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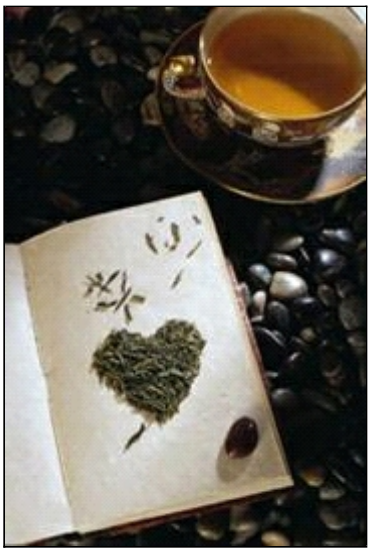
REPORT

GREEN
TEA

Good for the Soul-
but even better,
Good for the Heart.

by Ivy Greenwell



Part II:
Cardio-protective
properties of green tea

Since blood sugar tends to increase with age, accelerating aging by crosslinking with proteins (glycation), the ability of green tea to lower serum glucose levels is extremely important as part of its anti-aging benefits. Some would argue that tea's ability to lower blood sugar, and thus insulin levels and glycation, is its most important anti-aging property.

A study comparing the effects of 75-day feeding of green tea and black tea to aged rats found that green tea lowered blood sugar only slightly better than black tea (23.9% vs 22.8%), but was markedly superior in reducing triglycerides (33.3% vs 25%; high triglycerides are strongly associated a high risk of cardiovascular disease). A low ratio of triglycerides to HDL is an excellent marker of cardiovascular health.

Black tea, however, was a better inducer of superoxide dismutase (SOD; the activity of SOD was 117% higher in the black tea group vs. control, as compared to 90.8% higher in the green tea group), and a better blocker of the harmful malondialdehyde, a byproduct of lipid peroxidation (black tea reduced it by 34.6%; green tea by 25.4%). The authors' conclusion that black tea is a more powerful antioxidant in vivo needs to be confirmed by other studies.

The ability to significantly lower blood glucose has been confirmed also in studies using diabetic rats. Both green and black tea were shown to possess anti-diabetic activity, and to be effective both in the prevention and treatment of diabetes. The fact that aged rats responded so dramatically to these polyphenols implies that it is possible to reverse the age-related rise in glucose intolerance and the resulting degenerative cascade of atherosclerosis and other degenerative disorders.

In what way are tea polyphenols able to lower serum glucose? The main mechanism seems to be the inhibition of the activity of starch digesting enzyme amylase. Tea inhibits both salivary and intestinal amylase, so that starch is broken down more slowly, and the rise in serum glucose is thus minimized. In addition, according to one recent study, tea may reduce the intestinal absorption of glucose.

A relatively little known compound found in onions and in tea, especially green tea, called diphenylamine, seems to have a strong sugar-lowering action. Again, the lesson here is that we are barely beginning to identify the significant phenolic compounds and their interactions; it's best not to rely on a single ingredient such as epigallocatechin gallate, but rather to ingest the whole complex set of bioactive compounds present in tea for best results.

Thanks to the serum glucose-lowering effect of tea, we thus obtain significant anti-aging benefits of calorie restriction, reduced glycation, and lower insulin secretion. If you drink tea with a carbohydrate-rich meal, you slow down the release of glucose and reduce its absorption (you also reduce the absorption of iron, another anti-aging benefit). Thus, you prevent the harmful spiking of insulin. Since insulin is our most fattening hormone and, with cortisol, our most pro-aging hormone, you also derive the substantial range of benefits that go with calorie restriction and insulin control.

Some very exciting results were found when rats were fed 2.5% green tea leaves in their diet. The experimental group showed a drop in total cholesterol, low-density cholesterol, and triglycerides. The body weight of green tea-fed rats was 10 to 18% lower than that of rats not consuming green tea. In addition, the activity of antioxidant enzymes superoxide dismutase (SOD) and catalase, and of anticarcinogenic phase-II enzyme glutathione S-transferase (GST), were significantly higher in the green tea group, as was the glutathione level in the liver. There was no liver or kidney toxicity. Thus, the study demonstrated combined cardiovascular and anticancer effects of green tea.

