Mushrooms & Health 2010: Antioxidant properties

Background

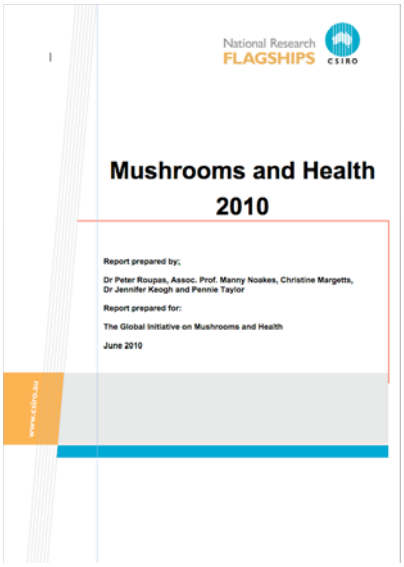
Compiled by Initiative Team Member Glenn Cardwell APD

Antioxidant is an umbrella term to cover the range of compounds in the diet that appear to suppress or counter the oxidation of molecules in the body. In using oxygen, the body produces free radicals, a molecule with one or more unpaired electrons. Such a molecule is unstable and tends to steal electrons from other molecules. Antioxidants neutralise free radicals by donating one of their own electrons while remaining stable, thus helping to protect the body from damage. For example, antioxidants appear to reduce the oxidisability of LDL cholesterol, the type of cholesterol associated with atherosclerosis. Free radicals are also implicated in damaging DNA causing cells to mutate into cancer cells.

There are many types of antioxidants, such as vitamins (eg vitamins C, E), minerals (eg selenium, copper) and a range of non-nutrient compounds (eg carotenoids, bioflavonoids, phenolics). The body produces its own antioxidant compounds, such as superoxide dismutase, catalase and glutathione peroxidase, while benefiting from the additional antioxidants provided in the diet. The ability for antioxidant compounds to protect the body from ill-health seems to work best when antioxidants are provided in the amounts naturally found in a healthy diet rather than through supplementation.

Several large clinical trials using supplements of vitamins C, E and beta-carotene have not shown protection against heart disease. Antioxidant supplements are not recommended by the American Heart Association (http://www.americanheart.org/presenter.jhtml?identifier=4452) or the National Heart Foundation in Australia (http://www.heartfoundation.org.au/SiteCollectionDocuments/Antioxidant_%20QAs_PROFESSIONALS_FINAL.pdf). The studies on antioxidant supplementation and cancer risk have been inconclusive (http://www.cancer.gov/cancertopics/factsheet/prevention/antioxidants). All major health authorities promote the consumption of a range of fruit and vegetables, including mushrooms.

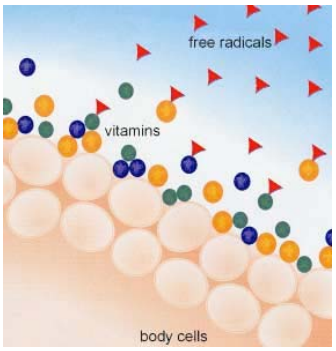
Antioxidants are abundant in plant foods, from fruits and vegetables to tea, coffee, red wine and cocoa. Although not a plant food, antioxidants are also found in mushrooms. As mushrooms reside in their own biological kingdom, there is great interest in their antioxidant profile as it is likely to differ to that of plant food and therefore have the ability to complement the benefits of antioxidants found in plant foods. One example is ergothioneine, a histidine-based amino acid that functions as an antioxidant. It is abundant in mushrooms, yet found in very few vegetables and none of the fruit.



