



Apple As A Functional Food

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Abstract

Many studies are being carried out in order to expose and determine the beneficial health effects of fresh fruits and vegetables. Together with these activities, there is an increased consumer interest on fresh fruits and vegetables. Among the fruits, apple has come into prominence because of its beneficial effects. Apple is known since ancient times and praised in inscriptions for its therapeutic properties. Apple contains valuable compounds especially phenolics and flavonoids. Latest researches have shown that apple can reduce the risk of prostate and lung cancer. Also, it reduces the risk of cardiovascular disease, other chronic diseases and DNA damage. In addition to these features, rich content of fiber effectively assist in the activities of cardiovascular system, weight loss and control of cholesterol. This study is aimed to set a collective perspective about the beneficial health effect of apple together with; relation between the beneficial effects and apple nutrients according to the recent scientific studies.

Key words: Apple, apple antioxidant, functional food

Fonksiyonel Bir Meyve Olarak Elma

Özet

Günümüzde taze meyve ve sebzelerin sahip oldukları fonksiyonel özelliklerinin ortaya konması amacıyla birçok bilimsel araştırma yürütülmektedir. Bu çalışmalara paralel olarak tüketicilerin sebze ve meyvelere olan ilgisi artış göstermiştir. Elma sahip olduğu faydalı etkiler nedeniyle öne çıkan bir meyvedir. Elma eski çağlardan beri bilinen bir meyvedir ve tedavi edici özellikleri nedeniyle tarihi yazıtlarda övülmektedir. Son yıllarda yürütülen araştırmalar elmanın, prostat ve akciğer kanserine yakalanma riskini azalttığını göstermiştir. Ayrıca kalp damar rahatsızlıklarına, kronik hastalıklara yakalanma riskini ve DNA hasarını azaltan değerli antioksidan bileşenler de içermektedir. Bu özelliklerine ilaveten, zengin lif içeriği kalın bağırsak faaliyetlerine yardımcı olmasının yanında kalp hastalıklarında, kilo vermede ve kolesterolün kontrolünde etkilidir. Bu araştırmada elmanın sahip olduğu fonksiyonel özellikler hakkında yapılan son bilimsel çalışmalar derlenerek, tüketici sağlığı üzerine olan etkilerine ve faydalı etkiler ile elma bileşenleri arasındaki ilişkilere toplu bir bakış açısı sağlanmaya çalışılmıştır.

Anahtar Kelimeler: Elma, elma antioksidanları, fonksiyonel gıda

INTRODUCTION

Specifically, the increase in dietary intake of fresh fruit and vegetables might be more effective than a dietary supplement, due to the synergistic effects of antioxidant combinations [1]. Apples are one of the more common fruits consumed on a regular basis by many cultures [2]. Apple fruit contain several health and sensory related constituents including dietary fibre, sugars, vitamins and phenolic compounds. Antioxidant capacity of apple is, however, mostly attributed to phenolic compounds such as flavonoids and phenolic acids [3,4]. There is strong evidence for a preventative effect of phenolic compounds on age-related diseases, including cardiovascular disease and cancer [2,5]. Indeed, 100g of fresh apple has an antioxidant activity equivalent to 1500mg of vitamin C [3].

The World Health Organisation identifies diet as a critical risk factor in the development and progression of this disease and the protective role of high levels of fruit and vegetable consumption. Several studies have shown that apples contain several phenolic compounds that are potent anti-oxidants in humans [6]. The major classes of flavonoids present in apple fruit are flavonols (quercetin glycosides), flavanols (catechin, epicatechin and procyanidins), dihydrochalcones (phloridzin) and anthocyanins (cyanidin glycosides), whereas the major phenolic acid is chlorogenic acid [7,8]. Phytochemicals present in apples were found to contribute over 80% of the antioxidant capacity of the cultivars used [4]. Apples have the second highest phenolic content after cranberries in a wide range of commonly consumed fruits [9].

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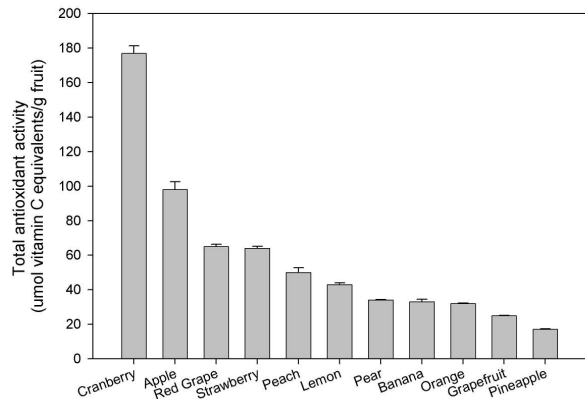


Fig.1. Antioxidant activity of various fruit extracts (mean \pm SD, n = 3) [2].

