International Journal of Tea Science
Vol. 9(2–3) 2013

Drinking tea: Potential health benefits

Vimal Rarh,[a]* Pradeep Dwivedi,[b] and Vandana Sharma[b]

[a]R&D Department, Prajana Agro Associates (PAA), New Delhi, India
[b]Department of Chemistry, S.G.T.B. Khalsa College, University of Delhi, New Delhi, India

Abstract: The health benefits of tea have been linked to its polyphenols (Flavonoids) contents. These naturally occurring compounds are believed to have antioxidant properties, neutralizing free-radicals and damaging tissues in the body, genetic material and lipids, thereby contributing to on-set of chronic diseases. Tea drinking has been associated with oral health and bone health, and flavonoids may lower the risk of certain cancers by inhibiting oxidative damage in DNA from free-radical, promote programmed cell death or apoptosis, inhibit the rate of cell division thereby decreasing the growth of abnormal cells. Flavonoids may play a vital role in reducing the risk of cardiovascular diseases by decreasing lipid peroxidation and reducing the instances of heart attacks and strokes; compounds other than flavonoids have been shown to support the human immune system. In this communication, authors have tried to reiterate the benefits of drinking both black as well as green tea with focus on medicinal properties associated with them.

Keywords: *Antioxidants; Flavonoids; Eugenol; CHD; CVD; LDL' Immune Modulator; Anti flammatory; Adaptogens; Obesity; Cancer; Tulsi Tea; Green and Black Tea*

Introduction

The word "Tea" comes from a Chinese ideogram pronounced "Tay" in Amoy dialect and came into English language with the pronunciation changing to its present form in the 18th Century. In Cantonese, it is known as "*Chah*", a name which came in to use in India and USSR (Hill 473; Chadha and Ramchandran in Swmi and Kochhar). Tea is a beverage originated in China in 2700 BC, which is produced by steeping processed top leaves and buds of the tea plants in boiled water, but the tea leaves have probably been in use as medicine much earlier than that. China was the first country to cultivate tea. The cultivation of tea plant in Japan began in about 200 AD. The use of tea later spread to the other Asian Countries. The earliest suggested tea cultivation in India was in 1778. The tea plants growing wild in upper Assam were discovered in 1823. First experimental plantation was established at Gabroo Hill in Assam and first shipment of 8 chest of Indian tea reached London in 1839 and was auctioned at fancy prices. In south India, experiments on culturing of tea were started in 1832 in the Neelgiri. Tea was grown as subsidarory crop in the coffee estate of the Nelgiri. When coffee decline became clear in the last quarter of the 19th Century, tea cultivation was extended in Java, Sri Lanka, etc. Tea was introduced as a beverage to Europe in 1610 AD by the Dutch and by the first half of the 18th Century, tea was a popular beverage in Holland, England and the American Continental. Tea cultivation has been tried in most tropical and sub-tropical countries including the new world and is grown over a wide range of agro-climatic conditions from 20° south to 43° north latitude and is cultivated from all most sea level to about 2460 m.

Over the past few decades, scientists have taken a closer look at the potential health benefits of tea including herbal tea and have discovered that much of the folk lure about tea may actually be true. Recent researches, exploring the potential health benefits/ attributes of tea both green and black (oxidized by fermentation) including herbal tea, have shown that they may contribute positively to healthy phytonutrients, present substantially due to presence of important anti-oxidants necessary for the promotion of one's health and the prevention of chronic diseases like cancer. Anti-oxidants may inhibit the growth of cancer cells.

The health benefits of tea have been linked to polyphenols (Flavonoids) contents of tea; green tea contains between 30% and 40% of water extractable polyphenol while black tea (oxidized by fermentation) contains between 3% and 10%. The four primary polyphenols found in fresh tea leaves are epigallocatechin gallate, epigallocatechin, epicatechin gallate and epicatechin. In today's scenario, tea beverage is a common hospitality drink offered throughout the world to the guests. In fact, drinking tea has been suggested to be better than drinking water. Water is essentially replacing fluid. Tea replaces fluids and contains anti-oxidants as well (Nutrition Communication BBC).

*Author for correspondence. E-mail: Dr. Vimal Rarh (info@chicoree.in; vimalrarh@yahoo.com)

ISSN: 0972-544X (print)

How Tea Works in the Body

Tea contains flavonoids, naturally occurring compounds that are believed to have antioxidant properties. Antioxidants work to neutralize free radicals, which over time, damage important components in the body, such as genetic material and lipids, and contribute to onset of chronic diseases. Recent research has explored the potential health attributes of tea through studies in human and animal models through *in vitro* laboratory research. For the most part, studies conducted on green and black tea, which are both from the *Camellia sinensis* plant, have yielded similar results. Tea flavonoids may play important roles in various areas of health and may operate through a number of different mechanisms still being explored. Latest findings include: The antioxidant properties of tea flavonoids may play a role in reducing the risk of cardiovascular disease by decreasing lipid oxidation,[1] reducing the instances of heart attacks and stroke,[2,3] and may beneficially impact blood vessel function, an important indicator of cardiovascular health. Tea flavonoids may lower the risk of certain cancers by inhibiting the oxidative damages in DNA from free-radicals and some carcinogens.[1] Tea may also promote programmed cell death, or apoptosis,[4,5] and inhibit the rate of cell division, thereby decreasing the growth of abnormal cells.[1] Tea-drinking has been associated with oral health[6] and bone health.[7] Compounds in tea other than flavonoids have been shown to support the human immune system.[8]