From the Executive Summary

Antioxidant Activity: Significant antioxidant activities *in vitro* have been reported in several varieties of mushrooms, with one study reporting antioxidant capacity comparable to vitamin C. The antioxidant activities appear to be related to the polyphenolic content. Of particular interest is that the antioxidant activity (free radical scavenging activity) along with total phenolic and flavonoid concentrations appear to be similar in mushrooms before and after boiling, suggesting that the antioxidant capacity of mushrooms is thermostable (to heating over 100ºC for extended periods of time e.g. 30 min) and in some cases increases during heating suggesting that antioxidant activity would be maintained in cooked mushrooms. L-ergothioneine is a biologically active antioxidant in mushrooms and its production in mushrooms can be enhanced by addition of histidine to the growth medium/compost.

Antioxidant Properties



*Agaricus bisporu*s (Savoie et al., 2008), *Ganoderma lucidum* (Reishi), *Phellinus rimosus*, *Pleurotus florida* and *Pleurotus pulmonaris* (Ajith and Janardhanan, 2007), *Volvariella volvacea* (Mathew et al., 2008), *Thelephora ganbajun*, *Thelephora aurantiotincta*, *Boletopsis grisea*(Liu et al., 2004a) and others have been reported to have significant antioxidant activities. Of particular interest is that the antioxidant activity (free radical scavenging activity) along with total phenolic and flavonoid concentration of *Agaricus bisporu*s appears to be similar before and after boiling (Jagadish et al., 2009). It has also been suggested that the antioxidant capacities of mushrooms may have a potentially protective effect against a variety of disease states, including some cancers (Matsuzawa, 2006) and irritable bowel disease (Najafzadeh et al., 2007).

Antioxidant activity via inhibition of lipid peroxidation has been described in several studies. The antioxidant effects of *Hypsizygus marmoreus* have been studied for peroxyl and alkoxyl radicals by ordinary, non-tumour-bearing and tumour-bearing mice. Oral administration of the fruit body of *H. marmoreus* exhibited potent anti-tumour or cancer-preventive effects and caused a significant decrease in lipid peroxide levels, which were determined as thiobarbituric acid reactive substances. These results showed that the intake of *H. marmoreus* fruit body could induce an antioxidant effect, and the increase of antioxidant activity in the plasma of tumour-bearing mice was an important mechanism in cancer prevention. It was also suggested that the mushroom might play a role in the decrease of lipid peroxides through antioxidant activity induction (Matsuzawa, 2006).

Ethanol extracts of the mushroom *Phellinus linteus* have been shown to have antioxidant activities comparable to vitamin C in scavenging the stable free radical 1,1-diphenyl-2-picrylhyrazyl (DPPH).

The extracts also inhibited lipid peroxidation (LPO) in a concentration-dependent manner. The study also reported anti-angiogenic activities of *Phellinus linteus*(Song et al., 2003).

A hot water extract from *Ganoderma lucidum* has been shown to have an antioxidative effect against heart toxicity in mice. *Ganoderma lucidum* exhibited a dose-dependent antioxidative effect on lipid peroxidation and superoxide scavenging activity in mouse heart homogenate. Furthermore, this result indicated that heart damage induced by ethanol showed a higher malonic dialdehyde level compared with heart homogenate treated with *Ganoderma lucidum*. The authors concluded that this effect of *Ganoderma lucidum* may protect the heart from superoxide induced damage (Wong et al., 2004).

A more recent study has examined the effects of an extract of *Ganoderma lucidum* for its free-radical scavenging property and for effects on liver mitochondrial antioxidant activity in aged BALB/c mice (50 and 250 mg/kg body weight for 15 days) (Cherian et al., 2009). *G. lucidum* increased antioxidant status in liver mitochondria of aged mice compared with the aged controls. The extract possessed significant 2,2-diphenyl-1-picrylhydrazil (DPPH), 2, 2'-azinobis (3-ethylbenzothiazolin-6-sulphonic acid) (ABTS) radical scavenging activities and ferric reducing antioxidant power (FRAP) as well as superoxide and hydroxyl radical scavenging activities.

