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## Green tea *Camellia sinensis*

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Common names: Chinese tea, camellia tea, gruner tea, Matsu-cha, Lu cha (Braun 2007, Harvey 2004)

Family: Theaceae

Parts used: leaf

Major constituents: polyphenols (catechins [approx 30-40%]: catechin, gallaogatechin, epicatechin, epigallocatechin, epicatechin gallate and epigallocatechin gallate [EGCG] and flavonoids), proanthocyanidins, alkaloids (caffeine [approx 3%], theobromine, theophylline), amino acid (theanine:  $\gamma$ -ethylamide of glutamic acid), polysaccharides, volatile oils, small amounts common methylxanthines, tannin, diphenylamine, oxalic acid, trace elements, vitamin C (Braun 2007, Chopade 2008, Hara 2001).

### Traditional Usage

Green tea has a long history of medicinal use in Asian countries such as India, China, Japan and Thailand (Chopade 2008) as ancient as 500 000 years ago (Hawkins 2007). The consumption of green tea as a healthful beverage is widespread in China (Hara 2001).

According to Chinese legend, in 2737 BC the Emperor Sheng Nung (the 'Divine Healer') discovered the healing power of tea leaves and passed this knowledge on to his subjects (Hara 2001).

Green tea is used in traditional Chinese and Ayurvedic medicine primarily as a stimulant, diuretic, astringent and for heart health (Chopade 2008, Hawkins 2007). It has also been used to treat flatulence, to regulate body temperature and blood sugar, and to improve both digestion and mental function (Chopade 2008, Hawkins 2007). Other actions attributed to green tea include improving eyesight strengthening arteries, reducing excess fats, clear phlegm and neutralising poisons (imgateway nd).

In India decoctions of dried or fresh buds and leaves were taken for headache and fever, applied topically to prevent tooth decay, fresh leaf juice was taken as an abortifacient, contraceptive and for hemostatic actions (Ross 2005). The tea was drunk in Mexico as a galactagogue and in Thailand for its cardiogenic and neurotonic properties (Ross 2005). It was applied topically in Guatemala as an eyewash for conjunctivitis and in Kenya to treat corneal opacities, chalazion (inflamed eyelid gland) and conjunctivitis (Ross 2005).

### Introduction

Green tea is made from the unfermented leaves of the *Camellia sinensis* plant. It is this minimal processing that results in the preservation of the highest proportion of active polyphenols compared to oolong (partially fermented) or black (fully fermented) tea (Chopade

2008, Hawkins 2007, Nagaya 2004). Green tea has less caffeine than black tea (Hawkins 2007).

Polyphenols act as antioxidants and can neutralise free radicals, reducing or helping to prevent some of the damage they can do to the body (Chopade, 2008, Hawkins 2007). Antioxidants such as the polyphenols in green tea can help treat or prevent some of the diseases caused by free radical damage such as cancer and heart disease, as well as the effects of ageing (Hawkins 2007). Polyphenols appear to have a stronger antioxidant effect than vitamin C alone (Hawkins 2007, Chopade 2008).

Green tea demonstrated stronger free radical scavenging activity at lower doses than *Centaureum erythraea* in vitro (Valentao 2003).

A human trial was carried out on 24 women who drank 2 cups a day of green tea standardised to 250 mg catechins for 42 days. Compared with controls the women had significantly higher plasma antioxidant status, lower plasma peroxides and lower LDL cholesterol levels (Braun 2007).

### Major medicinal uses

A review of recent human studies states that green tea may reduce cardiovascular disease and some cancers, promote oral health, reduce high blood pressure, help control body weight, have antibacterial and antiviral properties, offer protection against UV light, increase bone mineral density and have anti fibrotic and neuroprotective powers (Cabrera 2006).

