

PG & RESEARCH DEPARTMENT OF ZOOLOGY
MUSLIM ARTS COLLEGE
 (Affiliated to Manonmaniam Sundaranar University)
 Thiruvithancode-629174, Kanyakumari District,
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 On

**CURRENT ENVIRONMENTAL ISSUES
 AND MEASURES OF MITIGATION
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This is to certify that Prof./Dr./Mr./Mrs./Ms. N. MATHAN Assistant Professor
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 *Recent Advances in Health Benefits of Phytochemicals and their Applications*
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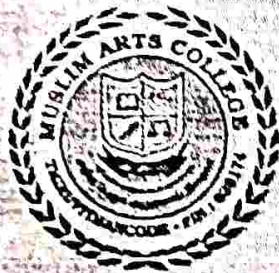
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A REVIEW ARTICLE RELATED TO HEALTH BENEFITS & PHYTOCHEMICALS OF APPLE FRUIT

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Abstract

Apples are a widely consumed, rich source of phytochemicals, and epidemiological studies have shown that consumption of apples with reduced risk of some cancers, cardiovascular disease, asthma, and diabetes. In laboratory, apples have been found to have very strong antioxidant activity, inhibit cancer cell proliferation, reduce lipid oxidation, and lower cholesterol. Apples contain a variety of phytochemicals, including quercetin, kaempferol, phloridzin and chlorogenic acid, all of which are strong antioxidants. The phytochemical composition of apples varies greatly between different varieties of apples, and there are also small changes in phytochemicals during the maturation and ripening of the fruit. Storage has little to no effect on apple phytochemicals, but processing can greatly affect the levels of phytochemicals. The purpose of this paper is to review the most recent literature regarding the health benefits of apples and their phytochemicals, phytochemical bioavailability and antioxidant behavior.

Keywords: apples, antioxidants, phytochemicals, cancer, cardiovascular disease, phenolics, flavonoids, fruit

Introduction

In the United States, as well as in most industrialized countries, cardiovascular disease and cancer are ranked as the top two leading causes of death. The causes of both diseases have been linked to lifestyle choices, and one of the most important is diet. It has been estimated that a healthy diet could prevent approximately 30% of all cancers [Doll R, et al, 1981, Willett W.1995]. High cholesterol and obesity are greatly influenced by diet and lifestyle and are costing the United States billions of dollars in health-related expenses. High cholesterol, a risk factor for cardiovascular disease, is commonly treated with statin drugs, and it has been estimated that the United States will spend 30 billion dollars per year on cholesterol treatment by statin drugs [Woffram S et al, 2002]. In 1998, obesity, a risk factor for cardiovascular disease, cancer, and diabetes, has been estimated to cost the United States over 92 billion dollars per year [Finkelstein EA et al 2003]. Understanding the effects of diet on chronic disease may greatly aid in the prevention of chronic disease.

As children, many of us were told to "eat your vegetables because they are good for you", and the adage "an apple a day keeps the doctor away" is still quite popular. Recently, many studies have provided the scientific backing for both of these very common phrases. In the early 1990's, researchers examined well over one hundred epidemiological studies relating to diet and cancer, and in 128 of 156 dietary studies, fruits and vegetables had a significant protective effect against a variety of different cancers [Wood

al 1992]. They found that those who consumed low amounts of fruits and vegetables were 50% as likely to have cancer compared to those who ate high amounts of fruits and vegetables. Recently, a study linked intake of fruits and vegetables with a reduced risk in breast cancer. A woman in China [Malin A, et al 2005]. In a population based, case-control study of women in Shanghai, pre-menopausal women who ate more dark yellow-orange vegetables and more fruits tended to have lower breast cancer risk. Fruit and vegetable intake also appears to have a protective effect against coronary heart disease [Joshipura K, et al 2001]. Approximately 10,000 women were followed for 14 years and 10,000 men were followed for 8 years. They found that people who ate the highest amount of fruits and vegetables had a 20% lower risk for coronary heart disease, and the lowest risks were seen in people who consumed more green leafy vegetables, and fruits rich in vitamin C. It may be that a diet high in fruits and vegetables may help protect against a variety of other chronic diseases. For example, a diet high in fruits and vegetables may help protect against cataracts, Alzheimer disease, and even asthma [Wood et al 2003].

A major class of phytochemicals found commonly in fruits and vegetables are the flavonoids. Flavonoids are a very significant source of flavonoids in people's diet in the US and in Europe. In the United States, twenty-two percent of the phytochemicals in apples

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A major class of phytochemicals found in fruits and vegetables are the flavonoids. Flavonoids are a very significant source of antioxidants in people's diet in the US and in Europe. In the United States, twenty-two percent of the phytochemicals consumed from fruits are from apples and in Europe, they are the largest source of phenolics [Viscusi et al 2003].

al 2001]. In Finland, apples and onions are main sources of dietary flavonoids, while in the Netherlands apples rank third behind tea and onions as top sources of flavonoids [Hertog M, et al 1993]. In a Finnish study of approximately 10,000 people, flavonoid intake was associated with a lower total mortality [Knekt P, et al 2002]. Apples were one of the main sources of dietary flavonoids that showed the strongest associations with decreased mortality.

