Tea, Chocolate and Coffee

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Polyphenols

- A large family of natural compounds widely distributed in plant foods.
- Polyphenols have specific health-promoting actions, and it is generally recognized that they can reduce the risk factors for many types of chronic diseases.

The largest and best studied polyphenols are the flavonoids, which include several thousand compounds, among them the flavonols, flavones, catechins, flavanones, anthocyanidins, and isoflavonoids.

Important dietary sources of polyphenols in Western societies are onions (flavonols); cocoa, tea, apples, and red wine (flavonols and catechins); citrus fruit (flavanones); berries and cherries (anthocyanidins); and soy (isoflavones).
Drinking a daily cup of tea will surely starve the apothecary

--Chinese Proverb

Proceedings of the Third International Scientific Symposium on Tea and Human Health: Role of Flavonoids in the Diet

Camellia sinensis is an evergreen plant that grows mainly in tropical climates.

However, some varieties can also tolerate marine climates and are cultivated as far north as Cornwall on the UK mainland and Seattle in the US.
Processing of tea

- Tea is traditionally classified based on producing technique:
  - **White tea**: Unwilted and unoxidized
  - **Green tea**: Wilted and unoxidized
  - **Oolong**: Wilted, bruised, and partially oxidized
  - **Black tea**: Wilted, crushed, and fully oxidized

Catechins are polyphenols and tea has a large concentration of catechins.

Green Tea

- Major polyphenols in green tea are catechins.
- There are 4 major green tea catechins:
  - Epigallocatechin-3-gallate (EGCG)
  - Epicatechin-3-gallate
  - Epigallocatechin
  - Epicatechin
- It’s antioxidant activity is reported to be 100X stronger than vitamin C and 25X stronger than vitamin E in protecting DNA from mutations associated with oxidative damage.
Mechanism of action of tea on health

**Action of tea polyphenols**
- Potent antioxidant activity
- Selectively induce Phase I and Phase II metabolic enzymes
- Inhibit cell proliferation rates
- Improved composition of intestinal bacterial flora
- Prevents angiogenesis

**Consequence**
- Lower risk of heart disease; ↓ LDL oxidation, ↓ lipid peroxidation, ↓ oxidation of DNA and inhibition of carcinogenesis.
- Detoxification of carcinogens
- Decreased growth of abnormal cells and neoplasms
- Undesirable components of flora replaced by beneficial bacteria.
- Reduce blood vessel growth (↓ metastasis)

Catechins / EGCG in Green Tea

- Antioxidant (↓ LDL oxidation, ↓ lipid peroxidation, and ↓ DNA oxidation)
- ↓ cholesterol levels
- ↓ platelet aggregation
- ↓ cancer risk in lungs, stomach, breast, colon cancers- detoxification of carcinogens (phase I and phase II)
- ↑ thermogenesis (fat oxidation & energy expenditure)
- Anti-inflammatory (skin disorders, arthritis)

Daily supplements of extracts from green tea (Camellia sinensis) was effective for decreasing, in as quickly as 3 weeks, blood pressure, LDL cholesterol, oxidative stress, and a marker of chronic inflammation, all independent cardiovascular risk factors.
Mechanisms by which tea may confer its cardiovascular protective properties

- Inhibition of oxidized LDL cholesterol
- Attenuation of the inflammatory process in atherosclerosis
- Reduction in thrombosis
- Promotion of the normal endothelial function
- Blocking of adhesion molecules
- Reduction in plasma total and LDL cholesterol (LDL-C)

Tea flavonoids gain recognition as powerful weapon against disease

- People who drink five cups of tea daily are not only likely to improve their cholesterol levels but may also protect against damage from smoking


Effect of Increased Tea Consumption on Oxidative DNA Damage among Smokers: A Randomized Controlled Study