Tea's Role in Coronary Heart Diseases (CHD) Risk Factor and Health

Human population studies have found that people who regularly consume three or more cups of black tea per day have a reduced risk of heart disease and stroke. Clinical studies suggest that the risk-reduction associated with black tea consumption may be due to improvement in some risk factors for cardiovascular disease, including cholesterol levels, blood vessel function and a reduction in oxidative damage. While researchers are still examining the various mechanisms by which tea flavonoids function, some studies suggest multifunctional mechanisms, meaning that several mechanisms work *in tandem* to collectively improve markers for cardiovascular health. Important areas of tea and cardiovascular health research include blood vessel and endothelial function, or the ability of the blood vessels to dilate to allow for proper blood flow, serum cholesterol levels and Low Density Lipoprotein (LDL) cholesterol oxidation. Each of these factors has impact on the risk of myocardial infractions (heart attacks), stroke and cardiovascular disease. Study findings in the area of tea and the reduction in cardiovascular disease risk include the following: The Zutphen Study, which assessed 805 male subjects over a period of 5 years, found that the incidence of fatal and non-fatal first myocardial infarction and mortality from stroke decreased significantly as intake of flavonoids, derived mainly from tea, increased in a dose-dependent manner.[2] A follow-up of this study found that high intake of flavonoids significantly lowered the risk of stroke in study participants.[3] A Harvard Study examined 340 men and women who had suffered heart attacks and compared them to matched control subjects. They found that those who drank a cup or more of Black Tea daily had a 44% reduction in the risk of heart attack compared to non-tea drinkers.[11] Another recent Harvard Study of 1,900 people found that those who consumed tea during the year prior to a heart attack were up to 44% more likely to survive over the 3–4 years following the event. Those who consumed fewer than 14 cups of tea per week experienced a 28% reduced death rate and those who consumed more than 14 cups of tea per week were found to have a 44% reduced death rate, as compared to non-tea drinkers.[12] A recent meta-analysis discovered that consumption of three cups of tea per day was associated with an estimated decrease of 11% in the incidence of myocardial infarction, or heart attack.[14]

Coronary Heart Disease (CHD)

A total of 3,430 men and women aged 30–70 years from the Saudi Coronary Artery Disease Study were examined, and 6.3% were found to have indications of coronary heart disease (CHD). The researchers found that those who drank more than six cups of tea per day (>480 mg) had significantly lower prevalence of CHD than non-tea drinkers, even after adjustment for risk factors like age and smoking.[9] The researchers also found that drinking six or more cups of black tea per day was associated with decreased serum cholesterol and triglyceride concentrations. Dutch researchers found that study participants who drank one to two cups of black tea daily had a 46% lower risk of severe aortic atherosclerosis, a strong indicator of cardiovascular disease. Those who drank more than four cups of tea a day had a 69% lower risk.[10]

Other CHD Risk Factors

A recent clinical study showed that short- and long-term consumption of black tea by subjects with coronary artery disease restored endothelial and blood vessel function to

levels similar to that of healthy subjects.[16] Endothelial function is the ability of the inner lining of blood vessels to dilate in response to increased blood flow. Another clinical study found that regular ingestion of tea resulted in a significant and consistent increase in endothelium-dependent and endothelium-independent blood vessel dilation.[17] Subjects with mild elevations in serum cholesterol or triglyceride concentrations consumed either five cups of black tea per day for four weeks or hot water. The researchers hypothesized that one mechanism for the apparent beneficial effects of tea on cardiovascular health could be this improved vasodilator function. An *in vitro* study found that green tea polyphenols inhibit the proliferation of aortic smooth muscle cells to prevent the development of atherosclerosis.[18] *In vitro* studies have shown that tea flavonoids protect low-density lipoproteins from oxidation, inhibit plasma lipid peroxidation, platelet aggregation and thromboxane formation—all factors important for maintaining a healthy circulatory system.[19,20] Studies in animals are promising, but human studies conducted to date on the effect of tea consumption on LDL oxidation are inconclusive.

