

Apple and Apple Products: Properties and Health Benefits

Mini Review

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Received: April 14, 2023; **Accepted:** May 19, 2023; **Published:** May 23, 2023

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Abstract

Apples contain a number of phytochemicals that have been found to possess higher antioxidant and anticancer activity. Apples contain about 85 % water and are rich sources of fibre that makes it best for patients suffering from obesity and heart ailments. Starches, sugars, pectin, cellulose and hemicelluloses accounted for the major principle carbohydrates in apples, the concentration of which varies with ripening stages. The pectin in apple fibres prevents a body from cardiovascular diseases and reduces the hike in blood glucose levels by regulating metabolism of sugars and thus proves a good food for patients with diabetic complications. The flavonoid Quercetin present in apples has been found to be greater in its peels than flesh possess antioxidant, anti cancer, anti viral and anti-inflammatory properties by preventing creation of reactive free radicals.

Introduction

Apple (*Malus Domestica*) known as miracle food belongs to family Rosaceae, is among the top three grown fruit cultivars of world and is widely cultivated with greater nutritional value. A famous adage “an apple a day keeps the doctor away” has been marked based on it highly recommended nutritional and health benefits by its fighting ability against chronic diseases. India scored second position in fruit production and in exporting of apples it holds fifth rank throughout the world [1]. The production of apples holds fourth rank among the majorly produced fruits in the world after banana, orange and grape. As apple is a climacteric fruit and is perishable accounting about 12.3% of post harvest losses, so there is a necessity of processing this fruit to different value added products to ensure its functional properties through processed products. Apples contain a number of phytochemicals that have been found to possess higher antioxidant and anticancer activity.

Apples contain about 85 % water and are rich sources of fibre that makes it best for patients suffering from obesity and heart ailments, as apple fibre has been found beneficial in lowering bad LDL cholesterol in human body [2]. Apples are rich sources of micro and macro nutrients like nitrogen, phosphorus, zinc, manganese, copper, potassium, calcium, magnesium, sulphur, iron, boron, and molybdenum. Among which nitrogen, calcium, and potassium are the main elements that determine the quality parameters of apple fruit [3]. Starches, sugars, pectin, cellulose and hemicelluloses accounted for the major principle carbohydrates in apples, the concentration of which varies with ripening stages. Starch is maximum in immature apples with concentration of 3-4%, which gets converted into sugars fructose, sucrose and glucose as apple ripens [4]. The fibre of apple takes longer time to digest and has the ability to minimise absorption of fat and acid reflux in body, due to which it is regarded best source in aiding weight loss.

The fibre in apples is high in pectin content that acts as a soluble fibre and prebiotics and has been found to feed the gut lining Bifidobacteria and thus improves the immunity and digestion functions properly. The pectin in apple is considered a suitable agent in reducing constipation by drawing and retaining water and thus increasing the bowel movement [5]. The pectin in apple fibres also prevents a body from cardiovascular diseases and reduces the hike in blood glucose levels by regulating metabolism of sugars and thus proves a good food for patients with diabetic complications [6]. The bacteria in colon ferments pectin producing short chain fatty acids that are played an important role in preventing chronic diseases such as cancers and bowel disorders. This fibre in apples also binds the carcinogenic agents and prevents the mucous membrane of colon from attack of toxic chemicals [7]. Apple pomace has been found to be effective in increasing protein content, fibre solubility and mineral bioavailability in sourdough formulated products, thus its by products could be an essential ingredients in formulating lower glycemic index food products. The bioactive compounds extracted from pomace and seed of apple fruit has been validated as significant compounds in formulation of nutraceuticals due to their proven health benefits. As per literature only 30% of the apple production is used in processing of juices, concentrates and cider, the remaining is mainly generated as waste. Which is mainly undervalued and are usually thrown in land fillings, sewage or incinerated. Recognising the potential attributes of apple by-products, like reservoir of polyphenolic and flavonoid compounds, terpenes, fatty acids and dietary fibre. Green technologies have emerged to improve the functionality of apple waste generated during apple processing operation as raw materials for their applications in novel product developments. The presence of oleic, linoleic, and linolenic acids in fatty acid profiling of oil from apple seeds have received attraction in various healthcare products due to multifunctional uses including antioxidant, antimicrobial, and anti-proliferative activities.

