

Tea and Antioxidant Properties

Introduction

Increasing evidence is highlighting the role antioxidants may have in protecting against certain conditions such as heart disease, stroke and cancers. It has been proposed that the mechanisms leading to these diseases may be promoted by free radicals and that antioxidants may oppose the action of these molecules. In addition to the well known antioxidants such as Vitamins C and E, there is growing research demonstrating the potentially beneficial effects of plant-derived antioxidants, polyphenols, found in fruits, vegetables, nuts, cereals and drinks such as tea and red wine.

Free radicals explained

Free radicals are unstable molecules that include the hydrogen atom, nitric oxide (NO) and reactive oxygen species. These naturally occur in the body as a result of chemical reactions during normal cellular processes. They can also be formed in response to excess pollution, too much UV sunlight and exposure to cigarette smoke. In an attempt to stabilise, they attack other molecules in the body potentially leading to cell damage and triggering the formation of another free radical resulting in a chain reaction. Some scientists believe that this type of free radical action has been implicated in certain chronic and ageing diseases such as cancer, heart disease, stroke, rheumatoid arthritis, cataracts and Alzheimer's disease.

Protective mechanisms of antioxidants

Antioxidants are compounds that help to inhibit the many oxidation reactions caused by free radicals thereby preventing or delaying damage to the cells and tissues. Their mechanisms of action include:-

- Scavenging reactive oxygen and nitrogen free radical species
- Decreasing the localised oxygen concentration thereby reducing molecular oxygen's oxidation potential
- Metabolising lipid peroxides to non-radical products
- Chelating metal ions to prevent the generation of free radicals

In this way antioxidants limit the free radical damage from:-

- Oxidising Low Density Lipoprotein (LDL) cholesterol, which may increase the risk of atherosclerosis
- Promoting platelet adhesion, which can lead to thrombosis thereby increasing the risk of heart disease or stroke
- Damaging the cell's DNA, which may lead to cancer
- Blocking the normal endothelial cell function and vasodilatation in response to nitric oxide, a potential mechanism for heart disease and cancer
- Triggering inflammation
- Impairing immune function

Some antioxidants are synthesised within the cells themselves (endogenous) and others need to be provided in the diet. Table 1 gives examples of antioxidants with established or proposed activity in the body.

Table 1

Endogenous Antioxidants	Antioxidants provided in the diet
Polyamines Melatonin Oestrogen Superoxide dismutase Glutathione peroxidase Catalase Lipoic Acid Caeruloplasmin Albumin Lactoferrin Transferrin	Vitamin E Vitamin C Carotenoids Polyphenols Copper

Sources of dietary antioxidants

Traditionally dietary antioxidants were thought of as Vitamin E and C and the carotenoid β - carotene. In recent years there has been particular interest in the antioxidant activity and health benefits of other phytochemicals. Table 2 lists two examples of phytochemicals and their food sources.

Table 2

Phytochemical	Categories	Sub-category	Food Sources
Carotenoids	Carotene	α -carotene	Carrots, pumpkins, avocados
		β - carotene	Carrots, red peppers, apricots, spinach
	Lycopene		Tomatoes, pink grapefruit, watermelons
	Lutein		Spinach, kale, brussel sprouts
Polyphenols	Flavonoids	Anthocyanins	Berries, red wine, black grapes
		Flavones	Celery, parsley, olives
		Flavonols; Quercetin, Rutin	Tea, apples, onions, wine, garlic
		Flavanols; Catechins	Tea, wine, pears, apples, chocolate
		Flavanones	Citrus fruit
		Isoflavones	Legumes
	Phenolic Acids	Hydroxybenzoic Acid; Gallic Acid,	Berries, Tea, Grapes, Walnuts

		Ellagic Acid, Salicylic Acid, Caffeic Acid	
	Other Phenolic compounds	Capsaicin	Chillies, Peppers
		Tannins	Tea, red wine, grapes

Tea has one of the highest total flavonoid contents of all plants at 15% of the leaf by dry weight¹ and is also the major source of flavonoids in the UK diet, providing approximately 80% of dietary flavonoids for the population as a whole.¹ According to a survey conducted by MAFF, approximately 30mg of flavonoids/ person/ day is consumed in the UK.²

Tea Flavonoids

The types and amounts of flavonoids present in tea will differ dependent on the variety of leaf, growing environment, processing, manufacturing, particle size of ground tea leaves and infusion preparation.^{3,4,5} Green teas contain more of the simple flavonoids called catechins, while the oxidation that the leaves undergo to make black tea converts these simple flavonoids to the more complex varieties called theaflavins and thearubigins. For more information about green and black teas please refer to the fact sheet 'Black and Green Tea: How do they differ?'