ABSTRACT: Tea drinking has been associated with decreased occurrence of cancer and heart disease. One potential mechanism for these findings is the strong antioxidant effect of theolipid compounds. A unique randomized controlled intervention trial was designed to study the effect of high consumption of green or black tea in healthy smokers. The trial enrolled 120 healthy smokers with mean age of 45 years, who were randomized to drink either green or black tea four times daily for 12 weeks. At baseline and after the 12-week intervention period. A total of 140 healthy women, aged 18–70, were randomized to drink either green or black tea or a control beverage. Levels of plasma and urine catechins and urinary 4- and 8-hydroxy-2′-deoxyguanosine measured at baseline and at the end of the intervention period. A total of 120 of 140 women completed the 12-week intervention period, with no serious adverse effects or changes in smoking. These data suggest that regular green tea drinking might protect smokers from oxidative damages and could reduce cancer risk or other diseases caused by free radicals associated with smoking.

Foods provide key nutrients that support these detoxification pathways

- Indoles, phytochemicals found in broccoli, cauliflower and other cruciferous vegetables, and **green tea catechins** markedly enhance phase I pathways.
- Dithiolthiones and isothiocyanates; liminoids, phytochemicals in citrus, organosulfuric compounds found in the allium family vegetables (garlic, onions, shallots, and leeks), **green tea catechins** and curcumin increase phase II enzymes, including Glutathione S Transferase which blocks carcinogens from damaging cellular DNA.

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“Green tea polyphenols, major constituents of green tea, are potent chemopreventive agents in a number of experimental models of cancer in animals...This indicates that GTP stimulates the transcription of Phase II detoxifying enzymes through the antioxidant responsive element (ARE).”


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Nakachi (1998) found that the consumption of 5 or more cups of green tea per day was associated with decreased recurrence of stage I and II breast cancer in Japanese women.

Epidemiological studies on Japanese women report that those who drink 2-3 cups or more of green tea a day have a lower incidence of cancer (or develop the disease at a later date).

The custom of drinking green tea with meals in Japan may be one reason for the low cancer rates. The Japanese smoke nearly twice as many cigarettes as Americans, yet they have approx. half the incidence of lung cancer.

In vitro showed inhibitory effect on the growth of mammary cell cancer. Prevents angiogenesis (blood vessel growth).

The results demonstrate a clear inverse correlation between green tea consumption and the risk of CRC—most notably those women who regularly consumed green tea over a longer period of time.

“With research showing protection against ovarian cancer, breast cancer, as well as a reduction in mortality due to cardiovascular disease in women, it's time for practitioners to begin advising their female patients to start adding green tea to their daily regimen.”

**Green Tea Prevents Colorectal Cancer in Women**

- **Key Findings:** The multivariate relative risk of colorectal cancer (CRC) was 0.63 (95% confidence interval, 0.45-0.88) for women who reported drinking green tea regularly at baseline compared with non-regular tea drinkers.
- A significant dose-response relationship was found for both the amount of green tea consumed (p trend = 0.001) and the duration in years of lifetime tea consumption (p trend = 0.006).
- Compared with non-drinkers, each 1.67 g increase (approximately equal to the amount of tea in one tea bag) in daily green tea consumption was associated with a 10% reduction in CRC risk (RR, 0.90; CI: 0.80-1.00).
- Additional 5-year consumption of green tea was also associated with a 10% reduction in CRC risk (RR, 0.90; 95% CI: 0.83-0.97) after fully adjusting for potential confounding variables (e.g. cigarette smoking, alcohol consumption, exercise).
- The reduction in risk was most evident for those women who reported to drink tea regularly at both baseline and during follow-up surveys (RR, 0.43; 95% CI: 0.24-0.77).
For a long time, it was believed that these cancer-fighting polyphenols could only be obtained from **green** tea, not **black**.

However, recent research has shown that both **green** and **black** tea can inhibit lung cancer in animal experiments.