Functional value of apple and apple products

The flavonoid Quercetin present in apples has been found to be greater in its peels than flesh possess antioxidant, anti cancer, anti viral and anti-inflammatory properties by preventing creation of reactive free radicals [8]. This flavonoid has been found to possess neuroprotective effect by helping neurons to survive and function properly, thus helping in preventing age-related

loss of neurons [9]. The presence of simple sugars fructose, glucose and sucrose in apples along with polyphenols and anthocyanins that it contains has been associated with preventing type 2 diabetes by slowing the rate of sugar absorption in human body besides their antioxidant properties [10]. The polyphenols in apples have been found to prevent carcinogenic cells from multiplying [11]. The flavonoid phlorizin present in skin of apples has been found in reducing sugar uptake by intestines and in strengthening bones by preventing inflammation and free radical formation leading loss of bones in menopausal women’s (Figure 1,2). The polyphenols and pectin in apples have been found in preventing cardiovascular diseases by reducing the hardening of arteries due to reduction of plaque build up, damaging of cardiac muscles and blood vessels. The acetylcholine production in apples has been linked to enhance signalling of neurotransmission between nerve cells of brain and thus boosts the memory by optimal functioning of brain and preventing against Alzheimer’s disease [12]. The malic acid in apples plays an important role in cleansing and eliminated the bacterial growth in oral cavity by enhancing production of saliva. The phytonutrients in apples has been linked with

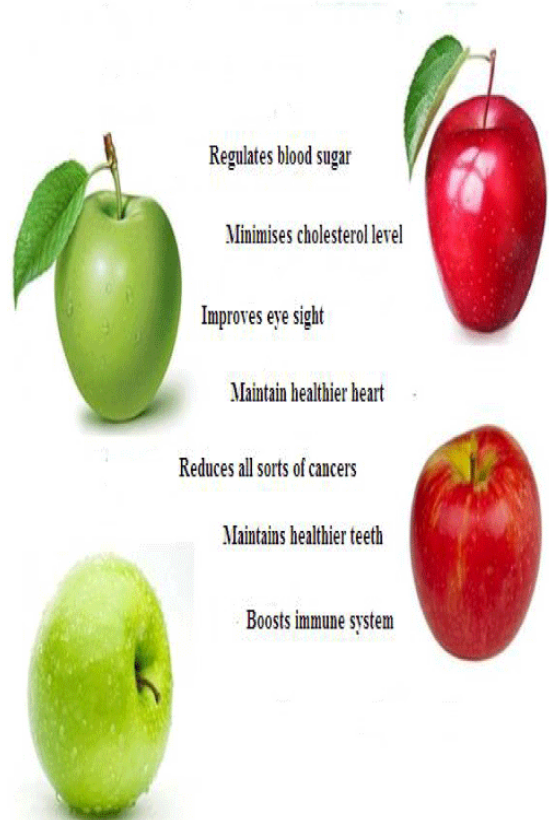


Figure 1: Health benefits of Apple

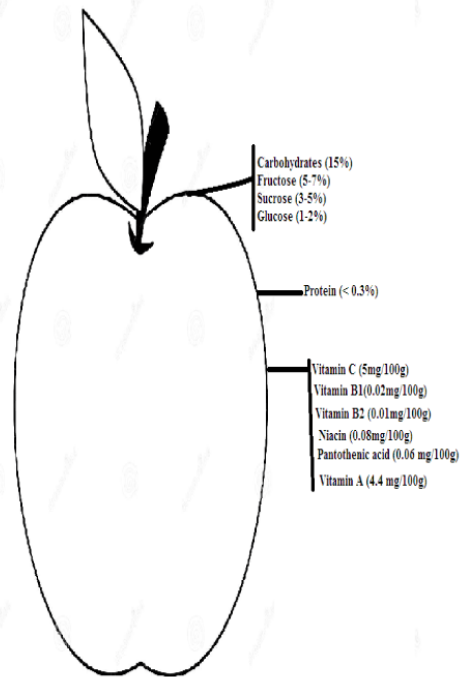


Figure 2: Nutritional composition of an apple

along with prevention of diseases. Apples contain good content of vitamin-C and β -carotene that are having antioxidant properties and prevents the body against various types of infectious diseases [13]. The iron content in apple fulfils the body's need of iron and is effective in preventing anaemia. Apples are having plenty of calcium that is essential maintain the strength of bones and teeth. Apples contain sufficient quantity of collagen and elastin that has been found to keep the skin younger and glowing.