Cholesterol

Researchers from the United States Department of Agriculture (USDA) studied the effect of tea on 15 mildly hypercholesterolemic adult participants following a "Step I" type diet moderately low in fat and cholesterol, as described by the American Heart Association and the National Cholesterol Education Program. After 3 weeks, researchers found that five servings of black tea per day reduced LDL ("bad") cholesterol by 11.1% and total cholesterol (TC) by 6.5% compared to placebo beverages.[15]

Tea's Role in Cancer Risk Reduction

Preliminary research suggests that the flavonoids in tea could play a role in human cancer risk reduction possibly by combating free-radical damage, inhibiting uncontrolled cell growth (cell proliferation), and by promoting programmed cell death (apoptosis). Leading scientists worldwide are actively studying these potential mechanisms and clinical trials and population studies are underway. More evidence is needed before any definitive conclusions can be drawn. A recent study found that smokers who drank four cups of decaffeinated Green Tea per day demonstrated a 31% decrease in biomarkers of oxidative DNA damage in white blood cells as compared to those who drank four cups of water. Oxidative DNA damage is implicated in the development of various forms of cancer.[21] Epigallocatechin gallate (EGCG) may protect normal cells from cancer-causing hazards as well as eliminate cancer cells though apoptosis. Researchers tested the potential anti-cancer benefits of Green Tea polyphenol, EGCG, in hamster cells and discovered that EGCG suppressed DNA changes and damage from carcinogens. EGCG also protected from further damage from the carcinogens and inhibited growth and multiplication of cancer cells.[22]

Digestive Cancers

An epidemiological study conducted by the University of North Carolina found consumption of the equivalent of 2.5 cups of tea per day or more was associated with a 60% drop in rectal cancer risk among Russian women from Moscow, as compared to women who drank relatively less than 1.2 cups of tea per day. Those women who drank approximately 1.2–2.5 cups of tea per day had a 52% reduction in the risk of rectal cancer.[23] Based on data from the NHANES I Follow-Up study (NHEFS), researchers found that tea drinkers had about a 42% reduced risk of colon cancer as compared to non-tea drinkers. Men who drank more than 1.5 cups of tea per day were found to have a 70% lower colon cancer risk.[24] Researchers who followed a group of over 34,000 postmenopausal healthy women aged 55–69 years for 12 years found that those consuming high levels of catechins experienced up to a 45% decrease in the instances of rectal cancer. Catechins are a class of flavonoids found in tea, fruits and vegetables. Catechins derived from tea were most strongly linked to a decrease in rectal cancer.[25] The Iowa Women's Study, which followed post-menopausal women between the age of 55 and 69 for 8 years, found that participants who drank two or more cups of tea per day had a 32% and 60% reduced risk of developing digestive and urinary tract cancers, respectively.[26] A study conducted with members of the Shanghai Cohort (18,244 men aged 45–64 years at recruitment with up to 12 years of follow-up) discovered a statistically significant inverse relationship between positive tea polyphenol levels (as measured in urine) and gastric cancer.[27] A large population-based case-control study found an inverse relationship between Green Tea consumption and the risk of colon, rectal and pancreatic cancer. Male participants, who drank the equivalent of 4.5 servings of tea per day, had an 18% decrease in colon cancer risk and 28% decreased risk of rectal cancer. Female participants, who drank 3 servings of tea per day, were observed to have a decreased risk of colon and rectal cancer by 33%

and 43%, respectively. Risk of pancreatic cancer was also reduced in both men and women by 37% and 47%, respectively.[28] Researchers examined whether a combination of two compounds known to exhibit anti-cancer activity, Green Tea polyphenol, EGCG, and Sulindac (a non-steroidal anti-inflammatory drug), would work synergistically to prevent colon cancer carcinogenesis in rats. Findings suggested that EGCG and sulindac worked together to suppress pre-cancerous lesion formation by enhancing programmed cell death, or apoptosis.[29] Researchers sought to investigate the effect of Black Tea polyphenols (BTP) on induced DNA damage to colon mucosa in an animal model. Findings suggest that induced DNA damage to the colon mucosa is prevented by consumption of Black Tea polyphenols.[30] Major compounds of Green and Black Tea, EGCG and theaflavins respectively, are known to inhibit proteins which are closely associated with tumour growth and metastasis. These polyphenols exhibited apoptosis-inducing activity for human colon cancer cell lines.[31]

Researchers in Taiwan discovered a link between EGCG and cancer risk reduction. The researchers found that the Green Tea polyphenol inhibited proliferation of the cancer cells by inducing cell death and blocking cell cycle progression.[32] According to a study conducted by the University of Arizona, participants who drank iced Black Tea and citrus peel had a 42% reduced risk of skin cancer.[33] Hot Black Tea consumption is associated with a significantly lower risk of squamous cell carcinoma (SCC), a form of skin cancer; tea concentration (strength), brewing time and temperature all influence the potential protective effects of hot Black Tea on SCC.[34] Oral consumption of Green or Black Tea decreased the number of tumours in mice, following exposure to UV radiation.[35] Green Tea polyphenols may have cancer preventive potential, especially in the case of solar UV-induced cancer.[36] Research suggests that compounds in Green Tea may protect skin from ultraviolet (UV) radiation-induced damage when applied topically.[37] Topical treatment of Green Tea polyphenols on human skin prior to UV exposure inhibited indicators of DNA damage, thus inhibiting photocarcinogenesis, or UV-induced skin cancer.[38] Experiments that show that administration of Green Tea, Black Tea or specific flavonoids in tea inhibited the growth of established nonmalignant and malignant skin tumours in tumour-bearing mice. In addition, oral administration of Black Tea inhibited DNA synthesis and enhanced cell death (apoptosis) in both nonmalignant and malignant tumours in tumour-bearing mice.[39]

