Apple as a Functional Food: Nutritional and Therapeutic Properties

CHAPTER 20

MOMNA[1], ZAMAN ALI[1], HINA YASSEN[1], MUHAMMAD BILAL BHATTI[2]

[1]Department of Chemistry, University of Engineering and Technology, Lahore, Pakistan
[2]Department of Speech Therapy, Riphah, International University, Lahore, Pakistan
*Corresponding author: dn.momna@gmail.com

SUMMARY

Apples have become one of the most frequently eaten fruits because of the nutritional and healing purposes they serve, and are considered a functional food. The consumption of apples is known to boost general well-being due to their high fiber, presence of vitamin C and it's rich in minerals. The high content of polyphenols in apples has a rather powerful antioxidant, anti-inflammatory and anticancer properties particularly flavonoids and phenolic acids. According to studies, there is a protective association between apple consumption and chronic diseases like heart disease, diabetes, and certain cancers. The polyphenols in apples can have an anti-inflammatory action and may help with conditions associated with oxidative stress as well as inflammation. Furthermore, apples are beneficial for the intestines and promote proper body fats and brain functioning. In this review, the various health benefits of apples are presented and explained making apples more useful in everyone's diet. Further studies need to be carried out on the mechanisms underlying these benefits and the potential use of apple-derived compounds in the clinic.

INTRODUCTION

Functional foods are defined as foods providing health benefits in addition to their basic nutrition. Foods of this category usually contain bioactive compounds. Most of the attention has been paid to apples as a functional food due to their balanced nutrition and complex phytochemicals. This may be because different combinations of several antioxidants produce much greater effects rather than dietary supplements (Cantuti-Castelvetri et al., 2000). Of all the fruits consumed widely in different parts of the world, apples are exceptional in that they tend to possess different health-related ingredients like dietary fibers, sugars, vitamins and phenolic compounds (Boyer & Liu, 2004). It impacts primarily the market for apples to the greatest extent as the main sources of antioxidants come from phenolic compounds like flavonoids and phenolic acids (Eberhardt et al., 2000; Lee et al., 2003). Ample evidence exists on the effect of these compounds in preventing elderly degenerative diseases such as cardiovascular diseases and cancer.

The World Health Organization stresses that diet is one of the leading risk factors in the initiation and evolution of many diseases, concerning those meals high in fruits and vegetables. Various investigations have shown that apples possess several polyphenolic compounds, which are highly effective in fighting free radical damage in man (McCann et al., 2007). Some common classes of flavonoids found within apple fruit include; flavonols e.g quercetin glycosides, flavanols catechin epicatechin and procyanidins, dihydrochalcones (particularly phloridzin), and anthocyanins (especially cyanidin glycosides) with chlorogenic acid as the major aliphatic phenolic acid. Phytochemicals from apples have been reported to make up over 80% of the antioxidant capacity in the cultivars studied. In addition, apples also have the second highest amounts of free phenolics in commonly consumed fruits after cranberries (Awad et al., 2000). More free phenolic compounds are found in apples than in some other common fruits like oranges and strawberries (Sun et al., 2002; Tsao et al., 2003). Free phenols are in contrast to bound phenols, which are more difficult to target and use in other interactions. It has been reported that apples alone contribute around 22% of the total dietary phenolics consumed (Vinson et al., 2001).

HEALTH BENEFITS OF FRESH APPLE

Prevention from Cancer

In relation to cancer, epidemiological studies examined risk factors and health benefits of vegetables and fruits highlighting lung and colorectal cancers above others. The relationship was established often in regard to several fruits and vegetables, lime being among the only exceptions. Eleven-month longitudinal assessment showed that women who consumed at least one apple or pear a day had less risk of lung cancer (Feskanich et al., 2000). A similar case-control study in Hawaii also showed that consuming apples and onions reduced the risk of lung cancer in both sexes (LeMarchand et al., 2000).