In vitro evaluation of antioxidant activities of *Auricularia auricular* has also shown significant inhibition of lipid peroxidation, as well as potent hydroxyl radical scavenging activity when compared to catechin, while crude, boiled and ethanolic extracts were shown to significantly increase nitric oxide (NO) production over the control (Acharya et al., 2004). The natural mushroom pigment Norbadione A and three other pulvinic acids have been shown to display very efficient antioxidant properties in comparison to catechols, flavonoids, stilbenes, or coumarins (Habrant et al., 2009).

Antioxidant activity of submerged cultured mycelium extracts of higher *Basidiomycetes* mushrooms has recently been reported. Antioxidant properties were studied from 28 submerged cultivated mycelium *Basidiomycetes* strains of 25 species. Three solvents - ethanol, water (culture liquid), and ethyl acetate were used for extraction. Water extracts from *Coprinus comatus, Agaricus nevoi*, and *Flammulina velutipes* showed high antioxidant activities (AA) at 2mg/ml. When the ethanol extracts were tested, the highest AA were found in *Agaricus nevoi*, *Omphalotus olearius*, and *Auricularia auricula*-judae extracts at a concentration of 2mg/ml. The AA of ethanol extracts from *Agrocybe aegerita* and *C. comatus* increased from 46.6% to 82.7% and from 2.4% to 62.1%, respectively, when the concentration of the extract increased from 2mg/ml to 4-8mg/ml with the authors suggesting that the extracts could be suitable as antioxidative agents and bioproducts (Asatiani et al., 2007a, Asatiani et al., 2007b).

Antioxidant activities of ten natural p-terphenyl derivatives from the fruiting bodies of three edible mushrooms (*Thelephora ganbajun*, *Thelephora aurantiotincta*, *Boletopsis grisea*) from China have also been reported (Liu et al., 2004b).

In vitro evaluation of antioxidant activities of *Auricularia auric*ular has shown significant inhibition of lipid peroxidation, and potent hydroxyl radical scavenging activity when compared with the drug catechin. The IC_{50} value of crude, boiled and ethanolic extracts of *A. auricula* represented 403, 510, and 373 mg/ml respectively of hydroxyl radical scavenging activity and 310, 572 and 398 mg/ml respectively of lipid peroxidation, while crude, boiled and ethanolic extracts were shown to

significantly increase nitric oxide production (664, 191 and 850 pmole/mg dry wt/h respectively) over the control (Acharya et al., 2004).

Ganoderma lucidum (Reishi), *Phellinus rimosus*, *Pleurotus florida* and *Pleurotus pulmonaris* have also been reported to have significant antioxidant activities (Ajith and Janardhanan, 2007).

The antioxidative potency of commercially available mushrooms in Taiwan has been studied. The order of inhibitory activity of mushroom extracts on oxidation in an emulsion system was *Agaricus bisporus>Hypsizigus marmoreus>Volvariella volvacea>Flammulina velutipes>Pleurotus eryngii>Pleurotus ostreatus>Hericium erinaceus>Lentinula edodes*. In a thermal oxidative stability test, using lard, the order of antioxidative activity of the mushroom extracts showed similar tendencies, except for the extract of *Lentinula edodes*(Fui et al., 2002). Antioxidative activities of *Flammulina velutipes* extract have also been reported to be able to stabilize the fresh colour of tuna meat during ice storage (Bao et al., 2009).

Phenolic Content

Heat treatment of Shiitake (*Lentinus edodes*) significantly increases its antioxidant activity and polyphenolic compounds. The polyphenolic content and antioxidant activities in extracts have been shown to increase as heating temperature and time increased (100 and 121ºC for 15 or 30min). The free polyphenolic content in the extract heated at 121ºC for 30min was increased by 1.9-fold compared to that in the extract from the raw sample. The 2,2-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical and 1,1-diphenyl-2-picrythydrazyl (DPPH) radical scavenging activities were increased by 2.0-fold and 2.2-fold compared to the raw sample, respectively (Choi et al., 2006a). Thermostable antioxidant activity has also been reported from *Agaricus blazei* Murill (Izawa and Inoue, 2004).