The cholesterol-lowering (hypocholesterolemic) effects of green tea (as well as black tea) have been confirmed by both animal and human epidemiological studies. In addition to lowering the atherogenic index as expressed by the HDL/total cholesterol ratio in rats, green tea and jasmine green tea also reduced the increase of liver weight that results from fat deposition. High consumption of green tea by humans, especially more than 10 cups a day, was found to be associated with higher HDLs and lower LDL and VLDL cholesterol, as well as with various biomarkers indicating better liver health. Lower levels of lipid peroxides in the liver are one well-confirmed benefit of green tea supplementation, found in study after study. The pancreas is another organ that is protected by green tea.

Green tea may also lower intestinal fat absorption. One animal study found that rats fed a diet containing a significant amount of catechin had a higher excretion of fat in the feces compared to the control group on a polyphenol-free diet. If this holds for humans who take the green tea extract, then it's good weight-loss and cardiovascular news.

Supplementation with antioxidants is important in part because by protecting cholesterol from oxidation, antioxidants help protect against atherosclerosis. In an animal study comparing the effectiveness of various antioxidants in preventing the oxidation of VDL and LDL cholesterol, vitamin E, genistein (phytoestrogen found chiefly in soy products) and green tea were found to be effective antioxidants, with genistein being particularly effective (oxidation lag time of 49% on the high-genistein diet), but green tea also exerting considerable activity (lag time of 33%). It would be interesting to see the results of combined genistein and green tea supplementation, particularly in humans. On the other hand, it could be argued that this is precisely the case of the Japanese diet. Japan enjoys the longest life expectancy in the world, and the lowest cardiovascular mortality for men, in spite of heavy smoking.

The vasodilating effects of tea have also been documented. One interesting study compared the effect of coffee, tea, hot water with caffeine, and plain hot water on skin temperature, indicative of peripheral vasodilation. Tea produced the greatest vasodilating response. The authors speculate that this is due to the action of catechins. An increase in peripheral circulation is valuable for oxygenating tissue, and is also associated with a relaxed mood. Hence some alternative experts have advised drinking green tea in the evening as a relaxant.

A more detailed recent study compared the effectiveness of various catechins as vasorelaxants in rat arteries. All four main catechins present in green tea were shown to have a dose-dependent vasodilating effect, with epigallocatechin gallate being the most potent. Like human estrogens, catechins may act as calcium-channel blockers. Vasodilation is one of the cardioprotective effects of estrogens. Thus, green tea extract might be of particular importance to estrogen-deficient postmenopausal women.

Green tea catechins containing the galloyl group (epigallocatechin gallate, epigallocatechin, and epicatechin gallate) have been found to inhibit the proliferation of smooth muscle cells lining blood vessels in vitro (estrogens and progesterone also show this antiproliferative action; hence the natural protection against atherosclerosis seen in premenopausal women). Smooth muscle proliferation is one of the crucial processes involved in atherosclerosis and heart disease. One mechanism of the antiproliferative action of catechins is apparently the inhibition of protein tyrosine kinase activity (which is also involved in tumor growth).

The authors conclude that "tea catechins may be useful as a template for the development of drugs to prevent the pathological changes of atherosclerosis and post-angioplasty restenosis." (Restenosis is the narrowing of blood vessels after surgery, usually due to the rapid regrowth of plaque.) It seems more logical to use green tea for prevention of atherosclerosis to start with.

Green tea lowers fibrinogen, and inhibits excessive clotting and platelet aggregation.

A recent American in vivo study using hamsters found that while both green tea and black tea improved plasma lipid profiles and protected cholesterol against oxidation, green tea also lowered fibrinogen significantly more than black tea. One of the green tea polyphenols, epicatechin, was found to be able to significantly inhibit the production of thromboxane, one of the compounds required for platelet aggregation.