How to Cite: Momna, Z Ali, H Yassen & MB Bhatti, 2024. Apple as a functional food: Nutritional and therapeutic properties. In: Ethnopharmacology and Ethnobotany of Medicinal Plants (Sindhu ZuD, B Aslam, MN Faisal & W Majeed, eds): FahumSci, Lahore, Pakistan, pp. 154-157. ISBN: 978-627-7745-10-3. https://doi.org/10.61748/EEMP.2024/20

Quite a few studies suggested a protective role of apples against lung cancer but they focused primarily on the dietary catechins and excluded the multifunctional objects of apples. Moreover, the Zutphen Elderly Study added that elderly women who consumed more fruit and vegetable derived flavonoids had fewer cancers of the alimentary and respiratory tracts, resulting in a lower incidence of these cancers (Hertog et al., 1994).

A high intake of fruits and vegetables has been suggested to effect an impressive reduction in the incidence of colorectal cancers, with estimates of 50–80% of such cases predicted to be preventable by dietary changes (Potter, 1997; Parkin et al., 2005). Some apple extracts contain bioactive substances with supposed anticancer activity, especially against colon cancer and other cancers (Peng et al., 2003; Veeriah et al., 2006). In particular, apples and their peels are reported to have good free radical scavenging activities and inhibit liver and colon cancer cell line growth (Liu et al., 2001; Wolfe et al., 2003). Since apples are relatively low in fiber when compared to various other fruits, the fiber they contain is effective in bulk-forming laxatives which might be said to be helpful in colon cancer prophylaxis (Bazzano et al., 2003). The average in vivo ORAC value of the total antioxidant activity of dry whole apple with peel was about 83 μmol vitamin C equivalent, which means that the activity of a 175 g apple would be equivalent to ingestion of about 1500mg vitamin C in relation to hyphenated antioxidant equivalent, and, a 100g apple contains only about 5.7 mg of vitamin C which comes from the actual content of that particular fruit which all sorts it around that (Liu et al., 2001). Flavonoids isolated from apple cultivars have been shown to be capable of restricting excess cell proliferation of colon cancer cells and also remarkably affect the mRNA synthesis of peptide transporters and enzymes that play a major role in the metabolism of xenobiotics.

Flavonoids such as these may also help to explain the relations found to toxicological defenses against some risk factors of colon cancer (Veeriah et al., 2006). Also, the inhibition of tumor cell growth has been considered to be one of the main ways how apples help to lower the risk of developing a malignancy, with several studies bringing up their active anti proliferative properties (Boyer et al., 2004). The combination of phytochemicals in apples could be the reason for this ability to inhibit tumor cells. In terms of the effects of selected fruits on cultured cancer cells, the apples were ranked third out of 11 such fruits in terms of activity (Sun et al., 2002).

Apples and their constituent polyphenols have effective anti-tumor effects especially, procyanidins in vitro and in vivo studies. The most inappropriate, among the polyphenolic constituents of apples, were procyanidins, which were able to cause the most efficient inhibition of cell proliferation and induction of apoptosis in vitro. The cancer chemopreventive activities of oral apple procyanidins have been reported to be mediated by the mitochondrion dependent mechanism of apoptosis to exert their effect of preventing the growth of neoplastic cells (Miura et al., 2008).

Potent apple procyanidins have been shown to alter the intracellular signaling pathways, production of polyamines, and apoptosis of the cells in a tumor. These compounds have been known to possess antagonistic effects towards causing cancer in vivo. These are not like drugs that are prescribed and absorbed, rather, they are natural nonhopsycric food ingredients that come to the large intestine and are expected to carry an antitumor activity (Gossé et al., 2005). Moreover, different cultivars of apples have been shown to have varying effects on the proliferation of liver cancer cells. Of the extract concentration of 50mg/mL, Fuji apple extracts caused 39% inhibition on the proliferation of Hep G2 liver cancer cells, while red delicious apple extracts caused 57% inhibition on cell proliferation. On the other hand, Northern spy apples showed no marked action on cell proliferation (Liu et al., 2001). Also, Hep G2 cell proliferation inhibition was assessed using apple samples with and without peels, where the apple without the skin was markedly less potent than the whole apple, which suggests the presence of pharmacologically active substances with anti-proliferative action in the peel (Wolfe et al., 2003).