Not only are apples commonly enjoyed by many cultures, but they are also a good source of antioxidants. When compared to many other commonly consumed fruits in the United States, apples had the second highest level of antioxidant activity. Apples also ranked the second for total concentration of phenolic compounds, and perhaps more importantly, apples had the highest portion of free phenolics when compared to other fruits [Sun J, et al 2002]. This means that these compounds are not bound to other compounds in the fruits, and the phenolics may be more available for eventual absorption into the bloodstream.

Health Benefits of Apple

Cancer

Several studies have specifically linked apple consumption with a reduced risk for cancer, especially lung cancer. In the Nurses' Health Study and the Health Professionals' Follow-up Study, involving over 77,000 women and 47,000 men, fruit and vegetable intake was associated with a 21% reduced risk in lung cancer risk in women, but this association was not seen in men [Feskanich D, et al 2000]. Very few of the individual fruits and vegetables examined had a significant effect on lung cancer risk in women, however apples were one of the individual fruits associated with a decreased risk in lung cancer. Women who consumed at least one serving per day of apples and pears had a reduced risk of lung cancer [Feskanich D, et al 2000]. Of the men involved, there was no association seen between any individual fruit or vegetable and lung cancer risk.

Cardiovascular Disease

A reduced risk of cardiovascular disease has been associated with apple consumption. The Women's Health Study surveyed nearly 40,000 women with a 6.9-year follow-up, and examined the association between flavonoids and cardiovascular disease [Sesso H, et al 2003].

Women ingesting the highest amounts of flavonoids had a 35% reduction in risk of cardiovascular events. Flavonoid intake was not associated with risk of stroke, myocardial infarction, or cardiovascular disease death. Quercetin did not have any association with cardiovascular disease, cardiovascular events, myocardial infarction or stroke. However, both apple intake and broccoli intake were associated with reductions in the risk of both cardiovascular disease and cardiovascular events. Women ingesting apples had a 13-22% decrease in cardiovascular disease risk.

Diabetes and Weight Loss

Not only may apples help decrease the risk of heart disease, cancer, and asthma, but apple consumption may also be associated with a lower risk for diabetes. In the previously discussed Finnish study of 10,000 people, a reduced risk of Type II diabetes was associated with apple consumption [Knekt P, et al 2002]. Higher quercetin intake, a major component of apple peels, was also associated with a decreased risk in type II diabetes. Myrectin and berry intake were also associated with a decreased risk in type II diabetes, but onion, orange, grapefruit and white cabbage intake were not associated with a lowered risk.

Apple and pear intake has also been associated with weight loss in middle aged overweight women in Brazil [De Oliveira M, et al 2003]. Approximately 400 hypercholesteremic, but non-smoking, women were randomized to one of three supplement groups: oat cookies, apples or pears, and each subject consumed one of each supplement three times per day for twelve weeks. The participants who consumed either of the fruits had a significant weight loss after 12 weeks of 1.21 kg, whereas those consuming the oat cookies did not have a significant weight loss. Those consuming fruit also had a significantly lower blood glucose level when compared to those consuming the oat cookies [De Oliveira M, et al 2003].

Antiproliferative Activity

Apples have been shown to have potent antiproliferative activity in several studies. When Caco-2 colon cancer cells were treated with apple extracts, cell proliferation was inhibited in a dose-dependent manner reaching a maximum inhibition of 43% at a dose of 50 mg/mL. The same trend was seen in Hep G2 liver cancer cells with

maximal inhibition reaching 57% at a dose of 50 mg/mL [Eberhardt M, et al 2000]. proposed that it is the unique combination of phytochemicals in the apples that are responsible for inhibiting the growth of tumor cells. Apples had the third highest antiproliferative activity when compared to eleven other commonly consumed fruits [Sun J, et al 2002].

Different varieties of apples had different effects on liver cancer cell proliferation [Liu RH, et al 2001]. At a dose of 50 mg/mL, Fuji apple extracts inhibited Hep G2 cell proliferation by 39% and Red Delicious extracts inhibited cell proliferation by 57%. Northern Spy apples had no effect on cell proliferation [Liu RH, et al 2001]. Apples without peels were significantly less effective in inhibiting Hep G2 cell proliferation when compared to apples with the peel, suggesting that apple peels possess significant antiproliferative activity. Wolfe et al. [Wolfe K, et al 2003] demonstrated that apple peels alone inhibited Hep G2 cell proliferation significantly more than whole apples. For example, apple peels from Idared apples had an EC_{50} of 13.6 mg/mL whereas the whole apple had an EC_{50} of 125.1 mg/mL. The EC_{50} refers to the dose of the apple that is required to inhibit cell proliferation by 50%.

Summary

Based on these epidemiological studies, it appears that apples may play a large role in reducing the risk of a wide variety of chronic disease and maintaining a healthy lifestyle in general. Of the papers reviewed, apples were most consistently associated with reduced risk of cancer, heart disease, asthma, and type II diabetes when compared to other fruits and vegetables and other sources of flavonoids. Apple consumption was also positively associated with increased lung function and increased weight loss. Partially because of such strong epidemiological evidence supporting the health benefits in apples, there is increasing research using animal and *in vitro* models that attempts to more clearly explain these health benefits.

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