Green tea has been shown to protect the brain from oxidative stress, and lower monoamine oxidase (MAO) activity. Neurodegenerative diseases have been linked both to free radical damage and to excessive breakdown of neurotransmitters caused by high monoamine oxidase activity. Green tea in general, as well as its phenolic components catechin and epigallocatechin gallate, have been found to be effective at inhibiting MAO and lowering peroxide levels in glial cells in the brain.

Further evidence that green tea might be useful in preventing age-related brain degeneration comes from studies of the effects of catechins on nerve cell cultures. Thanks to their antioxidant properties, catechins were able to protect the cells from death induced

by glucose oxidase. Catechins are also able to restrain the production of nitric oxide by the glial cells surrounding the neurons. Nitric oxide plays an important role as a neurotransmitter involved in memory formation, but excess levels lead to neural death and neurodegenerative disorders. Flavonoids in general are particularly effective in regulating the levels of nitric oxide in the brain. Green tea is among a handful of substances that can reduce nitric oxide production at concentrations of less than 300 parts per million.

The ability to lower lipid peroxidation and to chelate iron in the nervous system is also of tremendous importance. Parkinson's disease involves the progressive destruction of the dopamine-releasing nigrostriatal dopaminergic system, and hence the ever-increasing dopamine deficiency. It is possible that sufficient green tea consumption might protect against Parkinson's disease.

Both green and black tea are also potent inhibitors of intestinal absorption of non-heme iron, lowering the amount of free iron reaching the brain in the first place.

Japan has a much lower rate of Alzheimer's disease than Western countries. The Japanese living in Hawaii have 2.5 times the incidence of Alzheimer's disease than do native Japanese in Japan. It would be interesting to see to what extent the Japanese custom of sipping green tea all day, as contrasted with much lower consumption of green tea by the American-Japanese, contributes to neural protection.

There is also some evidence that iron plays a part in epilepsy. Green tea polyphenols have been found to inhibit or diminish iron-induced epileptic seizures, and to inhibit the hyperactivity of dopaminergic neurons. It is in fact likely that green tea, especially the decaffeinated kind, acts as a mild sedative.

Theanine, an amino acid found in green tea, has also been found to have beneficial effects by raising the levels of serotonin and/or dopamine in various important brain regions, particularly the hypothalamus, hippocampus (memory center), and striatum.

A Japanese study of almost 6000 nonsmoking women over the age of 40 showed that those who drank five or more cups of green tea a day had only half the incidence of stroke compared with women who drank less than five cups. A smaller Dutch study found an even more dramatic effect in men who drank a lot of black tea: those men who drank close to five cups of tea a day had only 31% risk of stroke compared to those who drank less than about two and a half cups of tea.

These results were not replicated in England, however; based on existing in vivo plasma antioxidant measurements, it has been suggested that the English custom of putting cream or milk in tea destroys all antioxidant benefits.

A Japanese animal study done on spontaneously hypertensive rats has confirmed that epigallocatechin gallate reduces the incidence of stroke and prolongs life span.

The kidneys are another area where green tea has shown to have protective effects. Decreased kidney function due to aging and kidney failure are a frequent cause of death. The public is generally unaware that anything can be done to prevent the age-related decline in kidney function. Making use of a wide-range of antioxidant protection appears crucial, and flavonoids, including green tea catechins, are very potent antioxidants. Epigallocatechin gallate was shown to induce antioxidant enzymes in the kidneys, as well as to reduce uremic toxins in the blood, suggesting improved kidney function in an animal model of kidney failure.

Kidney problems are often associated with high blood sugar and consequent glycosylation of various proteins (hence the strong link between kidney failure and diabetes). Since green tea has the ability to lower serum glucose, this is another way in which it helps protect against kidney failure. Likewise, the antioxidant properties of green tea likely play a significant role in protecting the kidneys. Since green tea has been shown to lower the concentrations of free radicals and lipid peroxides in organs such as the liver and the pancreas, this is likely to be true in the kidneys as well.