### Cardiovascular: stroke and hypertension

It is the catechin polyphenols, particularly epigallocatechin gallate, and ascorbic acid in green tea that give its powerful antioxidant capabilities (Nagaya 2004). Consumption of a single dosage of 400 mL of green tea on two separate occasions was shown to reverse the endothelial dysfunction (impaired endothelium dependent vasodilation) in 20 healthy male smokers

compared with 7 age matched non smoking controls in a randomised trial (Nagaya 2004). Endothelial dysfunction is a factor in the development and clinical manifestation of cardiovascular disease, and particularly atherosclerotic vascular disease, so further randomised studies are called for to determine any effect of green tea consumption on reducing the risk of cardiovascular events and mortality (Nagaya 2004).

Beneficial effects on cardiovascular disorders have been documented, through reducing the absorption of cholesterol and lipids in the gastrointestinal tract (Koo 2004); green tea may also promote the excretion of cholesterol from the body (Hawkins 2007).

A population based prospective cohort study of 40,530 Japanese aged 40-79 years with no previous history of cardiovascular disease was carried out over 11 years (Kuriyama 2006). Reduced risk from cardiovascular disease, and especially from stroke, was found to be associated with increased consumption of green tea particularly in women. One study found an inverse relationship between the habit of drinking over 5 cups of green tea daily with having a history of stroke (Sato 1989). A follow up study showed those who drank less green tea were at least twice as likely to die of stroke or cerebral hemorrhage (Sato 1989). A more recent meta-analysis of current literature found people consuming 3 or more cups of green or black tea had 21% less chance of suffering a stroke (Arab 2009).

Epigallocatechin has been shown to lower cellular cholesterol concentrations in vitro (Bursill 2006) and catechins extracted from green tea have lowered plasma cholesterol levels in vivo (Bursill 2007). A review of the literature found numerous population based studies of green tea as a functional food with an inverse relationship with myocardial infarction and cardiovascular disease with doses ranging from 1-3 cups per day (Cabrera 2006).

Green tea enriched water given to animals is associated with lowered rates of hypertension in lab tests (Henry 1984, Sato 1989).

### **Cancer**

Green tea polyphenols have been shown to have antimutagenic and anticarcinogenic properties in vitro and in vivo (Santhosh 2005). A 50% inhibition of mutagenicity of tobacco was found at a concentration of 5 mg/plate on *Salmonella typhimurium* strains treated with 50 mg/plate of aqueous tobacco extract. An inhibition of tobacco induced urinary mutagenicity in rats was also found, indicating that green tea has some considerable action on reducing the mutagenic and carcinogenic effect of tobacco.

Green tea was found to activate intracellular antioxidants, inhibit precarcinogen formation and suppress angiogenesis and cancer cell proliferation in the gastrointestinal tract (Koo 2004); a major catechin present in green tea (epicatechin gallate) has been

shown to stimulate cell apoptosis and inhibition of cell growth in various cells and to induce the activation of tumour suppressor proteins in human colorectal cancer cells (Cho 2007).

Studies on esophageal cancer have shown inconsistent results (Koo 2004). However it may be that temperature has an effect with significantly increased risk of esophageal cancer associated with the consumption of green tea at high temperatures (Wu 2008).

Green tea and black tea polyphenols inhibit cell growth and induce apoptosis of human cervical cancer cells (Singh 2009).

A review of the literature concerning green tea and cancer research published to March 2008 found 43 epidemiological studies, 4 randomised trials and one meta-analysis of good to moderate quality (Liu 2008). Increased tea consumption is associated with reduced incidence of stomach & colon cancers (Koo 2004) and there is some suggestion that green tea benefits gastrointestinal cancers (Liu 2008).

Green tea consumption helps protect against colorectal cancer as suggested by a four year study of 69 710 women aged 40-70 years (Henson 2007).

### **Diabetes**

Green tea has an antidiabetic effect (Tsuneki 2004). It lowered glucose levels in the bloodstreams of diabetic mice without affecting insulin levels (Tsuneki 2004).

Doses of 1.5 g/body of green tea promoted glucose metabolism in healthy human volunteers (Tsuneki 2004). A five year follow up of 17 413 Japanese aged 40-65 years with no previous history of type 2 diabetes, cardiovascular disease or cancer found 33% lower risk of developing diabetes with consumption of more than six cups of green tea per day, compared with less than one cup (Iso 2006).