Recent studies indicate that the compounds contained in black tea – **theaflavins** and **thearubigens** – do more than contribute to its dark color and distinctive flavor. They also provide health benefits originally attributed solely to green tea.

Tea shown to fight infection

- Drinking tea appears to prime the immune system to fight infection and chronic disease.
- Subjects who drank five to six small cups of black tea daily for two weeks were better able to fight off bacterial infections.
- Gamma delta T cells act to prevent and reduce the effects of disease. Previous experiments have shown that exposing these cells to ethylamine, produced when the tea ingredient L-theanine is broken down in the liver, boosted the abilities of the cells to fight infections.
- The researchers also carried out in vivo studies on people who either drank about 20 ounces of tea a day for two weeks, or consumed coffee instead. The tea drinkers’ gamma delta T cells produced a wealth of anti-bacterial chemicals when exposed to bacteria.
- In contrast, people who drank coffee during the study produced no disease-fighting proteins in response to bacteria.

Proceedings of the National Academy of Sciences

2003;10.1073/pnas.1033603100
Green tea has thermogenic properties and promotes fat oxidation beyond that 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.

The outcome of several experimental studies suggests that green tea possesses anti-inflammatory and anticarcinogenic potential, which can be exploited against a variety of skin disorders...Supplementation of skin care products with green tea may have a profound impact on various skin disorders in the years to come.

Antioxidants in green tea may prevent and reduce the severity of rheumatoid arthritis. Polyphenolic action of the green tea can protect the body from oxidative stress that causes arthritis. Researchers chemically induced arthritis in mice: only 44% of mice given green tea developed arthritis (and a less severe form) compared to 94% in the control group.

Proceedings of the National Academy of Science, July 1999
Green tea catechins are chondroprotective and consumption of green tea may be prophylactic for arthritis and may benefit the arthritis patient by reducing inflammation and slowing cartilage breakdown.

Bioavailability of catechins from tea: the effect of milk.

van het Hof KA, Koits SB, Weststrate JA, Tilburg LB.
Unilever Research Vlaardingen, The Netherlands.

OBJECTIVES: To assess the bioavailability of catechins following green or black tea ingestion and the effect of addition of milk to black tea. DESIGN: Twelve volunteers received a single dose of green tea, black tea and black tea with milk in a randomized, cross-over design with one-week intervals. Blood samples were drawn before and up to eight hours after tea consumption. SETTING: The study was performed at the Unilever Research Vlaardingen in The Netherlands. SUBJECTS: Twelve healthy adult volunteers (7 females, 5 males) participated in the study. They were recruited among employees of Unilever Research Vlaardingen. INTERVENTIONS: Green tea, black tea and black tea with semi-skimmed milk (3 g tea solids each). RESULTS: Consumption of green tea (0.2 g total catechins) or black tea (0.3 g total catechins) resulted in a rapid increase of catechin levels in blood with an average maximum change from baseline (CV) of 0.46 nmol/l (33%) after ingestion of green tea and 0.10 nmol/l (15%) in case of black tea. These maximum changes were reached after (mean (s.e.m.)) 3.2±0.3h (3.2h) and 3.2±0.3h (2.7h) for green and black tea, respectively. Blood levels rapidly declined with an elimination rate (mean (CV)) of 0.12±0.4 h⁻¹ (91%) for green tea and 0.12±0.9 h⁻¹ (50%) for black tea. Addition of milk to black tea (120 ml in 400 ml) did not significantly affect the blood catechin levels (areas under the curves (mean (CV)) of 0.31±0.18 h nmol/l for green tea and 0.17±0.19 h nmol/l for black tea). CONCLUSION: Catechins from green tea and black tea are rapidly absorbed and milk does not impair the bioavailability of tea catechins.

A single dose of tea with or without milk increases plasma antioxidant activity in humans.

Unilever Nutrition Centre, Unilever Research Vlaardingen, PO Box 114, 2600 AC Vlaardingen, The Netherlands.