Oral Cancer

A human intervention trial the effect of treating superficial precancerous lesions (leukoplakia) in the mucosal lining of the mouth with a mixed-tea product. After the 6-month trial, partial regression of the lesions was observed in 37.9% of the group treated with tea as compared to only 10% of those treated with a placebo.[40] Researchers examined the effects of tea and curcumin, a spice and food-colouring agent, on oral cancer in hamsters. Hamsters were treated with a cancer-causing solution topically inside the cheek three times a week for 6 weeks. Two days after the last treatment of the solution, the hamsters were given Green Tea as drinking fluid or curcumin applied topically three times per week, the combination of Green Tea and curcumin treatment, or no treatment for 18 weeks. At the end of this period, the scientists observed that the combination of tea and curcumin significantly decreased the number of visible tumours and tumour volume. Furthermore, tea alone and in combination with curcumin increased cancer cell death, or apoptosis.[41] Studies comparing groups of mice treated with a tobacco-specific carcinogen and receiving either water or water enriched with tea-derived antioxidants found that the tea-fed mice developed 24% fewer lung tumours and the average size of the tumours was 38% smaller as compared to the water-fed mice.[42,43]

Ovarian Cancer

A case-control study conducted in China, which employed 254 patients with histologically confirmed epithelial ovarian cancer and 652 control subjects, determined tea consumption based on a validated questionnaire and found that, after accounting for demographic, lifestyle and familial factors, ovarian cancer risk declined with increasing frequency and duration of overall tea consumption.[44]

Tea's Role in Immune Function

Researchers from Brigham and Women's Hospital and Harvard University recently published novel new data indicating that tea contains a component that can help the body ward off infection and disease and that tea-drinking may strengthen the immune system. Researchers have identified a substance in tea, L-theanine, which primes the immune system in fighting infection, bacteria, viruses and fungi. A subsequent human clinical trial showed that certain immune cells of participants who drank five cups of Black Tea a day for 2–4 weeks secreted up to four times more interferon, an important part of the body's

immune defense, than at baseline. Consumption of the same amount of coffee for the same duration had no effect on interferon levels. According to the authors, this study suggests that drinking Black Tea provides the body's immune system with natural resistance to microbial infection.[45]

Tea's Role in Oral Health

Tea may also contribute to oral health. The flavonoids in tea may inhibit the plaque-forming ability of oral bacteria, and the fluoride in tea may support healthy tooth enamel.[46,47] A recent study conducted at the New York University Dental Center examined the effects of Black Tea extract on dental caries formation in hamsters. Compared to those who were fed water with their food, hamsters which were fed water with Black Tea extract developed up to 63.7% fewer dental caries.[48]

Tea and Obesity

Preliminary research suggests that drinking tea may have effects on body weight, fat accumulation and insulin activity. While it may be premature to draw firm conclusions based on early research, key findings include the following: Green Tea extract was found to significantly increase 24 hr energy expenditure and fat oxidation in healthy men.[49] After 3 months of consumption of green tea extract by moderately obese patients, it has been shown that body weight decreased by 4.6% and waist circumference decreased by 4.48%.[50] Researchers examined mice that were fed either a low-fat diet, high-fat diet or high-fat diet supplemented with 0.1–0.5% tea catechins for 11 months. The scientists then measured body weight, fat tissue mass and liver fat content and discovered that supplementation with tea catechins resulted in a significant reduction of high-fat diet-induced body weight gain and visceral and liver fat accumulation.[51]

Researchers at the Unites States Department of Agriculture (USDA) conducted a study to examine the insulin-enhancing properties of tea and its components. An *in vitro* test using a fat cell assay found that tea, as normally consumed, increased insulin activity >15-fold. Green, Black and Oolong Tea all yielded insulin-increasing results. The researchers separated the components of the tea using a high-performance liquid chromatography and discovered that several known compounds found in tea were shown to enhance insulin, helping cells recognize and respond to the hormone—the greatest activity was elicited by EGCG followed by epicatechin gallate, tannins, and theaflavins.[52]

Tea and Reduced Risk of Kidney Stones

Increased intake of fluids is routinely recommended for people who have had kidney stones to reduce the likelihood of recurrence. A recent study that followed 81,093 women for 8 years suggests that beverage choice may also affect kidney stones development. The study found that for each eight-ounce cup of tea consumed daily by female participants with no previous history of kidney stones, the risk of developing stones appeared to be lowered by 8%.[53] An earlier study of 45,289 men reported a similar relationship, suggesting that for each eight-ounce serving of tea consumed daily, a 14% decrease in risk of stone development was observed.[54]

