lipid intestinal absorption. Green tea also exhibits a fatty acid synthase inhibitor activity. In addition, green tea may have thermogenic properties not only attributable to its caffeine content, but to the joint-effect of caffeine and catechins. EGCG can act upon AMPc levels by increasing the energetic expenditure. Dulloo et al. using a
green tea extract rich in catechins and caffeine, concluded that green tea has thermogenic properties and promotes fat oxidation beyond than those explained by its caffeine content *per se*; the green tea extract may play a role in the control of body composition via sympathetic activation of thermogenesis, fat oxidation, or both.

Dulloo *et al.* indicated that the thermogenic properties of green tea could reside primarily in an interaction between its high content in catechins and the presence of caffeine with sympathetically released noradrenaline; since polyphenols are known to be capable of inhibiting catechol-o-methyl-transferase (the enzyme that degrades noradrenaline), and caffeine of inhibiting trancelular phosphodiesterases (enzymes that break down noradrenaline-induced AMPc). Such a synergistic interaction between polyphenols and caffeine to increase and prolong sympathetic stimulation of thermogenesis could be of value in assisting the management of obesity. Kovacs *et al.* reported that weight maintenance after 7.5% of body weight loss in overweight and moderately obese subjects was not affected by green tea treatment and that regular caffeine consumption affected weight maintenance in green tea treatment. According to some authors, green tea extracts (with a 25% of catechins content) may be advisable for overweight treatment in patients whose body mass index ranges between 25 and 29.9 kg/m², only if they do not present special sensitiveness to xantic bases. Wu *et al.* indicated that an inverse relationship may exit among regular green tea consumption, body fat percentage, and body fat distribution, especially for subjects who have maintained the habit of tea consumption for more than 10 years.

**Glucose Tolerance and Insulin Sensitivity**

Epidemiological observations and laboratory studies have shown that green tea has an effect on glucose tolerance and insulin sensitivity. It has been reported that green tea increases insulin activity, and that the predominant active compound is EGCG; these same authors indicated that addition of lemon to the tea did not affect the insulin-potentiating activity but the addition of 50 g of milk per cup decreased the insulin-potentiating activity similar to 90%. Wu *et al.* examined the effect of green tea supplementation on glucose tolerance and insulin sensitivity in rats; rats were divided into two groups: a control group was fed with standard chow and deionized distilled water, while the other was fed with the same chow diet but with green tea instead of water (0.5 g of lyophilized green tea powder dissolved in 100 mL of deionized distilled water); after 12 weeks of green tea supplementation, this group had lower fasting plasma levels of glucose, insulin, triglycerides, and free fatty acid than the control rats. In addition, GTP significantly increased basal and insulin-stimulated glucose uptake of adipocytes. Some investigations have also shown that EGCG does not only regulate the glucose level in blood, but also may rehabilitate damaged β-cells, which are responsible for producing insulin.

**Additional Upshots**

Green tea catechins have been reported to have antibacterial and antiviral activity. Green tea effectiveness against any type of diarrhoea and typhoid has been known in Asia since ancient times. Nowadays it is also known that it inhibits the reproduction and growth of many bacteria, among which some types of *Salmonella*, *Clostridium* or *Bacillus* can be named. Yee *et al.* reported an inhibitory effect of green tea catechins on *Helicobacter pylori* infection. Moreover, it has been shown that green tea has not effect over intestinal flora, which is a great advantage against other bactericide agents. Regarding its antiviral action, green tea is well known for preventing tobacco crops from being invaded by the ‘mosaic virus’ of tobacco. Recent investigations have confirmed that catechins completely inhibit its
growth and reproduction. Effects of green tea against the influenza virus, especially in its earliest stage, as well as against the Herpes simplex virus have also been demonstrated. Furthermore, Weber et al. observed that adenovirus infection is inhibited in vitro by green tea catechins. Researcher has indicated the antifungal activity of green tea catechins against Candida albicans, and the convenience of a combined treatment with catechins and lower doses of antimycotics; this treatment may help to avoid the side effects of antimycotics.

Green tea consumption has also been associated with increased bone mineral density, and it has been identified as an independent factor protecting against the risk of hip fractures; this fact has been considered independent of smoking status, hormone replacement therapy, coffee drinking and the addition of milk to tea. It has been observed the positive effects of green tea extracts and GTP on the proliferation and activity of bone cells. Wu and Wei indicated that bone mineral density may be influenced by several chemical compounds that are contained in tea extracts (i.e., caffeine, phytoestrogen, fluoride,...). Green tea polyphenols are known to have anti-fibrotic properties on the skin and on the arteries. The proliferation of hepatic stellate cells is closely related to the progression of liver fibrosis in chronic liver diseases, and EGCG has a potential inhibitory effect on the proliferation of these cells. Green tea strengthens the immune system action since green tea protects it against oxidants and radicals. It has been suggested that oral intake of green tea could act as an adjunctive therapy for prevention of transplant rejection in humans. The neuroprotective power of complex extracts rich in flavonoids like those of Ginkgo biloba, green tea or lyophilized red wine have been demonstrated in several studied. Recent studies suggest that GTP possibly protect against Parkinson’s and Alzheimer’s diseases and other neurodegenerative diseases. GTP have demonstrated neuroprotectant activity in cell cultures and animal models, such as the prevention of neurotoxin-induced cell injury; the biological effects of GTP may benefit patients with Parkinson’s disease, but further in-depth studies are needed to investigate the safety and effectiveness of green tea in humans and to determine the different mechanisms of green tea in neuroprotection (Borrelli et al., 2004).