Different varieties of apples retain different quantities of phytochemicals, the composition of which does varies little during the maturation and ripening stages of the fruit. While as the phytochemical composition is highly effected during the processing of apples into various values added products [14]. The protective effect of apples could be attributed to their phytochemicals content that included carotenoids, catechins, flavonoids, and phenolic acids. All of these makes apples a highly antioxidant rich fruit in comparison with other commonly used fruits. Apples also possess highest content of non bounded free phenolic compounds that are easily accessible for absorption into the human body [13]. The consumption of apples has been scientifically proved to decrease the chances of lung cancer, which has been linked to the flavonoids like quercetin and its conjugates as validated in the Finnish population [15].

The flavonoids catechin and epicatechin in apples have been found to reduce the risk of deaths due to coronary heart attacks.

Apples can be processed into jam, jelly, juice, sauce, concentrate slices and can be consumed in fermented forms like cider, wine and vinegar. Apple juice is the second most widely consumed fruit juice throughout the world due to its authentic taste and availability in a number of forms as single strength juice (100% juice), juice from concentrate, cloudy juice, clear juice, juice blends, and many others. Apple juice is also popular due to its valuable health benefits especially those associated with its antioxidant compounds, vitamins, and minerals. Apple peels are wasted during processing operations, which contains higher antioxidants than the flesh. So there is a great scope of processing the apple peels for their incorporation into functional foods and other value added products. Different techniques have been developed for preservation of processing of apple waste into powdered forms by applying solar drying, cabinet drying and freeze drying methodologies. Among the different drying methodologies applied to blanched apple peels, the freeze dried peels have been found to retain the maximum content of phenolic and flavonoids. The powdered form of apple peels was also found to possess strong antioxidant activity with cancer inhibition capability [16].

Apple pomace being the rich source of phenolics: Phloridzin, chlorogenic acid, epicatechin, and quercetin are the major industrial waste obtained during processing of apple juice. The phenolic compounds could be isolated and purified from the pomace and utilised in formation of nutraceuticals and other commercial uses, as these phenolics are associated with highly antioxidant properties and health benefits [17].

Apple juice concentrate has been found to reduce the accumulation reactive oxygen species in tissues of brain resulting in impairment of attenuated cognitive performance. It has also been reported that apple juice concentrate reduces the decline of acetylcholine production that usually occurs during aging and oxidative stress. This property of apple juice to reduce acetylcholine resulting in suppressing of over expression of presenilin-1 protein, which leads to the production of amyloid β peptide. This is considered a hallmark of Alzheimer's disease [18]. Apple products have been experimentally found to reduce the expression of enzyme cytochrome P450 1A1 that is

activating the chemical carcinogens [19]. Polyphenols chlorogenic acid and catechin in apple products have been found to release nitrogen oxides from saliva that causes scavenging of nitrogen oxides radicals and protection of gastrointestinal tract.

The polyphenols and flavonoids in apple juice have been found to prevent oxidation of bad cholesterol and their building up in the arteries resulting in reduction of coronary heart diseases [20]. The presence of malic acid in apple juice is considered to stimulate urination that in turn promotes liver functions by removing of harmful toxins, salts and fats. The alkalinity in apples helps in eliminating the destructive toxins/waste by-products from liver in addition to maintaining the pH levels of body. Malic acid has also been found to increases citrate production that prevents calcium binding and aggregation

of crystal thereby leads to lesser chances of kidney stones [21]. Apple juice is a rich source of vitamin C that has been found to enhance immunity and skin health by producing collagen and maintaining cell integrity, thereby preventing formation of wrinkles and premature aging of skin. The higher levels of fructose, glucose, and sorbitol in apple juice has been found to be incompletely absorbed up to 80% (Table) aiding in normalisation of constipation by causing frequent passing of stools [22-32].