Maintaining kidney health is a crucial though often neglected part of anti-aging medicine. Green tea is one of the resources we have for protecting this critical detoxification system, and it seems to be a particularly powerful one.

Green tea provides a wealth of simple phenolics; black tea provides more complex polyphenols. There is some controversy about which group has higher antioxidant potential in vivo.

An Italian study found that while green tea was six times more potent in inhibiting lipid peroxidation in vitro, when healthy human subjects ingested the same amount of either black or green tea, the plasma antioxidant capacity (expressed as TRAP, or total radical-trapping antioxidant parameter) was similar in both groups.

The increase in plasma antioxidant capacity was quite rapid, peaking at 30-50 minutes. This indicates that the most bioactive antioxidant compounds are quickly absorbed in the upper part of the gastrointestinal system.

Interestingly, while the addition of milk did not diminish antioxidant activity of either black or green tea in vitro, it completely

abolished it in vivo, according to an Italian study. Some authors, however, think that skim milk does not significantly interfere with the absorption of polyphenols.

One study found green tea polyphenols to be comparable to BHT (a well-known synthetic phenolic antioxidant) in antioxidant power when it came to protecting canola oil; green tea outperformed BHT when the oil was heated.

Catechins have also been found to outperform Vitamin C and beta-carotene ten times in scavenging the alkyl peroxyl radical. One study found green tea polyphenols to be more potent antioxidants than Vitamin C, Vitamin E, rosemary extract, and even curcumin in some systems.

Diabetics show premature aging and poor immune function due to the high oxidative stress that results from high serum glucose. When type-II diabetics were put on a diet that included 6 cups of tea a day plus some tomato sauce with onions, oxidative damage to the DNA of their lymphocytes was found to be markedly reduced. We already know that carotenoids can protect DNA; it is possible that compounds found in green tea may also be able to protect DNA, especially in synergistic action with other antioxidants.

One of the antioxidant properties of green tea catechins is their ability to protect against the ravages of oxidized linoleic acid - an omega-6 fatty acid usually consumed in excess in the Western world, from sources such as margarine, safflower oil and corn oil; excess linoleic acid (most likely in the peroxidized form, which activates various pro-inflammatory enzymes) is involved in promoting inflammation, tumor growth, and most degenerative disorders. Few people are aware that when polyunsaturated cooking oils are heated, the result is carcinogenic peroxides. A recent study discovered that catechins synergize with alpha-tocopherol (Vitamin E) to protect against oxidative damage by oxidized linoleic acid before this fatty acid is incorporated into cell membranes.

Catechins also have a sparing effect on Vitamin E (alpha-tocopherol) and beta-carotene, resulting in overall greater antioxidant protection of the polyunsaturated fatty acids that are incorporated into cell membranes. The sparing effect on tocopherol may be due to the fact that catechins are effective scavengers of aqueous oxygen radicals, and thus prevent their entry into the lipids, where these radicals would oxidize alpha-tocopherol. It is also possible that catechins can regenerate the antioxidant power of alpha-tocopherol by donating a hydrogen molecule to its oxidized form. Thus it appears that green tea polyphenols, like flavonoids in general, boost the levels of other antioxidants.

Of special interest is the ability of catechins to inhibit the dangerous peroxynitrite free radical, a strong reactant oxidant formed when the potent free radical superoxide encounters nitrogen-containing compounds such as nitric oxide. Peroxynitrite destroys proteins, as well as vital antioxidants such as glutathione and Vitamin E. Green tea catechins were shown to be more effective than Trolox, a synthetic antioxidant, in protecting critical amino acids such as tyrosine and the amino acids of apolipoprotein B in LDL cholesterol against nitration damage by the peroxynitrite radical.

Another interesting recent discovery concerns one particular green tea polyphenol called epicatechin. This particular polyphenol appears to be metabolized to an anthocyanin-like compound that is also an antioxidant, offering particularly long-lasting protection.

Returning to the question of antioxidant properties of simple catechins in green tea versus the complex polymeric polyphenols in black tea, a new study found that in lipids the simple compounds were more effective, while in aqueous conditions polymers had more activity, but only up to a point. Glycosylation, meaning cross-linking with glucose, decreased the antioxidant properties of all compounds tested.

