

An Apple a Day...

Australian Apples Health Report



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INTRODUCTION

Developed countries are burdened by an increasing rate of obesity, and it is widely known that lifestyle related diseases are a serious health issue. The latest National Health Survey, released in February 2006, highlights the prevalence of the problem in Australia: over the past decade, the proportion of obese adults (based on BMI) has jumped from 52 to 62 per cent among men and from 37 to 45 per cent in women [1].

Regular and frequent intake of fruits and vegetables has consistently been associated with a decreased risk of developing chronic diseases, such as cardiovascular disease and cancer.

Apples in particular have been shown to exert positive effects on a range of chronic health conditions: epidemiological studies indicate a beneficial effect of apples on reducing the risk of a range of cancers, cardiovascular disease, asthma, diabetes and weight loss.

Apples are a major contributor of important phytochemicals – bioactive compounds which have been identified as providing positive health effects – in human diets. Laboratory studies have found apples to have strong antioxidant and anti-proliferative properties related to their phytochemical profile. Thus, phytochemicals, combined with other nutrients provided by apples (and pears) contribute to reduced oxidative stress and improved health outcomes.

The type and amount of phytochemicals in apples may vary according to the variety and portion of the apple consumed. Recent research shows that apple peel contains almost 50% of the total phytochemical content of whole apple. **Unpeeled apples provide a range of health benefits and studies indicate that an apple a day really does keep the doctor away.**

With strong epidemiological evidence showing a positive association between apples and health, further research is now using animals and in vitro laboratory techniques to help provide a clearer understanding of *how* apples exert beneficial health effects. For example, a 2006 study has shown that supplementation with apples provided a greater beneficial effect when compared to other fruits for decreasing oxidative stress [2]. This study used pigs as a model for humans, and found the antioxidant effects of apples protected cells against DNA damage from oxidative stress.



Health Benefits

Cancer

There is significant research evidence indicating a protective effect of fruit on a range of cancers, however the extent of protection is an issue that continues to be widely debated. In recent years, apples have been considered independently and there are a number of studies which report a favourable effect of apple consumption on cancers of the breast [3,4,5,6], stomach [7], lung [8,9,10,11], colon [12], mouth [13] and kidney [14].

In 2005, a study was conducted to better understand the role of apples on the risk of cancer at several sites [15]. This Italian study of over 7,000 subjects found inverse associations between intake of at least one apple per day (compared to intake of less than one apple per day) and the risk of a range of cancers. The association was greatest for prostate cancer, followed by oral, oesophageal, breast, ovarian and colorectum cancer, with a relationship also identified for cancer of the larynx. This study considered other potential protective factors such as intake of other fruit and vegetables in order to clearly identify the independent positive health effects of apples.

Another 2005 study showed that whole apple extracts prevent mammary cancer in a rat model, with increased protection as intake increases [16]. Doses used in this study were comparable to human consumption of either one, three or six apples, indicating that a **higher intake may provide improved health outcomes and that apple consumption may be an effective way to reduce the risk of cancer development in humans.**

There is particular evidence for the protective effect of apples on lung cancer risk. A study of over 77,000 women and 47,000 men showed a decreased risk of lung cancer risk for women with fruit and vegetable intake. Apples and pears were found to have one of the most significant associations with reduced risk of lung cancer, with consumption of at least one serving of apples and pears per day [11].

An Hawaiian study compared 582 patients with lung cancer to matched controls subjects and found apple intake to be associated with reduced risk of lung cancer in women, and also men [8]. An association was observed between lung cancer and quercetin intake, although it did not reach a level of significance.



A study of 10,000 men and women in Finland observed an inverse association between flavonoid intake and lung cancer, with 95% of the flavonoid intake coming from quercetin. Significantly, apples were the only specific food to provide an inverse relationship [17].

Apples (rich in epicatechin) have been shown to exert a protective effect for lung cancer independent of catechin consumption, suggesting that catechins may work with other compounds to exert protective effect on lungs.