OBJECTIVE: To investigate the effect of black and green tea consumption, with and without milk, on the plasma antioxidant activity in humans. DESIGN: In a complete cross-over design, 21 healthy volunteers (10 male, 11 female) received a single dose of black tea, green tea (2 g tea solids in 200 ml water) or water with or without milk. Blood samples were obtained at baseline and at several time points up to 2 h post-tea drinking. Plasma was analysed for total catechins and antioxidant activity using the ferric reducing ability of plasma (FRAP) assay. RESULTS: Consumption of black tea resulted in a significant increase in plasma antioxidant activity reaching maximal levels at about 60 min. A larger increase was observed after consumption of green tea. As anticipated from the higher catechin concentration in green tea, the rise in plasma total catechins was significantly higher after consumption of green tea when compared to black tea. Addition of milk to black or green tea did not affect the observed increases in plasma antioxidant activity. CONCLUSIONS: Consumption of a single dose of black or green tea induces a significant rise in plasma antioxidant activity. Addition of milk to tea does not abolish this increase. Whether the observed increases in plasma antioxidant activity after a single dose of tea prevent in vivo oxidative damage remains to be established.

Adding milk does not seem to affect antioxidant status of tea, however, it may inhibit nitric oxide synthesis and thereby reduce vascular relaxation.

Cocoa

- A natural antioxidant
- Traditionally used in Mexico and parts of Latin America for medicinal purposes
- Theobroma cacao plant used to make chocolate
- Recent studies find cocoa to be cardioprotective improve blood flow to the heart muscle.
Chocolate Polyphenols

Cocoa is rich in antioxidant flavonoids called flavanols, which include procyanidins, epicatechins, and catechins.

Chocolate Polyphenols

- Antioxidant
- ↓ blood platelet aggregation
- ↑ flexibility of blood vessels and ↑ blood flow (↑ production of nitric oxide).
- ↓ moderately high BP
- ↓ LDL oxidation

High concentration of polyphenol compounds called flavanols, including epicatechin and catechin.

Cocoa flavanols improve endothelial function by enhancing nitric oxide bioactivity which helps dilate the blood vessels, increasing blood flow, reducing blood clot formation, and reducing blood pressure. Flavanols can also reduce LDL oxidation which may prevent buildup of atherosclerotic plaque in the artery walls.
Preliminary clinical studies, with participants consuming flavanol-rich cocoas and chocolates, have resulted in a number of positive effects relating to cardiovascular health, including decreased blood pressure and improved blood flow through the vessels.

In fact, a recent clinical study simultaneously compared low-dose aspirin and a flavanol-rich cocoa beverage, and found reductions in platelet "stickiness," which may improve blood flow, with both.

In vitro studies found that the flavanols in chocolate may decrease the oxidation of Low Density Lipoproteins (LDL), or "bad" cholesterol. When LDLs become oxidized, they promote the build up of plaque along the lining of blood vessels, which can reduce blood flow and supports the development of high blood pressure and atherosclerosis.

Additional in vitro studies found that flavanols may reduce platelet aggregation. Platelet aggregation is when blood components become "sticky" and adhere to the lining of the blood vessel. Platelet aggregation may be a risk factor for cardiovascular disease and is thought to lead to high blood pressure and other forms of heart disease.

A diet containing about an ounce of chocolate a day increases good cholesterol and prevents bad cholesterol from oxidizing.
Results demonstrate that cocoa has a high flavonoid content and substantial antioxidant capacity:
4-5 X stronger than black tea;
2-3X stronger than green tea;
Almost 2X stronger than red wine.

"It has been over 10 years since the first mention in a medical journal about cocoa and chocolate as potential sources of antioxidants for health. During this time, cocoa has been found to improve antioxidant status, reduce inflammation and correlate with reduced heart disease risk."