Prevention of Cardiovascular Diseases

Men reported eating apples contributing roughly 10% of the total ingested flavonoids which in turn correlates with lower coronary heart disease mortality (Hertog et al., 1993) in that population. That is, in a large cohort study of 40,000 women for more than 6.9 years, apple consumption and flavonoid intake have been conclusively shown to lower the risk of developing cardiovascular disease (Sesso et al., 2003). The present study provided evidence of this association demonstrating that apple consumption is associated with lower rates of coronary mortality among women. Additionally, this same cohort also reported the protective effect of quercetin and apple intake against cerebrovascular diseases where the highest apple consumers appear less likely to develop a thrombotic stroke than the lowest apple consumers (Knekt et al., 2000).

Of specific interest over the past few decades is flavonoids especially quercetin derivatives because of the possibility of their use for human health in the prevention of cardiovascular diseases and cancer (Chu et al., 2000). The so called health beneficial activities of flavonoids are believed to derive from their antioxidant, or free radical scavenging, properties (Murota & Terao, 20003). Isoquercetin (quercetin-3-O- β-glucoside) which is one of the major quercetin derivatives has high concentration in apple and pear peels (Schieber et al., 2002).

Asthma and Pulmonary Function

An apple day has also been shown to show possibilities where increased pulmonary function was noted and asthma has been in the opposite direction (Boyer et al., 2004). Apple and pear consumption was associated with less asthma and bronchial hyperreactivity in 1,600 adults in Australia. Interestingly, no association was observed between total fruit and vegetable intake on the one hand and risk of and severity of asthma on the other (Woods et al., 2002). Equally, there was also no association between asthma or bronchial hyper-

reactivity and the investigated antioxidants such as vitamins E and C, retinol, or β-carotene in this study. At the same time, other studies conducted in the population of the United Kingdom showed that the consumption of selenium along with apples was related to a lower rate of asthma in adults (Shaheen et al., 2001).

Moreover, similar results were achieved in a study involving 2500 middle aged male (45–59 years) inhabitants of Wales, where apple consumption has also improved lung function in patients suffering from chronic obstructive pulmonary disease (COPD) (Butland et al., 2000). There is substantial evidence that maternal apple and fish intake during pregnancy decreased the risk of development of allergic diseases, and asthma in children. A similar study of 5-year-old children concluded that maternal apple and fish consumption was associated with lower wheezing, asthma and medically confirmed asthma at age 5 years (Willers et al., 2007).

Diabetes and Weight Loss

In addition to the lower risk of developing heart disease, cancer and asthma, it appears that apple consumption will also decrease the risk of diabetes. In a Finnish study involving 10,000 participants, apple intake was found to relate to a decreased risk of type II diabetes (Knekt et al., 2002). Also, higher intake of quercetin which is known to be in high amounts in apple peels, was associated with a reduction in risk of type II diabetes (Boyer et al., 2004).

Gooseberries, oatmeal and pear intakes have also been reported as helpful in weight loss for middle-aged obese women. In a trial performed in Brazil, about 400 hypercholesterolemic nonsmoking women were randomly assigned in three arms- one who took oat cookies, one who consumed apples and the other pears. Each subject ingested one of the designated supplements three times a day for twelve weeks. Among those who used one of the fruits, apples, or pears, a significant weight loss of 1.21 kg was noted after 12 weeks, while no appreciable weight loss was recorded in the oat cookie group. More importantly, the groups that consumed fruits were able to record lower levels of blood glucose compared to the gac group that consumed oat cookies (de Oliveira et al., 2003).

Inhibition of LDL Oxidation

From both in vitro and in vivo studies, it was established that apple phenolics demonstrated a capacity to inhibit low-density lipoprotein (LDL) oxidation in a dose dependent fashion. DPHPC which is a surrogate marker of oxidation is incorporated within LDL, HDL and very low density lipoprotein VLDL fractions. The scavenging of DPHPC was diminished with the addition of apple phenolics which indicates the in vivo antioxidant potential of apples. The maximum protective effects of apples against LDL oxidation were observed at three hours following apple consumption and these effects returned to the baseline levels after a period of 24 hours (Mayer et al., 2001).