The antioxidant activities of two edible mushrooms (*Lentinus edodes* and *Volvariella volvacea*) against lipid peroxidation have been shown to correlate with the phenolic content in different sub-fractions of the mushroom extracts (Cheung and Cheung, 2005). Similarly, significant correlation was found between the total phenolic content from the fruiting bodies of *Agrocybe aegerite* and antioxidant activity in an ethyl acetate fraction and its sub-fractions (Lo and Cheung, 2005). Extracts of *Agaricus blazei, Agrocybe cylindracea*, and *Boletus edulis* have been shown to have significant antioxidant properties with the naturally occurring antioxidant components including total tocopherols (3.18-6.18mg/g) and total phenols (5.67-5.81mg/g) (Tsai et al., 2007).

Antioxidant polyphenols from the mycelial culture of the medicinal fungi *Inonotus Xeranticus* and *Phellinus Linteus* have been isolated and identified as hispidin and its dimers, 3,14'-bihispidinyl, hypholomine B, and 1,1-distyrylpyrylethan. These compounds exhibit potent free radical scavenging activity (Jung et al., 2008).

The antioxidant capacity and total phenolic content of *Agaricus brasiliensis* in two stages of maturity, young (YB) and mature (MB), have been evaluated with minor differences in the composition of phenolic compounds being detected, but with similar antioxidant activities, except for the chelating ability for ferrous ions, which was higher in MB than in YB (Soares et al., 2009).

Total phenols have been shown to be the major antioxidant components in ethanolic extracts in a variety of culinary and medicinal mushrooms (Tsai et al., 2008, Tsai et al., 2009). The antioxidant properties in mushrooms decrease significantly with storage time, with recommendations being made that mushrooms be stored at 4ºC for up to 6 days (Tsai et al., 2008). DPPH (1,1-diphenyl-2-

picrylhydrazyl) activities have also been shown to significantly correlate with total content of phenolic compounds in a variety of edible and medicinal mushrooms (Kim et al., 2008).

Ergothioneine

Ergothioneine is a native membrane-impermeable thiol compound that is specifically accumulated in cells via the organic cation transporter OCTN1. In humans, OCTN1 and ergothioneine have been implicated in the etiopathogenesis of autoimmune disorders. Few foods contain ergothioneine, with highest concentrations detected in specialty mushrooms, kidney, liver, black and red beans, and oat bran. Ergothioneine has been reported to exhibit cell protection only against copper(II)-induced toxicity but is far less potent than glutathione, indicting that ergothioneine is not involved in the intracellular antioxidant thiol defence system (Ey et al., 2007).

L-ergothioneine is a biologically active antioxidant produced by certain fungal species and mycobacterium. The precursors to the synthesis of L-ergothioneine are the amino acids histidine, cysteine, and methionine. Supplementation with L-ergothioneine has been shown to have a protective effect on the organs of rats against lipid peroxidation and to conserve the consumption of endogenous glutathione and alpha-tocopherol (Deiana et al., 2004).

The ergothioneine content of mushrooms has been reported to be in the range of 0.4-2.0mg/g (dry weight). White *Agaricus bisporus* contained the least ergothioneine and portabellas (brown) contained the highest within the varieties of *A. bisporus* studied. The specialty mushrooms tested (*Lentinus edodes, Pleurotus ostreatus, P. eryngii, Grifola frondosa*) all contained a statistically significant greater amount of ergothioneine compared to *A. bisporus*; however, no significant difference was found between the specialty mushrooms studied (Dubost et al., 2006).