Tea and Reduced Risk of Osteoporosis

Although high caffeine intake has been suggested to be a risk factor for reduced bone mineral density (BMD), research indicates that drinking tea does not negatively affect BMD, and while it may be too soon to state definitively, findings suggest that tea may even play a role in bone health. A study published recently in the *American Journal of Clinical Nutrition* found that older women who drank tea had higher BMD measurements than those who did not drink tea. The researchers concluded that the flavonoids in tea might influence bone mass and that tea drinking may reduce the risk of osteoporosis.[55] Another recent study found that habitual tea-drinking was seen to have a significant beneficial effect on the BMD of adults (30 years and older), especially in those who had been habitual tea-drinkers for 6 or more years.[56] Studies in adolescent[57] and postmenopausal women[58] found no relationship between caffeine intake and bone health.

Six phenolic compounds isolated from Basil, including eugenol, rosmarinic acid, apigenin and three other flavonoids showed good-to-excellent antioxidant activity *in vitro*.[63] Ursolic acid isolated from Basil protected against lipid peroxidation in liver microsomes *in vitro*.[64] Chemoprevention refers to protective activity against chemically induced malignant tumours. Oral treatment with very high doses of Basil leaf extract for 15 days resulted in significantly elevated activities of enzymes (cytochrome P-450, cytochrome b5, aryl hydrocarbon hydroxylase and glutathinone S-tranferase) involved in the detoxification of carcinogens and mutagens.[74]

Conclusions

The potential health benefits attributes of both Black and Green Tea including Herbal Tea have been shown and suggested that they may contribute positively to healthy

phytonutrients present substantially due to presence of important anti-oxidants. Health benefits have been shown for those who take three or more cups of green or black tea per day face reduced risk of heart disease and stroke, decreased chances of coronary artery disease. It has also been shown that total cholesterol (TC) and LDL ("bad") cholesterol can be reduced. There is reduced risk of developing various types of cancers like colon cancer, rectal cancer, digestive and urinary tract cancers, gastric cancer.

Acknowledgements

Authors are thankful to the "International Society of Herbal Medicine" for providing necessary data and feed-back for completing this study. They are also thankful to different libraries of CSIR, Delhi, Government of India, and Department of Chemistry, Delhi University, New Delhi, India.

References

1. Weisburger JH. 1999. Tea and health: The underlying mechanisms. *Proc Soc Exp Biol Med* 220: 271–275.
2. Hertog MGL, Feskens EJM, Hollman PCH, *et al.* 1993. Dietary antioxidant flavonoids and risk of coronary disease: The Zutphen Elderly Study. *Lancet* 342: 1007–1011.
3. Keli SO, Hertog MGL, Feskens EJM, & Kromhout D. 1996. Dietary flavonoids, antioxidant vitamins, and incidence of stroke. *Arch Intern Med* 156: 637–642.
4. Duffy SJ, Keaney JF Jr, Holbrook M, Gokce N, Swerdloff PL, Frei B, & Vita JA. 2001. Short- and long-term black tea consumption reverses endothelial dysfunction in patients with coronary artery disease. *Circulation* 104: 151–156.
5. Isemura M, Saeki K, Kimura T, Hayakawa S, Minami T, & Sazuka M. 2000. Tea catechins and related polyphenols as anti-cancer agents. *Biofactors* 13(1–4):81–85.
6. Sarkar S, Sett P, Chowdhury T, & Ganguly DK. 2000. Effect of black tea on teeth. *J Indian Soc Pedod Prev Dent* 18: 139–140.
7. Hegarty VM, May HM, & Khaw K-T. 2000. Tea drinking and bone mineral density in older women. *Am J Clin Nutr* 71: 1003–1007.
8. Kamath AB, Wang L, Das H, Li L, Reinhold VN, & Bukowski JF. 2003. Antigens in tea-beverage prime human Vgamma 2Vdelta 2 T cells *in vitro* and *in vivo* for memory and nonmemory antibacterial cytokine responses. *Proc Natl Acad Sci USA* 13; 100(10): 6009–6014.
9. Hakim IA, Alsaif MA, Alduwaihy M, Al-Rubeaan K, Al-Nuaim AR, & Al-Attas OS. 2003. Tea consumption and the prevalence of coronary heart disease in Saudi adults: Results from a Saudi national study. *Prev Med* 36(1): 64–70.
10. Geleijnse JM, Launer LJ, Hofman A, Pols HAP, & Witteman JCM. 1999. Tea flavonoids may protect against atherosclerosis: The Rotterdam Study. *Arch Intern Med* 159: 2170–2174.
11. Sesso HD, Gaziano JM, Buring JE, & Hennekens CH. 1999. Coffee and tea intake and the risk of myocardial infarction. *Am J Epidemiol* 149: 162–167.
12. Mukamal KJ, Maclure M, Muller JE, Sherwood JB, & Mittleman MA. 2002. Tea consumption and mortality after acute myocardial infarction. *Circulation* 105: 2476.
13. Geleijnse JM, Launer LJ, Van der Kuip DA, HofmanA, & Witteman JC. 2002. Inverse association of tea and flavonoid intakes with incident myocardial infarction: The Rotterdam Study. *Am J Clin Nutr* 75(5): 880–886.
14. Peters U, Poole C, & Arab L. 2001. Does tea affect cardiovascular disease? A meta-analysis. *Am J Epidemiol* 154(6): 495–503.
15. Davies MJ, Judd JT, Baer DJ, Clevidence BA, Paul DR, Edwards AJ, Wiseman SA, Muesing RA, & Chen SC. 2003. Black tea consumption reduces total and LDL cholesterol in mildly hypercholesterolemic adults. *J Nutr* 133(10): 3298S–3302S.
16. Duffy SJ, Keaney JF Jr, Holbrook M, Gokce N, Swerdloff PL, Frei B, & Vita JA. Short- and long-term black tea consumption reverses endothelial dysfunction in patients with coronary artery disease. *Circulation* 104: 151–156.
17. Hodgson JM, Puddey IB, Burke V, Watts GF, & Beilin LJ. 2002. Regular ingestion of black tea improves brachial artery vasodilator function. *Clin Sci* 102(2): 195–201.
18. Hofmann CS & Sonenshein GE. 2003. Green tea polyphenol epigallocatechin-3 gallate induces apoptosis of proliferating vascular smooth muscle cells via activation of p53. *FASEB J* 17(6): 702–704. Epub 2003 Feb. 05.
19. Ishikawa T, Suzukawa M, Ito T, Yoshida H, Ayaori M, Nishiwaki M, Yonemura A, Hara Y, & Nakamura H. 2003. Effect of tea flavonoid supplementation on the susceptibility of low-density lipoprotein to oxidative modification. *Am J Clin Nutr* 66: 261–266.
20. Vinson JA, Dabbagh YA, Serry MM, & Jang J. 1995.