Apple juice pure has also been reported to be one of the main sources of dietary antioxidants, despite its lower phenolics content when compared to whole apples. A study performed to compare the inhibition of human LDL oxidation by six commercial apple juices and ‘Red Delicious’ whole, peels or flesh found the inhibitions of LDL oxidation by juices to vary with brands between 9 and 34%. Whole and peels of apples showed a success of 34% in the inhibition of LDL oxidation while the inner flesh portion showed a success of 21% in the inhibition of LDL oxidation (Pearson et al., 1999).

Lipid Lowering Activity

In cholesterol fed rats, it has been found that there is a substantial decrease in plasma and liver cholesterol levels and an increase in HDL levels with supplementation of lyophilized apples. Moreover, there was an observation of enhanced cholesterol excretion in the feces when an apple was given, indicating improved cholesterol absorption (Aprikian et al., 2001). More recent studies have demonstrated that apple pectin and apple phenolic fractions when combined against plasma and liver cholesterol, triglycerides, and apparent cholesterol absorption are more efficient than of the use of pectin or phenolics only (Aprikian et al., 2003).

More recently it was noted that the crude extracts from Paru apples from immature and mature leaves respectively to older plants effectively inhibited cholera toxin enzymatic activities in a dose dependent manner. The fluid accumulation induced by cholera toxin also decreased dose dependently as the concentration of the apple extract increased (Saito et al., 2002). Different levels of oxidative stress correlate with neurodegeneration in aging apprehension abilities. In some cases, the intake of vegetables and fruits that are filled with antioxidants may even dose offshore the risk brought about by taking pure. Apple consumption helps reverse cognitive performance losses brought in by diet, genetics and aging over a long period of time (et al., 2006). Crossover trial while judging the role played by apple fruit in the protection of human lymphocyte DNA from peroxide damage, single dose studies were carried out. These data provided the basis for the formulation of the study hypothesis that stomach meant that the consumption of whole apples may serve as a dietary source of active scavengers of tissue and cellular oxidative stress and related injury to DNA (Maffei, et al., 2007).

CONCLUSION

Apples have great health importance among their various fruits owing to the nutritious density that the flesh contains. Certain aspects such as fiber, vitamins and the presence of bioactive compounds particularly flavonoids also play a good therapeutic role. These fruits have been associated with reducing the risk of heart related diseases, cancer, asthma and type 2 diabetes amongst other diseases. Apple polyphenols and especially quercetin are believed to be partially responsible for the more beneficial effects of normal apple consumption of their antioxidant and anti-inflammatory activity. There is overwhelming evidence to suggest that apples bear lower calories and they are widely available making them pleasant and healthy. Furthermore, in recent scientific studies apple has a preventative role over the health risk factors of a number of chronic diseases. Alternatively, useful for healthy active living. Among the various sources of natural antioxidants,

apples are most common with reduced risk of cancer, heart disease, and asthma and type II diabetes. There was also a positive relationship between apple cuts in the cholesterol scale and weight loss and lung function improvement Also apples cut down on dietary related diseases. Probably all these studies concerning health benefits shall be growing deeper with the looking thoroughly at both consumption of fresh cut apple and various apple products.

REFERENCES

Aprikian O, M Levrat-Verny, C Besson et al., 2001. Apple favourably affects parameters of cholesterol metabolism and of anti-oxidative protection in cholesterol-fed rats. Food Chemistry 75:445-52. https://doi.org/10.1016/S0308-8146(01)00235-7

Aprikian O, V Duclos, S Guyot et al., 2003. Apple pectin and a polyphenol-rich apple concentrate are more effective together than separately on cecal fermentations and plasma lipids in rats. Journal of Nutrition 133:1860-5. https://doi.org/10.1093/jn/133.6.1860

Awad MA, A de Jager & LM vanWesting, 2000. Flavonoid and chlorogenic acid concentrations in apple fruit: Characterisation of variation. Scientia Horticulturae 83:249-63. https://doi.org/10.1016/S0304-4238(99)00124-7

Bazzano LA, J He, LG Ogden et al., 2003. Dietary fiber intake and reduced risk of coronary heart disease in US men and women: The national health and nutrition examination survey i epidemiologic follow-up study. Archives of Internal Medicine 163:1897-1904. https://doi.org/10.1001/archinte.163.16.1897

Boyer J & RH Liu, 2004. Apple phytochemicals and their health benefits. Nutrition Journal 3:3-5. https://doi.org/10.1186/1475-2891-3-5