An ergothioneine derivative, b-hydroxyergothioneine has been isolated from the mushroom *Lyophyllum connatum*. Ergothioneine,N-hydroxy-N',N'-dimethylurea, and connatin (N-hydroxy-N',N'-dimethylcitrulline) were also isolated. All the compounds displayed the ability to scavenge free radicals, based on a 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay. The radical scavenging activity of b -hydroxyergothioneine was very similar to that of ergothioneine. b-Hydroxyergothioneine showed the greatest protective activity against carbon tetrachloride-induced injury in primary culture hepatocytes (Kimura et al., 2005).

Protein supplement treatments during mushroom growth do not have a significant effect on the amount of L-ergothioneine produced by mushrooms, but the addition of histidine to compost has been reported to significantly increase the amount of L-ergothioneine. Furthermore, L-ergothioneine was increased by up to 1.3mg/g dry weight in later flushes by several stress factors placed on the mycelia, such as dry compost, indicating that L-ergothioneine may be a stress factor. A postharvest shelf-life study has also demonstrated that L-ergothioneine significantly decreased during postharvest storage for up to 6 days at 12ºC (Dubost et al., 2007).

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Heart Foundation™

Q&A

Antioxidants in food, drinks and supplements for cardiovascular health: professionals

Summary of recommendations for adult Australians

Antioxidant sources reviewed	Good choice for heart health	Recommendation
Fruit and vegetables	Yes	At least two serves of fruit per day. At least five serves of vegetables per day.
Tea	Yes	Either black or green tea made with leaves or tea bags. May add reduced, low or no fat milk.
High polyphenol* cocoa	Yes	Use raw cocoa powder in drinks and cooking.
Chocolate	No	Most commercial cocoa and chocolate will be poor sources of antioxidants.
Coffee	Limit	People who already drink coffee should drink less than five cups per day of paper-filtered, percolated, café-style or instant coffee in preference to boiled or plunger coffee.

* Polyphenols are a type of antioxidant.

Antioxidant sources reviewed	Good choice for heart health	Recommendation
Red wine	No	The **amount** of alcohol consumed has more impact on cardiovascular health than the **type** of alcohol consumed. Healthy Australians who already drink alcohol should drink no more than two standard drinks per day.
Antioxidant supplements	No	Combination or individual antioxidant supplements are not recommended for the prevention of cardiovascular disease.

Why did the Heart Foundation review the evidence on antioxidants?

There are many foods, drinks and supplements that claim to have cardiovascular health benefits due to their antioxidant content. Consumer confusion around the health benefits of antioxidants led us to review the evidence and provide recommendations for antioxidants and cardiovascular health.

The scope of foods and drinks included in our review was based on consumer and health professional enquiries to the Heart Foundation. As such, we focused on fruit and vegetables, tea, cocoa, coffee, red wine and supplements.

We know that there are other whole foods, herbs and spices that may contribute to our daily antioxidant intake. We recommend these foods be included as part of a healthy balanced diet.

What is the Heart Foundation's message on antioxidants?

The Heart Foundation's review of antioxidants in food, drinks and supplements for cardiovascular health found that a balanced diet with a wide variety of plant-based foods will provide the antioxidants beneficial for cardiovascular health.

The Heart Foundation has not set daily requirements or limits on antioxidant intake. It would not be useful to set these amounts until food labelling laws require antioxidants to be written on the label.

Even if we know the antioxidant capacity of a food, individuals will absorb and metabolise antioxidants differently. In addition, foods and drinks may have health effects that are independent from their antioxidant component.

Fruit and vegetables

How many serves of fruit and vegetables should people consume?

The Heart Foundation recommends consuming at least two serves of fruit and five serves of vegetables every day, in line with national recommendations.

State and national statistics tell us that slightly more than half the number of Australian adults consume two serves of fruit a day, but that few consume five serves of vegetables a day.

How can people increase their intake of fruit and vegetables?

For ideas on increasing fruit and vegetable intake:
- visit our Healthy Eating webpages at www.heartfoundation.org.au/sites/healthyeating/
- use our free online recipes at www.heartfoundation.org.au/recipes
- buy a cookbook from our online shop at http://heartfoundationshop.com/main_menu/.