British Journal of Nutrition, 2008
“Cocoa powder and dark chocolate may favorably affect cardiovascular disease risk status by modestly reducing LDL oxidation susceptibility, increasing serum total antioxidant capacity and increasing HDL-cholesterol concentrations, and not adversely affecting prostaglandins.


- Researchers found that cocoa flavanol and procyanidin supplementation for 28 d significantly increased plasma epicatechin and catechin concentrations and significantly decreased platelet function. These data support the results of studies that used higher doses of cocoa flavanols and procyanidins. Am J Clin Nutr. 2003 Jun;77(6):1466-73.
"The inclusion of small amounts of polyphenol-rich dark chocolate as part of a usual diet efficiently reduced BP and improved formation of vasodilative nitric oxide."

"This study suggests that higher cocoa intake is associated with reduced blood pressure and reduced risk of cardiovascular and all-cause mortality in elderly men."

Cocoa increases blood flow to brain

- Cocoa flavonols have been directly linked with improved cerebral blood flow.
- Thirteen men and women (avg age 72) consumed flavonol-rich cocoa and a 21 participants consumed a flavonoid-poor cocoa product.
- Ultrasound methods were used to analyze blood flow to the brain.
- The 13 participants who consumed flavonol-rich cocoa for 2 weeks (900 mg flavanols daily) achieved a 10% increase in cerebral blood flow.

Cocoa increases blood flow to brain

Harvard researchers report that cocoa flavanols improve brain flow in older adults. It has been speculated that increasing blood flow to the brain could help reduce cognitive decline in aging individuals. The current finding could be helpful in improving cognitive function among individuals suffering from conditions in which brain flow is impaired, such as stroke and dementia.


The researchers tested the effects of beverage containing high amounts of cocoa flavanols on participants between the ages of 59 and 83. The investigators found an 8 percent increase in the participants' brain blood flow following one week of consuming the beverage, and a 10% increase after 2 weeks.

Neuropsychiatric Disease and Treatment, 2008; 4(2), 433-330.
Effects of ingesting 100g dark chocolate (DC), 100g dark chocolate with 200 ml milk (DC+MK), or 200g milk chocolate on total antioxidant capacity and epicatechin content of human plasma. (red=DC; blue DC+MK; grey=MC. FRAP = ferric-reducing antioxidant potential was used to measure antioxidant capacity. Asterisk = P<0.001)
Coffee Is No. 1 Source of Antioxidants (Fox News)

That daily cup of coffee can help prevent cancer, researchers find (Detroit Free Press)

'Joe' gives free radicals a jolt (Newsday)

Grounds for Health (San Jose Mercury News)

Study says coffee delivers more health benefits than fruit and veg (Scotsman)

What apples? A cup of coffee a day keeps the doctor away (Newwindpress.com – India)

Coffee found to be high in health-giving antioxidants (The Independent – UK)

Coffee came out on top, on the combined basis of both antioxidants per serving size and frequency of consumption

Chlorogenic acid and caffeic acid are strong antioxidants in vitro.

The amount of chlorogenic acid or caffeic acid available to act as an antioxidant in vivo will depend on absorption from the gut. It has recently been demonstrated that humans absorb about 33% of ingested chlorogenic acid and about 95% of ingested caffeic acid.

Coffee beans are one of the richest dietary sources of chlorogenic acid and for many consumers this will be their major dietary source.

It has been estimated that coffee drinkers might ingest as much as 1 g per day of chlorogenic acid and 500 mg per day of caffeic acid.

Coffee could supply as much as 70% of the total making it far and away the most important dietary source of this group of antioxidants.
The roasting of coffee beans dramatically increases their total antioxidant activity. A roasting time of 10 minutes (medium-dark roast) was found to produce coffee with optimal oxygen scavenging and chain breaking activities in vitro.

It can be concluded that coffee possesses greater in-vitro antioxidant activity than other beverages, due in part to intrinsic compounds such as chlorogenic acid, in part to compounds formed during roasting such as melanoidins and in part to as yet unidentified compounds.