Recent laboratory studies investigating the mechanisms behind the positive effect of apples on cancer development have shown that apple flavonoids can inhibit colon cancer cell growth and proliferation and may also modulate gene expression involved in cancer development [18]. Different phytochemicals such as epicatechin, chlorogenic acid and phloridzin may play different roles and work together in the process of reducing the oxidative cell damage in human colon cells.

It is predicted that various phytochemicals may interact to protect against cancer, and that various flavonoids may have a particular influence on a range of cancer-related biological pathways [19].

Cardiovascular disease

Apples contain procyanidins, a subclass of flavonoids, that have been linked to a range of positive effects on the vascular system, including decreased platelet aggregation, decreased LDL and increased HDL concentrations, decreased LDL oxidation, decreased blood pressure, increased plasma homocysteine and vitamin B6 concentrations [20].

Quercetin is another strong antioxidant found in apples that accumulates in the blood and has been shown to protect against cardiovascular disease [21]. A study of 40,000 women found that subjects ingesting apples had a 13-22% decreased risk of cardiovascular disease and cardiovascular events [22].

Apple catechins and epicatechins have been found to be more strongly associated with coronary heart disease mortality compared to the catechins in tea, in a study of 35,000 post-menopausal women [23]. A Finnish cohort study found that apple intake was associated with reduced risk of thrombotic stroke among over 9,000 men and women [24]. However, no independent effect was observed between the flavonoid quercetin and cerebrovascular disease.



These results indicate that it may not be quercetin in isolation that exerts beneficial effects, but a combination of phytochemicals and other nutrients in apples that may provide protection against disease.

The Zutphen Elderly study in 1993 examined the association between flavonoids and coronary heart disease and showed that apple intake was related to a reduced risk of coronary heart disease in 805 men aged 65-84 years [25]. This study found flavonoid intake to be inversely associated with mortality from coronary heart disease and mild association with incidence of myocardial infarction. A later study in Finland showed that among a group of over 5000 adults, those with a very low intake of flavonoids had a higher risk of coronary disease [26].

There is some evidence that apples inhibit the oxidation of LDL cholesterol, therefore improving blood lipid profile [27]. This study indicated a more pronounced effect of peel, compared to whole fruit, and whole fruit was more effective than juice. A 2002 study showed that dietary supplementation with apples, and to a lesser extent pears, can improve lipids in rats fed with extra cholesterol [28].

The antioxidant and anti-proliferative effects of the phytochemicals in apples are predicted mechanisms for the protective effects on cardiovascular disease risk. It is important to remember that apples (and pears) also contain soluble fibre which has been shown to be protective for cardiovascular disease. Apples are a fat-free snack that can potentially take the place of higher fat foods that can contribute to the development of cardiovascular disease, therefore providing indirect protection.

Asthma/lung function

There has been recent interest in the role of dietary intake and the prevalence of asthma. A study in 2003 showed that good lung function (measured by forced expiratory volume) was associated with high intakes of apples and the frequent consumption of fruit juices [29]. Of the 2,512 male subjects, those consuming five or more apples per week had significantly better lung function (lung capacity increased by 168 millilitres).



A 2001 study in the UK indicated that two apples per week was associated with a reduced incidence of asthma [30]. A large Finnish study of 10,000 men and women showed apple intake to be associated with a reduced incidence of asthma, related to flavonoid intake and particularly quercetin, with no association observed with other fruit and vegetables [31].

A recent Australian study of 1,600 adults observed an association between apple and pear intake and decreased risk of asthma and bronchial hypersensitivity [32]. A 2006 study of 68,535 women in France also showed a decreasing trend in adult asthma prevalence with an increasing intake of apples [33].

In the Netherlands, a study of 13,000 adults showed that apple and pear intake was positively associated with pulmonary function and reduced incidence of chronic obstructive pulmonary disease [34].

More research into the effect of apples and pears on asthma and pulmonary function is required to determine the mechanisms for observed beneficial effects.