Apples also have a higher proportion of unbound or free phenols than other common fruits such as oranges and strawberries. Unlike bound phenols, free phenols are available to interact with other molecules [6]. It has been estimated that 22% of the dietary phenolics consumed from apples [10]. The aim of this paper is to review the most recent literature regarding the health benefits of fresh apples and to establish relations between beneficial effects and specific apple phytochemicals.

HEALTH BENEFITS OF FRESH APPLE

Prevention from Cancer

Only a few of the individual fruits and vegetables 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 [11]. In a case control study in Hawaii, it was found that apple and onion intake was associated with a reduced risk of lung cancer in both males and females [12]. Apples were significantly inversely associated with lung cancer, and may suggest that catechins alone do not have an effect against lung cancer. Other data from the Zutphen Elderly study showed an inverse association between fruit and vegetable flavonoids and total cancer incidence and tumors of the alimentary and respiratory tract [13].

It is thought that a healthy diet high in fruit and vegetables could significantly alter the incidence of 50–80% of colorectal cancers [14,15]. Chemical analysis of the apple extract indicated that it contained bioactive compounds that have been linked with protective effects both in colorectal and other cancers [16,17].

Apples, and especially apple peels, have been found to have a potent antioxidant activity and can greatly inhibit the growth of liver cancer and colon cancer cells [18,19]. Also The fiber content, while less than in most other fruits, helps regulate bowel movements and may thus reduce the risk of colon cancer [20]. The total antioxidant activity of apples with the peel was approximately 83 μmol vitamin C equivalents, which means that the antioxidant activity of 100g apples (about one serving of apple) is equivalent to about 1500mg of vitamin C. However, the amount of vitamin C in 100g of apples is only about 5.7mg [19]. Apple flavonoids from an apple extract inhibit colon cancer cell growth and significantly modulate expression of genes related to xenobiotic metabolism. apple flavonoids modulate toxicological defense against colon cancer risk factors. In addition to the inhibition of tumor cell proliferation, this could be a mechanism of cancer risk reduction [16]. Apples have been shown to have potent antiproliferative activity in several studies [2]. Eberhardt et al. [19] 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 [9].

The anti-tumor activity of apple polyphenols and procyanidins, namely condensed tannins, both *in vitro* and *in vivo* studies. Among the apple polyphenols, the apple procyanidins specifically, rather than other polyphenols such as chlorogenic acid, (–)-epicatechin, phloridzin and procyanidin B2, had a major effect on cell proliferation, and induced apoptosis *in vitro*. The oral administration of apple procyanidins inhibits the proliferation of tumor cells by inducing apoptosis through the intrinsic mitochondrial pathway [21].

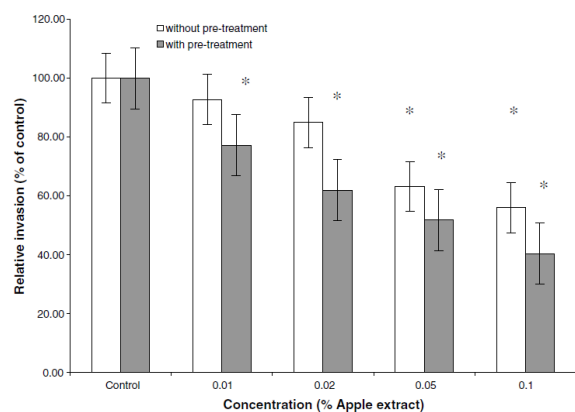


Fig. 2. The effect of apple extracts on the invasion of HT115 cells. Cells were either treated during the assay or pre-treated with extracts for 24 h prior to assay. Data are expressed relative to the control as the mean (\pm standard error of the mean) of triplicate independent experiments. The percentage invasion of the control cells was $13.6 \pm 0.5\%$. Significant differences ($p < 0.05$) between the control and treatments are indicated by *. (SPSS, one-way ANOVA with LSD test) [6].

Apple procyanidins alter intracellular signaling pathways, polyamine biosynthesis and trigger apoptosis in tumor cells. These compounds antagonize cancer promotion *in vivo*. In contrast with absorbable drugs, these natural, non toxic, dietary constituents reach the colon where they are able to exert their antitumor effects [22]. Different varieties of apples had different effects on liver cancer cell proliferation. At a dose of 50mg/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 [19]. 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 [18].

Prevention from Cardiovascular Diseases

Apple intake contributed to approximately 10% of the total ingested flavonoids and was also associated with a reduced risk of death from coronary heart disease in men [23]. A reduced risk of cardiovascular disease has been associated with apple consumption in a 40,000 women with a 6.9-year follow-up study. This study showed an association between flavonoids and cardiovascular disease [24]. Apple intake was also inversely associated with coronary mortality, especially in women. Data collected from this same cohort study also showed the effect of quercetin and apple intake on cerebrovascular disease. Those who had the highest consumption of apples had a lower risk of thrombotic stroke compared to those who consumed the lowest amounts of apples [25]. Flavonoids, and particularly quercetin derivatives, have received special attention as dietary constituents during the last few years. The epidemiological studies point out to their possible role in preventing cardiovascular diseases and cancer [26]. This health-promoting activity seems to be related to the antioxidant (free-radical scavenging) activity to flavonoids [27]. A considerable amount of isoquercetin (quercetin-3-O-b-glucoside) has been found in apple and pear peels [28].