Consumption of coffee, a major source of dietary antioxidants, may inhibit inflammation and thereby reduce the risk of cardiovascular and other inflammatory diseases in postmenopausal women.

Researchers say they’ve found a highly active anti-cancer compound, called methylpyridinium, in coffee that may prevent colon cancer. In studies with animals, this potent antioxidant compound appears to boost the activity of phase II enzymes, which are believed to protect against colon cancer.

Coffee May Protect Against Colon Cancer

Journal of Agricultural and Food Chemistry, Nov. 5, 2003

Researchers say they’ve found a highly active anti-cancer compound, called methylpyridinium, in coffee that may prevent colon cancer. In studies with animals, this potent antioxidant compound appears to boost the activity of phase II enzymes, which are believed to protect against colon cancer.
- Espresso-type coffee contains about two to three times more of the anticancer compound than a medium roast coffee.
- Methylpyridinium is found almost exclusively in coffee and coffee products. It's not present in raw coffee beans. It's formed during the roasting process from its chemical precursor, trigonellin.
- The anticancer compound is present in both caffeinated and decaffeinated coffee and is even found in instant coffee.

Journal of Agricultural and Food Chemistry, Nov. 5, 2003

Effects of coffee consumption on glucose tolerance, serum glucose and insulin levels—a cross-sectional analysis

- Coffee consumption showed positive effects on glucose tolerance, and on glucose and insulin levels.
- Coffee consumption was significantly and inversely associated with fasting glucose, two-hour plasma glucose, and fasting insulin, in both men and women.
- Additionally, coffee consumption was significantly and inversely associated with impaired fasting glucose, impaired glucose regulation, and hyperinsulinemia, in both men and women, and inversely associated with isolated impaired glucose tolerance in women.
- Thus, this cross-sectional analysis suggests that the consumption of coffee exerts positive effects on glucose tolerance, and glucose and insulin levels.

Horm Metab Res., 2006; 38(1): 38-43

Long term prospective studies revealed that coffee may improve fasting glucose, glucose tolerance and insulin sensitivity. Habitual coffee drinkers have a lower total and cardiovascular mortality among diabetic subjects.
This study confirms a striking protective effect of caffeinated coffee by reducing incidence of diabetes independent of multiple plausible confounders.

Prospective cohort study from NHANES I found a negative association between diabetes risk and consumption of ground coffee and regular tea in those under 60y.o. who had lost weight.

Higher caffeinated beverage consumption in the elderly (aged 65 years or over) without HBP experienced a lower risk of heart disease mortality than did those who reported a lower intake of caffeinated beverages.
Caffeinated coffee consumption was associated with lower risk of CHD mortality and heart valve disease development or progression in older Framingham subjects without moderate or severe hypertension.

Caffeine May Provide Protection from Parkinson's Disease

- As part of a long-term study of the Honolulu Heart Program, a team of researchers examined the relationship between coffee intake and the incidence of Parkinson's disease.
- Researchers studied 8,004 Japanese-American men over a 30 year period. Of these men, 102 developed Parkinson's disease.
- The incidence of Parkinson's disease was found to be lower in those who drank coffee. In fact, the men who drank the most coffee were the least likely to get Parkinson's disease. Men who did not drink any coffee were five times more likely to exhibit symptoms of Parkinson's disease than men who drank more than 23 ounces of coffee each day. Consumption of caffeine from other sources such as green tea, black tea, chocolate and soda was also associated with a lower risk of Parkinson's disease.
- Caffeine belongs to the xanthine chemical group. A naturally occurring xanthine in the brain called adenosine is used as a neurotransmitter at some synapses. When adenosine receptors are blocked, levels of the neurotransmitter dopamine increase. Caffeine may protect against Parkinson's disease by blocking adenosine receptors, thus increasing the amount of dopamine in the brain.