Diabetes

The antioxidant benefits of apples have been well investigated for cancer and cardiovascular disease, however a recent study has shown that apples are also associated with reduced risk of Type 2 diabetes [35]. This study investigated the role of individual flavonoids and flavonoid rich foods on type 2 diabetes and insulin resistance in 38,018 women. No association was observed between individual flavonoids, however apple and tea consumption was associated with reduced risk of Type 2 diabetes. Women who consumed one or more apples per day had a significant 28% less risk of type 2 diabetes compared to women who consumed no apples. The effect of tea was less significant.

These results indicate that flavonoids alone may not influence health, but the combination of nutrients in apples provides a protective effect against development of Type 2 diabetes.



The study by Knekt et.al. in 2002 [31] showed not only an association of apple intake with reduced incidence of asthma, but also reduced risk for Type 2 diabetes. Quercetin intake was one component of apples observed to be associated with a decreased risk of Type 2 diabetes. Other foods high in quercetin did not provide the same protective effects as apples, which reinforces the suggestion that it is the combined effect of multiple components in apples that provides benefits.

Weight loss

Increased fruit and vegetable intake is often recommended for weight loss and a recent study has observed that apples and pears specifically promotes weight loss in overweight women [36]. Amongst a group of 411 Brazilian women following a hypocaloric diet designed for weight loss for 12 weeks, the subjects including either three apples or three pears per day lost more weight. Those consuming apples or pears were found to have a greater reduction in energy intake and also lower blood glucose levels.

Researchers indicate the enhanced weight loss with the inclusion of fruit may be related to the fibre content and low glycemic index (GI) effect on satiety, leading to increased feelings of fullness. Fruits also have a high water content and low-energy density which also helps to reduce total daily kilojoule intake.

Age-related memory loss

An exciting new study indicates that apples and apple juice can help protect our brain cells from oxidative damage as we age, and lead to improved memory and brain function [37]. The study used mice as a human model and showed a greater positive effect of apples on the brains of aged mice compared to younger adult mice. Stronger mental acuity resulted when the aged mice consumed the human equivalent of 2-3 cups of apple juice or approximately 2-4 apples per day. It is suggested that the antioxidants found in apples are responsible for the observed protective effect on brain health.

Hair-growth

The health benefits of apples are remarkable, and studies show that procyanidin B2 in apples promotes hair growth. A 2002 study showed that procyanidin B2 promote hair epithelial cell growth [38].



PHYTOCHEMICALS IN APPLES

Phytochemicals are the non-nutrient compounds found in plants. Thousands of phytochemicals have been identified, however it is likely there are many present in foods that may have positive health effects yet to be identified. Phytochemicals play an important role in protecting from oxidation.

The phytochemicals found in apples include phenolics and flavonoids. The predominant flavonoids in apples are strong antioxidants such as quercetin, epicatechin and procyanidin B(2). Chlorogenic acid and phloridzin are further phytochemicals also found in apples that may have protective effects against colon cancer.

Polyphenols

There are a number of classes of polyphenols with a range of effects on humans. These compounds reach concentrations in the blood stream that exert positive health effects.

Flavonoids

Flavonoids are a major class of phytochemicals and apples are a rich source. Studies in the US, Finland and the Netherlands show that apples provide a significant percentage of the total dietary flavonoids consumed [31,39,25].

Epicatechin is a flavonoid, apples and pears were found to be the second greatest dietary source behind tea for adults and elderly in a Dutch study of 6,200 men and women [40]. Catechins have been observed in human intervention studies to increase plasma antioxidant activity and should be taken into account when studying the relationship between diet and chronic diseases. Catechins may have particular effects on protection of LDL from oxidation.

Quercetin is a major flavonoid and strong antioxidant and potentially may effect carcinogenesis. Quercetin is found at high concentrations in onions, apples, red wine, broccoli and tea [20].