Plant flavonoids, especially tea flavonols, are powerful antioxidants using an *in vitro* oxidation model for heart disease. *J Agric Food Chem* 43: 2800–2802.

21. Hakim IA, Harris RB, Brown S, Chow HH, Wiseman S, Agarwal S, & Talbot W. 2003. Effect of increased tea consumption on oxidative DNA damage among smokers: A randomized controlled study. *J Nutr* 133(10): 3303S–3309S.
22. Roy M, Chakrabarty S, Sinha D, Bhattacharya RK, & Siddiqi M. 2003. Anticlastogenic, antigenotoxic and apoptotic activity of epigallocatechin gallate: A green tea polyphenol. *Mutat Res* 523–524: 33–41.
23. Dora I, Arab L, Martinchik A, Sdvizhkov A, Urbanovich L, & Weisgerber U. 2003. Black tea consumption and risk of rectal cancer in Moscow population. *Ann Epidemiol* 13(6): 405–411.
24. Su LJ & Arab L. 2002. Tea consumption and the reduced risk of colon cancer – Results from a national prospective cohort study. *Public Health Nutr* 5(3): 419–425.
25. Arts IC, Jacobs DR Jr, Gross M, Harnack LJ, & Folsom AR. 2002. Dietary catechins and cancer incidence among postmenopausal women: the Iowa Women's Health Study (United States). *Cancer Causes Control* 13(4): 373–382.
26. Zheng W, Doyle TJ, Kushi LH, *et al.* 1996. Tea consumption and cancer incidence in a prospective cohort study of postmenopausal women. *Am J Epidemiol* 144: 175–181.
27. Sun CL, Yuan JM, Lee MJ, Yang CS, Gao YT, Ross RK, & Yu MC. 2002. Urinary tea polyphenols in relation to gastric and esophageal cancers: A prospective study of men in Shanghai, China. *Carcinogenesis* 23(9): 1497–1503.
28. Ji BT, Chow WH, Hsing AW, McLaughlin JK, Dai Q, Gao YT, Blot WJ, & Fraumeni JF Jr. 1997. Green tea consumption and the risk of pancreatic and colorectal cancers. *Int J Cancer* 70(3): 255–288.
29. Ohishi T, Kishimoto Y, Miura N, Shiota G, Kohri T, Hara Y, Hasegawa J, & Isemura M. 2002. Synergistic effects of (–)-epigallocatechin gallate with sulindac against colon carcinogenesis of rats treated with azoxymethane. *Cancer Lett* 177(1): 49–56.
30. Lodovici M, Casalini C, De Filippo C, Copeland E, Xu X, Clifford M, & Dolara P. 2000. Inhibition of 1,2-dimethylhydrazine-induced oxidative DNA damage in rat colon mucosa by black tea complex polyphenols. *Food Chem Toxicol* 38(12): 1085–1088.
31. Isemura M, Saeki K, Kimura T, Hayakawa S, Minami T, & Sazuka M. Tea catechins and related polyphenols as anti-cancer agents. *Biofactors* 13(1–4): 81–85.
32. Kuo PL & Lin CC. 2003. Green tea constituent (–)-epigallocatechin-3-gallate inhibits Hep G2 cell proliferation and induces apoptosis through p53-dependent and Fas-mediated pathways. *J Biomed Sci* 10(2): 219–227.
33. Hakim IA & Harris RB. 2001. Joint effects of citrus peel use and black tea intake on the risk of squamous cell carcinoma of the skin. *BMC Dermatol* 1(1): 3. Epub 2001 Aug. 01.
34. Hakim IA, Harris RB, & Weisgerber UM. Tea intake and squamous cell carcinoma of the skin: Influence of type of tea beverages. *Cancer Epidemiol Biomarkers Prev* 9(7): 727–731.
35. Lu YP, Lou YR, Lin Y, Shih WJ, Huang MT, Yang CS, & Conney AH. Inhibitory effects of orally administered green tea, black tea, and caffeine on skin carcinogenesis in mice previously treated with ultraviolet B light (high-risk mice): Relationship to decreased tissue fat. *Cancer Res* 61(13): 5002–5009.
36. Ahmad N & Mukhtar H. 2001. Cutaneous photochemoprotection by green tea: A brief review. *Skin Pharmacol Appl Skin Physiol* 14(2): 69–76.
37. Katiyar SK, Bergamo BM, Vyalil PK, & Elmets CA. 2001. Green tea polyphenols: DNA photodamage and photoimmunology. *J Photochem Photobiol B* 65(2–3): 109–114.
38. Katiyar SK, Perez A, & Mukhtar H. 2000. Green tea polyphenol treatment to human skin prevents formation of ultraviolet light B-induced pyrimidine dimers in DNA. *Clin Cancer Res* 6(10): 3864–3869.
39. Conney AH, Lu Y-P, Lou Y-R, Xie J-G, & Huang M-T. Inhibitory effect of green and black tea on tumor growth. *Proc Soc Exp Biol Med* 220: 229–233.
40. Li N, Zheng S, Han C, & Chen J. 1999. The chemoprotective effects of tea on human oral precancerous mucosa lesions. *Proc Soc Exp Biol Med* 220: 218–224.
41. Li N, Chen X, Liao J, Yang G, Wang S, Josephson Y, Han C, Chen J, Huang MT, & Yang CS. Inhibition of 7,12-dimethylbenz[a]anthracene (DMBA)-induced oral carcinogenesis in hamsters by tea and curcumin. *Carcinogenesis* 23(8): 1307–1313.
42. Yang G, Liu Z, Seril DN, *et al.* Black tea constituents, theaflavins, inhibit 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK-induced lung tumorigenesis in A/J mice. *Carcinogenesis* 18: 2361–2365.