Butland BK, AM Fehily & PC Elwood, 2000. Diet, lung function, and lung decline in a cohort of 2512 middle aged men. Thorax 55:102-8. https://doi.org/10.1136/thorax.55.2.102

Cantuti-Castelvetri I, B Shukitt-Hale & JA Joseph, 2000. Neurobehavioral aspects of antioxidants in aging. International Journal of Developmental Neuroscience 18:367-81. https://doi.org/10.1016/S0736-5748(00)00008-3

Chan A, V Graves & TB Shea, 2006. Apple juice concentrate maintains acetylcholine levels following dietary compromise. Journal of Alzheimer's Disease 9:287-91. https://doi.org/10.3233/JAD-2006-9308

Chu YH, CL Chang & HF Hsu, 2000. Flavonoid content of several vegetables and their antioxidant activity. Journal of the Science of Food and Agriculture 80:561-6. https://doi.org/10.1002/(SICI)1097-0010(200004)80:5<561::AID-JSFA574>3.0.CO;2-#

de Oliveira ML, R Sichieri & A Moura, 2003. Weight loss associated with a daily intake of three apples or three pears among overweight women. Nutrition 19:253-6. https://doi.org/10.1016/S0899-9007(02)00850-X

Eberhardt MV, CY Lee & RH Liu, 2000. Antioxidant activity of fresh apples. Nature 405:903-4. https://doi.org/10.1038/35016151

Feskanich D, R Ziegler, D Michaud et al., 2000. Prospective study of fruit and vegetable consumption and risk of lung cancer among men and women. Journal of the National Cancer Institute 92:1812-23. https://doi.org/10.1093/jnci/92.22.1812

Gossé F, S Guyot, S Roussi et al., 2005. Chemopreventive properties of apple procyanidins on human colon cancer-derived metastatic SW620 cells and in a rat model of colon carcinogenesis. Carcinogenesis 26:1291-5. https://doi.org/10.1093/carcin/bgi074

Hertog MGL, EJM Feskens, PCH Hollman et al., 1993. Dietary antioxidant flavonols and risk of coronary heart disease: The Zutphen Elderly Study. Lancet 342:1007-111. https://doi.org/10.1016/0140-6736(93)92876-U

Hertog MGL, EJM Feskens, PCH Hollman et al., 1994. Dietary flavonoids and cancer risk in the Zutphen Elderly study. Nutrition and Cancer 22:175-84. https://doi.org/10.1080/01635589409514342

Knekt P, J Kumpulainen, R Jarvinen et al., 2002. Flavonoid intake and risk of chronic diseases. American Journal of Clinical Nutrition 76:560-8. https://doi.org/10.1093/ajcn/76.3.560

Knekt P, S Isotupa, H Rissanen et al., 2000. Quercetin intake and the incidence of cerebrovascular disease. European Journal of Clinical Nutrition 54:415-7. https://doi.org/10.1038/sj.ejcn.1600974

Le Marchand L, S Murphy, J Hankin et al., 2000. Intake of flavonoids and lung cancer. Journal of the National Cancer Institute 92:154-60. https://doi.org/10.1093/jnci/92.2.154

Lee KW, YJ Kim, DO Kim et al., 2003. Major phenolics in apple and their contribution to the total antioxidant capacity. Journal of Agricultural and Food Chemistry 51:6516-20. https://doi.org/10.1021/jf034475w

Liu RH, M Eberhardt & C Lee, 2001. Antioxidant and antiproliferative activities of selected New York apple cultivars. New York Fruit Quarterly 9:15-7.