Tea flavonoids are water-soluble and one study¹ has shown that a cup of UK tea that has been allowed to brew for 40-60 seconds will typically deliver approximately 140mg of flavonoids, whilst a second carried out by the UK Tea Trade Technical Committee⁶ using typical UK consumer brewing conditions and encompassing the range of blends and bag weights commonly on sale in the UK gives a figure of 125mg/ 235ml serving. The longer the tea is left to brew, the higher the concentration of flavonoids.⁵

Tea flavonoids, in both green tea and black tea, demonstrate antioxidant activity^{7,8,9,10,11,12,13} and while not a replacement for fruit and vegetables, the antioxidant activity of tea has been compared to that of fruit and vegetables in a number of studies. One study concluded that 3 cups of tea a day has approximately the same antioxidant power as eating six apples.¹⁴ Another study found that one or two cups of tea has the same 'radical scavenging capacity' as five portions of fruit and vegetables or 400mg vitamin C equivalents.¹⁵ In fact many common flavonoids are several times more potent than Vitamin C or E.^{16,17}

Health benefits of tea flavonoids

The antioxidant activity and potential health benefits of flavonoids has been well documented and extensively reviewed in the literature.^{18,19,20,21} Interest in this field has resulted in a growth in the amount of research being undertaken in the area of flavonoids and heart disease, cancer and oral health. For more information on these topics please refer to the fact sheets, 'Tea and Cardiovascular Disease', 'Tea and Cancer' and 'Tea and Oral Health'.

Furthermore, because of the accumulating evidence to suggest that oxidative stress plays a pivotal role in neurodegenerative diseases, the effect of tea's polyphenols are now being considered as possible neuroprotective agents in progressive neurodegenerative disorders such as Parkinson's and Alzheimer's diseases. Recent epidemiological studies have shown a reduced risk of Parkinson's disease associated with the consumption of 2 or more cups of tea a day,²² as well as a significant reduction of Parkinson's disease risk in tea drinkers in a Chinese population.²³ As well as antioxidant properties, animal and in-vitro studies suggest that certain polyphenols found in tea may have a protective role through their action on cell signalling pathways as well as their influence on the mortality of neuronal cells.²⁴ However, well controlled, in vivo studies are required to further understand the action of tea polyphenols in the brain.

Absorption of tea flavonoids

Until recently the majority of the research demonstrating the antioxidant activity of tea flavonoids was either using animal models or laboratory cellular studies. Increasing numbers of human studies are now concluding that the body does in fact absorb some of these antioxidants.^{25,26,27,28,29,30,31} For example, enhanced plasma levels of catechins have consistently been found following the consumption of green and black tea, ranging from 0.63–1.8 $\mu\text{mol/L}$ for green and 0.2–0.34 $\mu\text{mol/L}$ for black tea. The plasma levels peaked after 1.5–2.6 hours and were back to baseline within 24 hours. Further research is currently being undertaken on the metabolism, distribution and excretion of tea flavonoids and its metabolites.

As well as being absorbed these flavonoids demonstrate antioxidative potential in vivo.^{10,11,25,26,32,33,34} A number of studies have shown that plasma antioxidant activity peaks 30-60 minutes after moderate tea consumption (1-6 cups). Despite plasma catechin levels being higher following the consumption of green tea compared to black tea, their antioxidant activity is similar.^{12,18} This finding has led to the suggestion that the theaflavins and thearubigens in black tea also have antioxidative potential.³⁵

The addition of milk to tea, as enjoyed by the majority of the UK population, does not appear to affect the bioavailability or antioxidant activity of the tea flavonoids.^{25,26,36,37}

In summary...

It is well known that fruit and vegetables are good sources of antioxidants, however what is less well known is the presence of antioxidants in tea. The major group of antioxidants in tea are flavonoids that appear to be digested, absorbed and metabolised by the body. Furthermore, as well as demonstrating antioxidant activity in vitro they also appear to have antioxidative potential in vivo. The benefit this action may have to promoting good health provides a promising area of research for future human studies.

So as well as eating more fruit and vegetables, antioxidant intake can be topped up by drinking more tea, helping to promote overall health and well-being.

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