43. Yang G, Wang Z-Y, Kim S, *et al.* 1997. Characterization of early pulmonary hyperproliferation and tumor progression and their inhibition by black tea in a 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone-induced lung tumorigenesis model with A/J mice. *Cancer Res* 57: 1889–1894.
44. Zhang M, Binns CW, & Lee AH. 2002. Tea consumption and ovarian cancer risk: A case-control study in China. *Cancer Epidemiol Biomarkers Prev* 11(8): 713–718.
45. Kamath AB, Wang L, Das H, Li L, Reinhold VN, & Bukowski JF. 2003. Antigens in tea-beverage prime human Vgamma 2Vdelta 2 T cells *in vitro* and *in vivo* for memory and nonmemory antibacterial cytokine responses. *Proc Natl Acad Sci USA* 100(10): 6009–6014. Epub 2003 Apr. 28.
46. Sarkar S, Sett P, Chowdhury T, & Ganguly DK. 2000. Effect of black tea on teeth. *J Indian Soc Pedod Prev Dent* 18: 139–140.
47. Yu H, Oho T, & Xu LX. 1995. Effects of several tea components on acid resistance of human tooth enamel. *J Dent* 13: 101–105.
48. Linke HA & LeGeros RZ. 2003. Black tea extract and dental caries formation in hamsters. *Int J Food Sci Nutr* 54(1): 89–95.
49. Dulloo AG, Duret C, Rohrer D, Girardier L, Mensi N, Fathi M, Chantre P, & Vandermander J. 1999. Efficacy of a green tea extract rich in catechin polyphenols and caffeine in increasing 24-h energy expenditure and fat oxidation in humans. *Am J Clin Nutr* 70(6): 1040–1045.
50. Chantre P & Lairon D. 2002. Recent findings of green tea extract AR25 (Exolise) and its activity for the treatment of obesity. *Phytomedicine* 9(1): 3–8.
51. Murase T, Nagasawa A, Suzuki J, Hase T, & Tokimitsu I. 2002. Beneficial effects of tea catechins on diet-induced obesity: Stimulation of lipid catabolism in the liver. *Int J Obes Relat Metab Disord* 26(11): 1459–1464.
52. Anderson RA & Polansky MM. 2002. Tea enhances insulin activity. *J Agric Food Chem* 50(24): 7182–7186.
53. Curhan GC, Willett WC, Speizer FE, & Stampfer MJ. Beverage use and risk of kidney stones in women. *Ann Intern Med* 128: 534–540.
54. Curhan GC, Willett WC, Rimm EB, Spiegelman D, & Stampfer MJ. 1996. Prospective study of beverage use and the risk of kidney stones. *Am J Epidemiol* 143: 240–247.
55. Hegarty VM, May HM, & Khaw K-T. 2000. Tea drinking and bone mineral density in older women. *Am J Clin Nutr* 71: 1003–1007.
56. Wu CH, Yang YC, Yao WJ, Lu FH, Wu JS, & Chang CJ. 2002. Epidemiological evidence of increased bone mineral density in habitual tea drinkers. *Arch Intern Med* 162(9): 1001–1006.
57. Lloyd T, Rollings NJ, Kieselhorst K, Eggli DF, & Mauger E. 1998. Dietary caffeine intake is not correlated with adolescent bone gain. *J Am Coll Nutr* 17: 454–457.
58. Lloyd T, Johnson-Rollings N, Eggli DF, Kieselhorst K, Mauger EA, & Cusatis DC. 2000. Bone status among postmenopausal women with different habitual caffeine intakes: A longitudinal investigation. *J Am Coll Nutr* 19: 256–261.