Procyanidins

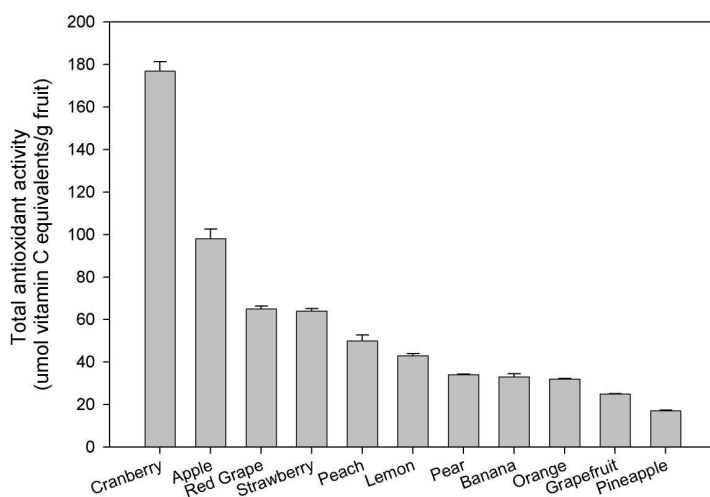
Procyanidins are oligomeric catechins, a subclass of flavonoids. Scientific studies have shown apples to be the richest source of procyanidins compared to a range of other foods [41].



They exert significant effects on the vascular system, particularly due to antioxidant activity. Procyanidins are usually present in conjunction with epicatechin, therefore it is difficult to differentiate whether observed health effects are related to procyanidins, epicatechin, or the interaction of both compounds [20].

Antioxidant activity

Apples have the second highest level of antioxidant activity and phenolic compounds, behind only cranberries, in comparison to other commonly consumed fruits [9,42]. The antioxidant activity is comes mostly from flavonoids (quercetin, epicatechin and procyanidin B2).



Antioxidant activity of various fruit extracts [42]

APPLE VARIETIES

The evidence is clear that apples contain phytochemicals that can play an important role in reducing the risk of chronic lifestyle diseases, but the type of apple you choose may also influence health outcomes. A 2000 study found the highest amount of procyanidins in Red Delicious and Granny Smith apples [41]. However, procyanadins are only one of the many phytochemicals in apples and it may be that other varieties have higher amounts of other components. Regardless, all apples contain a range of essential phytochemicals and nutrients to provide beneficial health effects.



PULP Vs. PEEL

A number of studies have investigated the phytochemical concentrations and antioxidant activity of various apple components. All components have been found to provide antioxidant activity, however the most concentrated source is the peel. A recent study of apples grown in New Zealand found that 46% of the polyphenolics in whole apples were found in the skin and all of the flavonols (quercetin) was found in the skin [42]. Another earlier study also indicated that the type of phytochemicals differed between peel and pulp. Peels were found to be richest in flavonols epicatechin and procyanadins [43].

Apple peel – the new super supplement?

With the amount of apple pulp being used for production of commercial apple products, there is most certainly a lot of apple peel as a by-product. With the peel being the most phytochemical rich portion of the fruit, there is increasing interest in the conversion of peels into an antioxidant rich powder supplement. Blanched, freeze-dried apple peels have been found to have high phenolic, flavonoid and anthocyanin contents, and one gram of powdered peel was found to have an antioxidant activity equivalent to 220mg of Vitamin C [44].

FUTURE DIRECTIONS/ PRACTICAL IMPLICATIONS

Apples are a popular fruit due to their availability, and ease of storage and transport. The phytochemicals and antioxidant activity in apples have been found to not be greatly affected by storage conditions, even after 52 weeks of storage in controlled atmospheric conditions or 25 weeks cold storage [45]. Other studies also indicate that cold storage for up to 9 months has little effect on apple phenolic content [46,47].

Apples are a delicious and versatile fruit that can be prepared and consumed in a variety of ways, making it easy to consume on a daily basis. Daily consumption of apples and pears provides variety, taste and a host of health benefits. It seems that it is the combination of a range of factors, rather than one particular phytochemical or nutrient that gives apples their unique health effects and makes them an essential daily snack.



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