Asthma and Pulmonary Functions

Apple consumption has been inversely linked with asthma and has also been positively associated with general pulmonary health [2]. In a recent study involving 1600 adults in Australia, apple and pear intake was associated with a decreased risk of asthma and a decrease in bronchial hypersensitivity, but total fruit and vegetable intake was not associated with asthma risk or severity [29]. Specific antioxidants, such as vitamin E, vitamin C, retinol, and β -carotene, were not associated with asthma or bronchial hypersensitivity. Previously it had been found that apple intake, as well as selenium intake, was associated with less asthma in adults in the United Kingdom [30]. A study of approximately 2500 middle aged (45–59 yrs) Welsh men also demonstrated a beneficial effect of apple consumption on lung function [31].

There was no evidence for associations between maternal intake of most foods during pregnancy and asthma, respiratory and allergic outcomes in 5-year-old children, except for apples and fish. Maternal apple and fish intake was beneficially associated with ever wheeze ever asthma and doctor-confirmed asthma in the children. Consumption of apples and fish during pregnancy may have a protective effect against the development of childhood asthma and allergic disease [32].

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 [33]. Higher quercetin intake, a major component of apple peels, was also associated with a decreased risk in type II diabetes [2].

Apple and pear intake has also been associated with weight loss in middle aged overweight women in Brazil. Approximately 400 hypercholesteremic, but nonsmoking, 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 [34].

Inhibition of LDL Oxidation

Addition of apple phenolics to human serum decreased diphenylhexatriene-labeled phosphatidylcholine (DPHPC) oxidation in a dose dependent manner. DPHPC is incorporated into low-density lipoprotein (LDL), high-density lipoprotein and very low-density lipoprotein (VLDL) fractions and is an indicator of oxidation. Apple ingestion led to a decrease in DPHPC oxidation, reflecting the apples antioxidant activity *in vivo*. The protective effects of apples on LDL oxidation reached its peak at three hours following apple consumption and returned to baseline levels by 24 hours [35]. Although apple juice typically contains less phenolics than whole apples, it is still a widely consumed source of dietary antioxidants. The effects of six commercial apple juices and Red Delicious apples (whole apples, peels alone, and flesh alone) were examined on human LDL oxidation *in vitro*. LDL oxidation inhibition varied greatly between brands of fruit juice, ranging from 9 to 34% inhibition and whole apples inhibited LDL oxidation by 34%. Apple peels inhibited LDL oxidation by 34%, while the flesh alone showed significantly less inhibition (21%) [36].

Cholesterol Lowering Effect

When cholesterol fed rats were supplemented with lyophilized apples, there was a significant drop in plasma cholesterol and liver cholesterol and an increase in high-density lipoproteins. Furthermore, cholesterol excretion increased in the feces of rats fed apples, suggesting reduced cholesterol absorption [37]. In more recent studies, found that combined apple pectin and apple phenolic fractions lowered plasma and liver cholesterol, triglycerides, and apparent cholesterol absorption to a much greater extent than either apple pectin alone or apple phenolics alone [38].

Other Health Benefits

Recently it has been found that crude extracts from

immature apples actually inhibited enzymatic activities of cholera toxin in a dose dependent manner. Additionally, apple extract reduced cholera toxin induced fluid accumulation in a dose dependent manner [39].

Oxidative stress contributes to age-related cognitive decline. In some instances, consumption of fruits and vegetables rich in antioxidant can provide superior protection than supplementation with purified antioxidants. Consumption of antioxidant-rich foods such as apples can prevent the decline in cognitive performance that accompanies dietary and genetic deficiencies and aging [40].

In a single-dosing crossover study, the ability of apple fruit consumption was investigated to protect human lymphocytes against peroxide-induced damage to DNA. These findings suggest that the consumption of whole apple provides a useful dietary source of active scavengers to protect cells and tissue from oxidative stress and related DNA injury [41].

CONCLUSIONS

Based on the recent scientific studies, fresh apples have a significant role in reducing the risk of a wide variety of chronic diseases. Also, they have therapeutic effects for maintaining the healthy lifestyle. Apple consumption is most consistently associated with reduced risk of cancer, heart diseases, asthma, and type II diabetes when compared to other sources of natural antioxidants. Apple consumption is also positively associated with increased lung function and increased weight loss and decreased cholesterol level. Future more all these health benefit studies should be carried out by integrating with the consumption of fresh cut apple and different apple products.

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