### **Antibacterial**

In vitro studies have inhibited the growth of such bacteria as 7 strains of *Staphylococcus* species, 7 strains of *Streptococcus* species, *Corynebacterium* spp, 19 strains of *Escherichia coli* and 26 strains of *Salmonella* species (Braun 2007).

### **Antiviral**

Nonfermented and semifermented *Camellia sinensis* methanol:water extracts have inhibitory effects in vitro on *Helicobacter pylori* and the enzyme urease necessary for its colonisation (Hassani 2009). A complete inhibition of two subunits of the urease enzyme was found with 2.5 mg/mL of nonfermented extract and 3.5 mg/mL of semifermented extract, while 4 mg/mL of nonfermented and 5.5 mg/mL of semifermented extract were bactericidal for *H. pylori* (Hassani 2009). Thus nonfermented *Camellia sinensis* extract reduces *H. pylori* colonies and inhibits urease production at lower strength doses than other teas, due to the polyphenol and catechin content.

Three in vitro studies have shown inhibition of HIV replication by epigallocatechin, although theaflavins in black tea have shown greater effectiveness against this virus (Braun 2007). Further studies involve Epstein Barr virus, HSV-1, influenza A & B, rotavirus and enterovirus (Braun 2007).

Green tea catechins used topically as a proprietary ointment (Polyphenon E) at 15% strength was shown in two trials to clear external genital and anal warts in a median of 16 and 10 weeks respectively when applied three times daily (Blumenthal 2007).

### Weight loss

Green tea extract standardised to 8.35% caffeine and 24.7% catechins has been shown to stimulate brown adipose tissue in vivo, with thermogenesis greater than the effect the caffeine content accounts for (Dulloo 2000). Long term ingestion of tea catechins stopped the accumulation of body fat in mice with high fat diet induced obesity, possibly due to the activation of hepatic lipid metabolism (Tokimitsu 2004). This effect was also found in non obese rats (Ito 2008).

Another clinical study found green tea significantly increased 24 hour energy expenditure and urinary noradrenalin excretion compared with both caffeine and placebo controls. On three separate occasions 10 healthy men were randomly given 3 daily doses of either green tea extract standardised to 50 mg of caffeine and 90 mg of epigallocatechin gallate, a caffeine or a placebo capsule (Dulloo 1999).

An open study found that an 80% ethanol extract of green tea standardised to 25% catechins reduced weight in moderately obese by 4.6% and waist circumference by 4.5% after 3 months use (Chantre cited in imgateway, nd). However a double blind placebo controlled parallel trial of 46 women showed no difference between the placebo and green tea groups over 87 days in either weight loss or metabolic parameters (Diepvens cited in imgateway, nd).

Tea catechins taken at a dose of 588 mg/day for twelve weeks were shown to significantly reduce both abdominal and total body fat in healthy male and female subjects compared with a control of 126 mg tea catechins per day (Tokimitsu 2004).

### Arthritis

Severity of arthritis symptoms in rats was significantly reduced by green tea polyphenols at a dose of 8 mg/L for nine days (Kim 2008).

A prospective cohort study of 31 336 women aged 55-69 drinking three or more cups a day of tea had a reduced risk of developing rheumatoid arthritis compared with those who drank no tea (Mikuls 2002).

### Dental caries

Green tea effectively prevents dental caries (Koo 2004). Both semifermented and nonfermented *Camellia sinensis* extracts (black and green teas) prevent the

growth of oral *Streptococci* responsible for dental caries and bacteremia following dental work, such as *Streptococcus mutans*, *S. mitis* and *S. sanguis*, with black tea showing a greater effect due to a higher content of volatile components (Hassani 2008). In vitro studies of the simple catechin component of green tea have suggested anticariogenic properties such as a bactericidal effect against *Streptococcus mutans* and *S. sobrinus*, prevention of bacterial adherence to teeth and inhibition of bacterial and human enzymes for production of the plaque and acid that lead to dental caries (Hamilton-Miller 2001, Jones 2006).