Are foods and juices with 'added antioxidants' a better choice than normal foods and juices?

Antioxidants are commonly added to foods such as vegetable oils and processed foods to prevent or delay them going off. However, some foods and drinks may be marketed as being a better choice than others because they have antioxidants added to them.

The Heart Foundation found that whole foods, such as fruit and vegetables, and tea and cocoa are a better choice than foods and drinks with added antioxidants, or using supplements, to boost daily antioxidant intake.

Chocolate

Why is the Heart Foundation recommending raw cocoa powder?

Our scientific review found that consuming high polyphenol cocoa/chocolate reduced risk factors for cardiovascular disease, such as endothelial function and high blood pressure. While the research showed benefits from high polyphenol cocoa/chocolate, everyday products that use high polyphenol cocoa/chocolate are not widely available.

Raw cocoa powder has high levels of polyphenols, and we support using raw cocoa powder in drinks and cooking. Raw cocoa powder is made from raw cocoa beans (cocoa beans that have not been fermented and roasted, a process that can lower their levels of polyphenols). However, roasted cocoa powder is used in most drinking chocolates and commercially available chocolates.

Raw cocoa powder and beans are not widely available in supermarkets, but may be found in health food shops. They can also be purchased from online health food stores.

You can use raw cocoa powder by:
- making a cocoa drink using warm reduced, low or no fat milk
- adding it to drinks
- adding it to fruit smoothies
- sprinkling it on dessert, chopped fruit and salads
- using it in desserts.

Do all chocolates contain antioxidants?

Commercial cocoa powders sold for baking and drinking, and commercial chocolate blocks and bars, lose their original antioxidants through processing. This means they are not good sources of antioxidants.

Will the product's label tell me which chocolates are high in antioxidants?

No, because food labelling laws in Australia don't require the levels of antioxidants in foods to be written on the label. It is very difficult to know if a type of chocolate is high in polyphenols.

Some products are labelled with % cacao (total chocolate liquor, cocoa butter and cocoa powder). The higher the percentage, the less sweetness and more flavour, but this is not an indication of the antioxidant content of the chocolate.

Therefore, we don't recommend some types of chocolate as being a better choice than others.

Isn't dark chocolate healthier than other chocolate?

The term 'dark chocolate' has come to be understood as chocolate with higher levels of cocoa solids and antioxidants, and is generally thought of as being a healthier type of chocolate. But this is not true of all dark chocolate. Some dark chocolate is processed to remove the bitter astringent taste of the antioxidants, and some may have been artificially coloured to make it look darker.

Even good quality dark chocolate that contains some antioxidants may also contain cocoa butter, sugar and whole milk powder, making it high in energy (kJ) and saturated fat. Saturated fat in food raises low-density lipoprotein (LDL) cholesterol, and too much energy can increase weight.

Although a chocolate may contain antioxidants, there are other foods and drinks that are better sources of antioxidants for cardiovascular health that do not have the negative effects of unhealthy fats. These foods include fruit, vegetables, nuts, seeds, wholegrains, cereals, black and green tea, garlic, herbs and spices.

How much chocolate can I eat?

The Heart Foundation suggests limiting sugary, fatty and salty snack foods, such as chocolate, crisps, cakes, pastries, biscuits and lollies, to once a week. Most chocolate will be a poor source of antioxidants.

Tea and coffee

How many cups of tea does the Heart Foundation recommend people have every day, and how should it be prepared?

The Heart Foundation does not set any limit on how many cups of tea people should drink every day, because the longitudinal studies we reviewed did not determine optimal amounts.

The quantity and type of tea someone drinks is up to them. However, we don't recommend that someone gets all of their recommended daily amount of antioxidants from one source. Therefore we suggest that people enjoy a variety of foods and drinks, and include plenty of fruit, vegetables, wholegrains, nuts and seeds.