In the same way, the neuroprotective effects of the theanine contained in green tea are a focus of considerable attention, and further studies are warranted (Weinreb et al., 2004, Thiagarajan et al., 2001).

Finally, the following health effects of green tea consumption have also been described. Green tea is considered to be useful for insect stings due mainly to its antiinflammatory effects and its capacity to stop bleeding.
Some studies have suggested an inverse association between green tea consumption and the risk of kidney stone formation. In addition, green and black tea extracts led to a retardation of the progression of lens opacity in rats with cataracts induced by selenite. It has been reported that green tea acts by preserving the antioxidant defense system of the lens. It’s indicated a beneficial effect of green tea in alcohol intoxication. Besides all the above mentioned properties, which have helped to the recognition of green tea as functional food by some authors it is not to forget its current use in the preparation of a variety of food, pharmaceutical preparations, dentifrices and cosmetics. This additional use is mainly due to its antioxidant activity, which makes it a natural, efficient and safe preservative.

**Food Additive and Deodorant Relevances**

Because of the high antioxidant activity of green tea extracts, they are hopefully to be used as a kind of innovative food additive to preserve pork, chicken meat, vegetable oil, fish oil and fish flesh, food emulsions and animal fat. This alternative antioxidant is suggested to be a healthier choice; a fairly successful instance may well be the application in Moon cake – the extracts both increase the shelf life and improve the flavor. In addition, green tea extracts are a promising solution to prevent apple juice and other foods from microbial contamination. Japanese scientists even have discovered that tea extracts can be developed as dyes that are not susceptible to microbial contamination and possess strong deodorant activity (Setiawan et al., 2001, Hoshiyama et al., 2002).

**CONCLUSION**

A study on the cancer-preventative qualities of green tea concluded that you could probably attain the desired level of polyphenols by drinking merely two cups per day. To date, the only negative side effect reported from drinking green tea is insomnia due to the fact that it contains caffeine. However, green tea contains less caffeine than coffee: there are ~ thirty to 60 mg of caffeine in 6 - 8 ounces of tea, compared to over one-hundred mg. in eight ounces of coffee. Green tea has been consumed in China and other Asian countries since ancient times in order to maintain and improve health. Nowadays, green tea is considered one of the most promising dietary agents for the prevention and treatment of many diseases and consequently, it is being studied extensively worldwide. Numerous studies in a variety of experimental animal models have demonstrated that aqueous extract of the mayor GTP designed as catechins (EGCG, EGC, ECG and EC) possess antioxidant, antimutagenic, anti-diabetic, anti-inflammatory, antibacterial and antiviral, and above all, cancer-preventive properties. Epidemiological studies suggest that consumption of green tea may have a protective effect against the development of several cancers. Preclinical studies of green tea and its polyphenolic components have demonstrated antimutagenic and anticarcinogenic activity, and inhibition of growth of tumor cell lines and animal tumor models, including cancer. Green tea may also have chemopreventive properties, and enhancement of chemotherapeutic agents has been demonstrated. In addition, several epidemiological studies with humans have demonstrated that regular green tea consumption has beneficial effects and it shows a significant rate of protection against the development of some oral diseases and against solar radiations. It also contributes to body weight control and to the rise of bone density as well as being able to stimulate the immune system. Furthermore, green tea consumption has been recently reported to act positively against neurodegenerative diseases such as Parkinson and Alzheimer disease. Catechin antioxidant power is also strengthened by the presence of other phenolic compounds,
vitamin C and minerals such as Cr, Mn, Se, and Zn, although specific data regarding this fact are still scarce. However, conflicting results between cohort studies conducted in different countries may also arise from confusion in the frequency and timing of intake, and the marked contrasts in the socioeconomic and lifestyle factors associated with tea drinkers. It is also important to consider the type of tea or its preparation (e.g., short time vs. long brewing time and hot tea vs. iced tea) due to the marked impact of these factors on polyphenol content and concentration. It is also important to draw attention on the need of further-in-depth studies on the nature and mechanisms of the active green tea compounds, on the bioavailability of the different catechins in humans, and appropriate dose levels to act as functional food. Since green tea beneficial health effects are being increasingly proved, it could be advisable to encourage the regular consumption of this widely available, tasty and inexpensive beverage as an interesting alternative to other drinks, which do not only show the beneficial effects of green tea, but are also more energetic, do contain more caffeine (green tea contains less caffeine than black tea, coffee or cola soft-drinks), are rich in additives and/or CO₂. While no single food item can be expected to provide a significant effect on public health, it is important to note that a modest effect between a dietary component and a disease having a major impact on the most prevalent causes of morbidity and mortality, i.e., cancer and heart disease, should merit substantial attention. Taking all this into account, it would be advisable to consider the regular consumption of green tea in Western diets.

REFERENCES


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