### Contraindications and warnings

- Pregnancy and lactation: high doses not recommended due to caffeine content.
- Pregnancy: caffeine crosses placenta and is associated with spontaneous abortion at doses over 100 mg/day (Cnatingius 2000).
- Lactation: transferred in breast milk may lead to sleep disturbances in infants (Basch 2008).
- Not recommended for children due to caffeine content (Basch 2008).
- Clients with heart problems, kidney disorders, stomach ulcers and anxiety disorders should avoid green tea, due to caffeine content (Hawkins 2007).
- Very rare reports of liver damage from concentrated green tea extracts (rather than tea infusions or beverages) suggest take with food and discontinue use if symptoms of liver disorder develop (abdominal pain, dark urine, jaundice) (NIH).
- Known allergy/hypersensitivity to caffeine or tannin; skin rashes and hives have been reported with caffeine ingestion (Basch 2008).
- Caffeine is a stimulant which may cause insomnia; may worsen ulcer symptoms; increase heart rate and blood pressure – effect lessens with regular use; high doses of caffeine are toxic; chronic use leads to tolerance, psychological dependence, habit forming; abrupt cessation results in withdrawal symptoms.
- Side effects of caffeine use may result in anxiety, irritability, upset stomach, nausea and diarrhea (NIH).
- Tannin may lead to constipation; tannin can contribute to iron deficiency, impaired iron metabolism and macrocytic anemia in infants (Basch 2008).

### Interactions

- The presence of theanine works against the stimulating effect of caffeine on the nervous system while having a vitalising action on brain neurons (Hara 2001). In amounts similar to those found in one cup of prepared beverage theanine was found to inhibit the excitatory effects of caffeine in rats (Kakuda 2000).
- Green tea may inhibit adenosine.
- May increase effectiveness of beta-lactam antibiotics.
- Caffeine reduces sedative effects of benzodiazepines.
- May cause an increase in blood pressure when taken with propranolol/metoprolol.

- Reduces effectiveness of warfarin in large doses.
  - May increase risk of bleeding with aspirin.
  - Contrary results as to interaction with chemotherapy drugs: increased effect with doxorubicin and tamoxifen in laboratory tests, reduced effect for prostate cancer.
  - Antipsychotic drugs (clozapine) should be taken more than 40 minutes after green tea to avoid any negative interaction.
  - Increases side effects of ephedrine (agitation, tremors, insomnia, weight loss).
  - Reduces serum levels of lithium.
  - Significantly increases blood pressure when taken concurrently with MAOIs.
  - Oral contraceptives slow breakdown of caffeine, increasing stimulatory effects.
  - Caffeine in conjunction with phenylpropanolamine can lead to mania and severe hypertension.
- (Hawkins 2007, NIH 2008, imgateway nd)

### Dosage and therapeutic guidelines

- Brewed beverage: studies range from 1-10 cups/day (1 cup = 50 mg caffeine, 80-100 mg polyphenol) (Basch 2008).
- 2-3 cups/day recommended for intake of 240-320 mg polyphenols (Hawkins 2007).
- Over 5 cups/day (equivalent to >300 mg caffeine) considered overdose with side effects of excessive caffeine intake (imgateway, nd).
- Capsules standardised green tea extract 100-750 mg/day (Hawkins 2007).
- Caffeine free products are recommended as they contain concentrated polyphenols of 60-89% (Hawkins 2007; imgateway nd).

### Conclusion

Green tea is a beverage with a long history of use for its medicinal properties as a stimulant, diuretic and cardiostimulant. It has been traditionally used to regulate blood sugar levels and weight loss, to improve digestion and mental function and to prevent tooth decay.

Modern science is supporting these traditional claims for the therapeutic action of green tea through in vitro, in vivo and population based studies as well as new avenues of research such as cancer prevention and treatment, and antimicrobial treatments against *Staphylococcus* spp and *Helicobacter pylori* virus.

The strong antioxidant effect of the phenols in green tea has been confirmed with implications for the use of this beverage against the increasing rates of conditions such as cardiovascular disease, some cancers, diabetes and obesity.

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