Remember that adding milk and sugar to tea may increase energy intake, depending on the number of cups consumed. Choose reduced, low or no fat milk.

Which has more antioxidants – tea or coffee?

The major antioxidants (polyphenols) in tea and coffee are flavonoids and phenolic acids.

Because of the differences in processing and preparation, the polyphenols in tea and coffee are difficult to compare.

A cup of green tea may contain up to 200 mg of catechins (a type of polyphenol) and a cup of coffee may contain 70–350 mg of chlorogenic acid (another type of polyphenol). Due to manufacturing, there is also a difference between black and green tea polyphenol content.

While coffee contains thousands of compounds, one group of compounds have attracted particular attention: caffeine, diterpene alcohols and polyphenols. Caffeinated and decaffeinated coffees contain polyphenols, which change greatly depending on how the coffee beans are roasted.

Coffee can provide some polyphenols, but the Heart Foundation recommends fewer than five cups per day and only of paper-filtered, percolated, café-style or instant coffee, as these types of coffee have little effect on LDL cholesterol levels.

Do herbal teas contribute to daily antioxidant intake?

Yes, herbal teas contribute to daily antioxidant intake because they contain some polyphenols.

Why is paper-filtered, percolated, café-style or instant coffee preferable to boiled or plunger coffee?

Coffee contains oils that raise LDL cholesterol levels. These oils are removed though paper, so instant coffee or coffee that is filtered through paper or the fine metal filter on an espresso machine won't contain these oils.

Coffee made with a plunger or by boiling grounds on the stove top (such as Greek or Turkish boiled coffee) contains the oils at levels that will raise LDL cholesterol more than paper-filtered (drip coffee), café-style (such as espresso, latte and cappuccino) or instant (regular and decaffeinated) coffee.

Red wine

Can red wine help to prevent cardiovascular disease?

The Heart Foundation found a lack of consistent evidence to confirm that the antioxidants in red wine can either prevent cardiovascular disease or be beneficial after a heart attack.

It is more important to abstain from drinking or if you drink alcohol, to avoid binge drinking to maintain long-term health. Therefore the **quantity** of alcohol drunk is more important than the **type** of alcohol drunk.

While red wine contains a variety of polyphenols (the amount varies greatly between each bottle), red wine is not a good source of antioxidants for preventing coronary heart disease or maintaining cardiovascular health.

How much alcohol can someone drink and still be healthy?

The Australian National Health and Medical Research Council recommends that healthy men and women drink no more than two standard drinks a day to reduce their risk of harm from alcohol-related disease or injury.[†]

These guidelines use the Australian standard drink, which is defined as containing 10 g of alcohol (equivalent to 12.5 mL of pure alcohol, 30 mL of spirits, 100 mL of wine, and 375 mL of beer).

If you drink alcohol, the Heart Foundation recommends you follow the above guidelines.

Supplements

Are antioxidant supplements beneficial for cardiovascular health?

Currently, there is insufficient data to recommend the consumption of a combination of antioxidants or individual antioxidant vitamin supplements for the prevention or treatment of coronary heart disease.

The best way to ensure adequate antioxidant intake is to eat a variety of plant-based foods, such as vegetables, fruits, legumes, wholegrain breads and cereals, nuts and seeds every day.

Further information

For more information, please contact the Heart Foundation's Health Information Service on 1300 36 27 87 (for the cost of a local call), email health@heartfoundation.org.au or visit www.heartfoundation.org.au.

For a detailed discussion of the evidence, please refer to the Heart Foundation's summary of evidence *Antioxidants in food, drinks and supplements for cardiovascular health*, available at www.heartfoundation.org.au/Professional_Information/Lifestyle_Risks/Nutrition.

[†] National Health and Medical Research Council. Australian Guidelines to Reduce Health Risks from Drinking Alcohol. Canberra: National Health and Medical Research Council, 2009.