Green tea polyphenols are also effective anti-inflammatory agents. Chronic inflammation has been linked to serious degenerative disorders associated with aging, including cardiovascular disease, cancer, and Alzheimer's disease. An important part of the inflammatory process is the excess production of nitric oxide, which in turn leads to the production of carcinogenic nitrous compounds. Epigallocatechin gallate has been found to inhibit the enzyme nitric oxide synthase, thus reducing the production of inflammation-related NO.

Tumor necrosis factor alpha also plays a pivotal part in inflammation. It has been found that green tea polyphenols downregulate the gene that causes the release of tumor necrosis factor alpha. Thus, it can be concluded that green tea reduces the inflammatory response by controlling the production of nitric oxide and tumor necrosis factor alpha.

Recent studies suggest that green tea catechins may inhibit the HIV virus replication, and various other viruses. A study done at the Laboratory of Viral Oncology in Nagoya, Japan, discovered that two catechins found in green tea, epigallocatechin gallate and epicatechin gallate, were able to differentially inhibit the enzymes used by the HIV virus for replication: reverse transcriptase and various DNA and RNA polymerases. A more recent Chinese study at the Institute of Medical Biotechnology in Beijing found that green tea catechins in general could inhibit the reverse transcriptase or polymerases of several types of viruses, including HIV-1 and herpes simplex 1. Various polymeric oxidation products of polyphenols have also been found to inhibit the herpes simplex virus. It seems that flavonoids in general ought to be more thoroughly researched for their ability to inhibit the replication of viruses and keep them in a state of latency.

A particularly exciting discovery related to the antibacterial properties of green tea polyphenols has been the finding that these compounds inhibit the growth and adherence of oral bacteria. Green tea extract has been found to strongly inhibit periodontal-causing bacterium, Porphyromonas, and decay-causing bacteria such as Streptococcus salivarius and Streptococcus mutans. A Chinese study showed that Streptococcus mutans could be inhibited completely by sufficient contact with green tea polyphenols. Using green tea as a mouth rinse resulted in less plaque and periodontal disease. Black tea has also been found effective.

One possible mechanism of the action of tea in preventing dental decay is its ability to inhibit the enzyme amylase present in the saliva. Thus, less starch gets converted in the mouth into bacteria-feeding simple sugars such as glucose and maltose. Bacterial amylase is likewise inhibited, making less nutrition available to the decay-causing organisms.

Green tea catechins also help destroy harmful intestinal bacteria. When tube-fed patients received 300 mg of tea catechins a day, the putrefactive products in their gastrointestinal tract decreased, and organic acids increased, lowering the pH. The greater acidity is highly beneficial, since it makes the environment inhospitable to harmful bacteria, while beneficial lactic acid bacteria can thrive. Indeed, the bactericidal activity of green tea does not affect lactic acid bacteria. Decreased levels of putrefactive products and improved intestinal flora lead to better digestion, better immune function, and lower risk of colorectal cancer.

In summary, green tea has numerous benefits for disease prevention and anti-aging purposes. In part I, we discussed the extensive anti-cancer benefits of green tea. Here we reviewed how green tea protects the cardiovascular system, the brain, the kidneys, and basically affects every aspect of our physiology. The ability to lower blood sugar and to chelate iron seems especially important. Green tea's ability to control the production of nitric oxide also deserves special mention. This ancient beverage seems custom-made to protect health and delay aging.

I have a Japanese neighbor, one of whose friends happens to be a teacher of the tea ceremony, even though she is over one hundred years old. She amazes her younger friends by how fast she can walk up the stairs and how sharp her mind is. (How many Western female centenarians are still active in their profession, and still able to climb stairs?) Now, the teachers of the Japanese tea ceremony drink a very potent brew of green tea. Basically, they sip it all day long. My neighbor reports that one time her centenarian friend gave her this piece of advice: "You want to live a long time? Drink a lot of tea."

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