Maffei F, A Tarozzi, F Carbone et al., 2007. Relevance of apple consumption for protection against oxidative damage induced by hydrogen peroxide in human lymphocytes. British Journal of Nutrition 97:921-7. https://doi.org/10.1017/S0007114507665192

Mayer B, M Schumacher, H Branstatter et al., 2001. High-throughput fluorescence screening of antioxidative capacity in human serum. Analytical Biochemistry 297:144-53. https://doi.org/10.1006/abio.2001.5333

McCann MJ, CIR Gill, GO O'Brien et al., 2007. Anti-cancer properties of phenolics from apple waste on colon carcinogenesis in vitro. Food and Chemical Toxicology 45:1224-30. https://doi.org/10.1016/j.fct.2007.01.003

Miura T, M Chiba, K Kasai et al., 2008. Apple procyanidins induce tumor cell apoptosis through mitochondrial pathway activation of caspase-3. Carcinogenesis 29:585-93. https://doi.org/10.1093/carcin/bgm198

Murota K & J Terao, 2003. Antioxidative flavonoid quercetin: Implication of its intestinal absorption and metabolism. Archives of Biochemistry and Biophysics 417:12-7. https://doi.org/10.1016/S0003-9861(03)00284-4

Parkin DM, F Bray, J Ferlay et al., 2005. Global cancer statistics, 2002. Cancer Journal for Clinicians 55:74-108. https://doi.org/10.3322/canjclin.55.2.74

Pearson D, C Tan, B German et al., 1999. Apple juice inhibits low density lipoprotein oxidation. Life Sciences 64:1919-20. https://doi.org/10.1016/S0024-3205(99)00137-X

Peng IW & S Kuo, 2003. Flavonoid structure affects the inhibition of lipid peroxidation in CaCo2 intestinal cells at physiological concentrations. The Journal of Nutrition 133:2184-7. https://doi.org/10.1093/jn/133.7.2184

Potter JD, 1997. Food, nutrition and the prevention of cancer: A global perspective. WCRF/AICR.

Saito T, M Miyake, M Toba et al., 2002. Inhibition by apple polyphenols of ADP-ribosyltransferase activity of cholera toxin and toxin-induced fluid accumulation in mice. Microbiology and Immunology 46:249-55. https://doi.org/10.1111/j.1348-0421.2002.tb02693.x

Schieber A, P Hilt, J Conrad et al., 2002. Elution order of quercetin glycosides from apple pomace extracts on a new HPLC stationary phase with hydrophilic endcapping. Journal of Separation Science 25:361-4. https://doi.org/10.1002/1615-9314(20020401)25:5/6<361::AID-JSSC361>3.0.CO;2-D

Sesso HD, JM Gaziano, S Liu et al., 2003. Flavonoid intake and risk of cardiovascular disease in women. American Journal of Clinical Nutrition 77:1400-8. https://doi.org/10.1093/ajcn/77.6.1400

Shaheen SO, JA Sterne, RJ Thompson et al., 2001. Dietary antioxidants and asthma in adults: Population based case-control study. American Journal of Respiratory and Critical Care Medicine 164:1823-8. https://doi.org/10.1164/ajrccm.164.10.2104061

Sun J, YF Chu, X Wu et al., 2002. Antioxidant and antiproliferative activities of common fruits. Journal of Agricultural and Food Chemistry 50:7449-54. https://doi.org/10.1021/jf0207530

Tsao R, R Yang, JC Young et al., 2003. Polyphenolic profiles in eight apple cultivars using high-performance liquid chromatography. Journal of Agricultural and Food Chemistry 51:6347-53. https://doi.org/10.1021/jf0346298

Veeriah S, T Kautenburger, N Habermann et al., 2006. Apple flavonoids inhibit growth of HT29 human colon cancer cells and modulate expression of genes involved in the biotransformation of carcinogenesis. Carcinogenesis 45:164-74. https://doi.org/10.1002/mc.20158

Vinson JA, X Su, L Zubik et al., 2001. Phenol antioxidant quantity and quality in foods: Fruits. Journal of Agricultural and Food Chemistry 49:5315-21. https://doi.org/10.1021/jf0009293

Willers SM, G Devereux, LCA Craig et al., 2007. Maternal food consumption during pregnancy and asthma, respiratory and atopic symptoms in 5-year-old children. Thorax 62:773-9. https://doi.org/10.1136/thx.2006.074187

Wolfe K, X Wu & RH Liu, 2003. Antioxidant activity of apple peels. Journal of Agricultural and Food Chemistry 51:609-14. https://doi.org/10.1021/jf020782a

Woods RK, HE Walters, J Raven et al., 2003. Food and nutrient intakes and asthma risk in young adults. American Journal of Clinical Nutrition 78:414-21. https://doi.org/10.1093/ajcn/78.3.414