Tea and theophylline

Coffee, hot chocolate or tea – what to drink? What's good for you? What's not?[1]

Tea has an image of being a healthy drink and there is certainly a lot of recent newsy advice about its potential health benefits due to its anti-oxidant content.

Black tea, green tea, white tea, red tea, herb tea – what to drink?

First, the word "tea" properly refers to drinks made from a shrub *Camellia sinensis*, native to southeastern Asia. Its name tells you that it is a camellia native to China, although the plant is now grown in many subtropical areas. These teas include black, oolong, green, and white tea; the difference among these teas is their decreasing degree of fermentation (oxidation) between when they are picked and when they are packed up and shipped out to consumers.

Second, red tea (rooibos) and herb teas are water solutions of leaves gathered and prepared from other plants. They have no caffeine, or the caffeine related compounds, theophylline (in tea) and theobromine (in tea and chocolate).

Black tea is the most common form of tea available in stores, cafes, and our diets. After the tea leaves are picked, they are "withered" and fermented. Oolong tea has been fermented for less time than black tea, and green tea has not been fermented at all. White tea, which is fairly new to the American market, is prepared from buds and young leaves, which are merely steamed and dried before packaging.

Active chemicals in tea

Tea contains many many compounds, including

- *caffeine,* plus, in lesser amounts, two of its metabolites, *theophylline* and *theobromine*.
- *polyphenols* (aka *flavanoids*) which are the anti-oxidants we read about as being desirable for good health, and
- *fluoride*.

The amount of caffeine and anti-oxidants in brewed tea depends on the amount of tea used, its source, and the length of time the tea is brewed. Since caffeine is very water soluble, a close approximation of decaf tea can be made by soaking tea leaves in hot water for about a minute, discarding the solution, and making new tea from the (mostly) decaffeinated tea leaves.

Theophylline relaxes smooth muscles, so it is used as a treatment for asthma as it makes breathing easier. Although it is often mentioned in connection with tea, it is present in very small

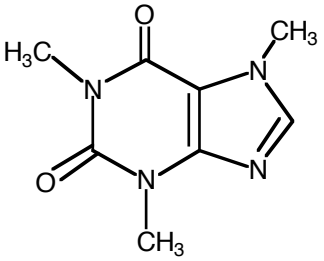
[1] For articles on coffee and chocolate, see previous *Molecule for the Month* entries on this web site.

quantities, on the order of about a milligram per five ounce cup of tea. Compared with the doses in tablets used to treat asthma (~100mg and on up to around 400 mg) this in pretty small potatoes.

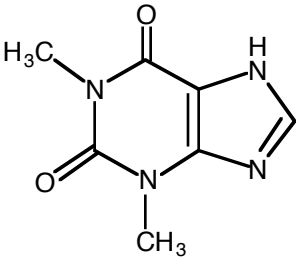
All three compounds, caffeine, theophylline, and theobromine are methyl xanthines; the xanthine structure is made up of the six and five membered rings plus the oxygen atoms, and the methyls are the CH3 groups scattered variously on the ring system. Once inside you, caffeine follows several metabolic pathways, two of which knock off one of the methyl groups to form either theophylline or theobromine

The chemical structures for caffeine, theophylline, and theobromine are shown below:

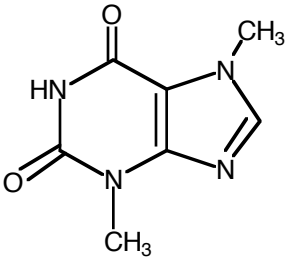
Methyl xanthines in coffee, tea, and chocolate



caffeine
In coffee, tea, and to a lesser extent, chocolate.



theophylline
In tea.



theobromine
In chocolate, with traces in tea.

The quantities of polyphenols[2] present in tea leaves decreases with increased fermentation (also known as oxidation), so white tea and green tea have more anti-oxidants than oolong and black tea, although these fermented teas actually contain compounds formed during the fermentation process that join two of the natural flavanoids together. These compounds, too, have been found to have health benefits.

Green tea, with its high polyphenol content, has a reputation as a health drink and many studies indicate that it might indeed be beneficial for health. Recent studies on black tea show it may have health benefits as well. Between the two, studies indicate that tea might have an effect on heart disease, cancer, arthritis, and even hearing and cancer risks involved in tanning. In some countries where tea drinking is a national sport, tea can be one of the major sources of flavanoids in the diet.

Tea is quite high in fluoride; tea leaves have an unusually fine ability to concentrate fluoride absorbed from the soil and the air. Good information on quantities of fluoride in tea can be hard

[2] The terms polyphenol, flavanoid, anti-oxidant are terms used for the same types of compounds.

to interpret because analyses are done on just "tea" or articles do not make it clear whether the data applies to brewed tea, tea leaves, or tea powder; in addition, different research reports use different units in reporting their analyses. Working through this mess of data leads to the conclusion that teas show a wide variety of fluoride levels, depending on the area the tea was grown, the fluoride content of the water, and the steeping time. Tea can be a major source of fluoride, and for heavy tea drinkers, this might become a health issue. For example, one report cited a serious case of skeletal fluorosis in a person who drank two gallons of reconstituted and very concentrated tea every day!

Assorted chemicals in different types of tea per 5 oz cup:

	Black Tea	Oolong Tea	Green Tea	White Tea
Caffeine	~ 50 mg	~40	~20	~10
Theophylline	~1 mg			
Polyphenols	~1/5 green tea		50 - 150 mg	
Fluoride	~0.25mg	~0.125mg	~0.25	

Other values of fluoride, mostly referring to or recalculating for fluoride in a 5 oz cup of black tea, report 0.5 - 1.4 - 7.8 mg.

How much tea do you need to drink to reap the reported health benefits? "Experts" say: 2 – 10 cups a day! That is quite a range. Of course, there are all sorts of opportunities to buy the purported health benefits in other forms – there are green tea capsules, patches, and other products.

One of the most interesting of these products is, believe it or not, a tea derived from , well, tea, and broccoli. Brassica Tea has been developed by scientists at Johns Hopkins University Medical School; the tea provides antioxidants native to tea, but has added sulforaphane, an antioxidant isolated from broccoli. The web sites for this tea sound like a pharmaceutical ad, promising a guaranteed dose of sulforophane per unit of tea. I have to say, I am intrigued

sulforaphane

So - which tea to drink? Black, oolong, green, white, other? Ads barrage the reader with promises of good health, all based on quite recent and possibly conflicting studies. Tea drinking is an ancient art, scientific research on research is young yet. There is a lot more work to do.

Meanwhile, just enjoy your cup of tea.

Bibliography:

Harold McGee. *On Food and Cooking; The Science and Lore of the Kitchen* (2nd edition). Scribner, 2004. This fascinating book will give you a lot of historical information as well as some details of the processing of tea leaves to give different types of tea.

T. P. Coltate. Food *: The Chemistry of its Components*. 4th ed'n (Royal Society of Chemistry (2002). A wonderful source - more chemical but definitely accessible.

Web resources:
http://lpi.oregonstate.edu/infocenter/phytochemicals/tea/index.html
Health benefits of green and black tea compared:
http://chinesefood.about.com/library/weekly/aa021103a.htm
Brassica Tea:
http://www.brassica.com/press/pr0014.htm

Fluoride concentrations in teas:
http://www.geocities.com/reddingsafewater/fluoridefood.html?1085262215670
http://www.inchem.org/documents/ehc/ehc/ehc227.htm#5.2.2
http://www.medscape.com/viewarticle/498254
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