59. Godhwani S, Godhwani JL, & Vyas DS. 1987. *Ocimum sanctum*: An experimental study evaluating its anti-inflammatory, analgesic and antipyretic activity in animals. *J Ethnopharmacol* 21: 152–163.
60. Godhwani S, Godhwani JL, & Vyas DS. 1988. *Ocimum sanctum* – A preliminary study evaluating its immunoregulatory profile in albino rats. *J Ethnopharmacol* 24: 193–198.
61. Rai V, Iyer U, & Mani UV. 1997. Effect of Tulasi (*Ocimum sanctum*) leaf powder supplementation on blood sugar levels, serum lipids and tissue lipids in diabetic rats. *Plant Foods Human Nutr* 50: 9–16.
62. Devi PU, Bisht KS, & Vinitha M. 1998. A comparative study of radioprotection by Ocimum flavonoids and synthetic aminothiol protectors in the mouse. *Br J Radiol* 71: 782–784.
63. Kelm MA, Nair MG, Strasburg GM, & DeWitt DL. 2000. Antioxidant and cyclooxygenase inhibitory phenolic compounds from *Ocimum sanctum* Linn. *Phytomedicine* 7: 7–13.
64. Balanehru S & Nagarajan B. 1991. Protective effect of oleanolic acid and ursolic acid against lipid peroxidation. *Biochem Int* 24: 981–990.
65. Mediratta PK, Dewan V, Bhattacharya SK, Gupta VS, Maiti PC, & Sen P. 1988. Effect of *Ocimum sanctum* Linn. on humoral immune responses. *Ind J Med Res* 87: 384–386.
66. Bhargava KP & Singh N. 1981. Anti-stress activity of *Ocimum sanctum* Linn. *Ind J Med Res* 73: 443–451.
67. Mandal S, Das DN, De K, *et al. Ocimum sanctum* Linn – A study on gastric ulceration and gastric secretion in rats. *Ind J Physiol Pharmacol* 37: 91–92.
68. Sembulingam K, Sembulingam P, & Namasivayam A. 1997. Effect of *Ocimum sanctum* Linn. on noise induced changes in plasma corticosterone level. *Ind J Physiol Pharmacol* 41: 139–143.

69. Archana R & Namasivayam A. 2000. Effect of *Ocimum sanctum* on noise induced changes in neutrophil functions. *J Ethnopharmacol* 73: 81–85.

70. Shyamala AC & Devaki T. Studies on peroxidation in rats ingesting copper sulphate and effect of subsequent treatment with *Ocimum sanctum.* J Clin Biochem Nutr 20: 113–119.

71. Ganasoundari A, Zare SM, & Devi PU. 1997. Modification of bone marrow radiosensensitivity by medicinal plant extracts. *Br J Radiol* 70: 599–602.

72. Ganasoundari A, Devi PU, & Rao MN. 1997. Protection against radiation-induced chromosome damage in mouse bone marrow by *Ocimum sanctum. Mutat Res* 373: 271–276.

73. Ganasoundari A, Devi PU, & Rao BS. 1998. Enhancement of bone marrow radioprotection and reduction of WR-2721 toxicity by *Ocimum sanctum. Mutat Res* 397: 303–312.

74. Banerjee S, Prashar R, Kumar A, & Rao AR. 1996. Modulatory influence of alcoholic extract of Ocimum leaves on carcinogen-metabolizing enzyme activities and reduced glutathione levels in mouse. *Nutr Cancer* 25: 205–217.