Conclusion

The polyphenols and flavonoids in apple juice have been found to prevent oxidation of bad cholesterol and their building up in the arteries resulting in reduction of coronary heart diseases. The presence of malic acid in apple juice is considered to stimulate urination that in turn promotes liver functions by removing of harmful toxins, salts and fats. The alkalinity in apples helps in eliminating the destructive toxins/waste by-products from liver in addition to maintaining the pH levels of body. Malic acid has also been found to increases citrate production that prevents calcium binding and aggregation of crystal thereby leads to lesser chances of kidney stones. Apple juice is a rich source of vitamin C that has been found to enhance immunity and skin health by producing collagen and maintaining cell integrity, thereby preventing formation of wrinkles and premature aging of skin.

References

1. Tsao R, Yang R, Xie S, Sockovie E, Khanizadeh S. Which polyphenolic compounds contribute to the total antioxidant activities of apple? J Agric Food Chem. 2005; 53: 4989-4995.
2. Knekt P, Kumpulainen J, Järvinen R, Rissanen H, Heliövaara M, Reunanen A, et al. Flavonoid intake and risk of chronic diseases. Am J Clin Nutr. 2002; 76: 560-568.
3. Fallahi E, Simons BR. Interrelations among leaf and fruit mineral nutrients and fruit quality in "Delicious" apples. J Tree Fruit Prod. 1996; 1: 15-25.
4. Lee KW, Kim YJ, Kim, DO, Lee HJ, Lee CY. Major phenolics in apple and their contribution to the total antioxidant capacity. Journal of Agricultural and Food Chemistry. 2003; 51: 6516-6520.
5. Veeriah S, Hofmann T, Gleit M, Dietrich H, Will F, Schreier P, et al. Apple polyphenols and products formed in the gut differently inhibit survival of human cell lines derived from colon adenoma (LT97) and carcinoma (HT29). J Agric Food Chem. 2007; 55: 2892-900.
6. Waldecker M, Kautenburger T, Daumann H, Veeriah S, Will F, Dietrich H, et al. Histone-deacetylase inhibition and butyrate formation: fecal slurry incubations with apple pectin and apple juice extracts. Nutrition. 2008; 24: 366-374.
7. Williamson G, Manach C. Bioavailability and bioefficacy of polyphenols in humans. II. Review of 93 intervention studies. Am J Clin Nutr. 2005; 81: 243-255.

Table 1: Functional properties of polyphenolic compounds in apple

Polyphenolic compounds	Health benefits	References
Hydroxycinnamic acids	Possess potent antioxidant and anti-inflammatory properties. These compounds were also showed potential therapeutic benefit in experimental diabetes and hyperlipidemia.	Alam et al., 2016
5-Caffeoylquinic acid (chlorogenic acid)	It has been found to have hypoglycemic, hypolipidemic, anti-inflammatory, antioxidant, and other pharmacological properties.	Wang et al., 2016
p-Coumaroylquinic acid	phytochemical with multiple health benefits, antioxidant activities in reducing oxidative stress and inflammatory reactions	Boo, 2019
Flavan-3-ols/ procyanidins Procyanidins B2 Procyanidins C1	Protect the heart and cardiovascular system. They may work as antioxidants and block nitrosamines from forming. They work with vitamin C to lower the risk of breast cancer	Rauf, 2019
Epicatechin	Diverse benefits to human health, reducing the risks of diabetes mellitus and cardiovascular diseases. Their pharmacological effects are anti-hyperlipidaemic, anti-inflammatory, antioxidative, anticarcinogenic, and cytoprotective.	Perumalla and Hettiarachchy, 2011
Oligomeric procyanidins	Improve blood flow, reduce symptoms of diabetes, and to ease swelling in the joints. It has also been used to improve vein function to ease swelling.	Jepson et al., 2012
Flavonols	Beneficial anti-inflammatory effects and they protect your cells from oxidative damage that can lead to disease. These dietary antioxidants can prevent the development of cardiovascular disease, diabetes, cancer, and cognitive diseases like Alzheimer's and dementia.	Liu et al., 2013
Dihydrochalcones	Health benefits of dihydrochalcones include also anticancer, antioxidant, antibacterial, antidiabetic, estrogenic, anti-inflammatory, antithrombotic, antiviral, anti-herpes simplex virus, neuroprotective, and immunomodulation properties	Lin et al., 2014
Anthocyanins (red peel)	Anthocyanins possess antidiabetic, anticancer, anti-inflammatory, antimicrobial, and anti-obesity effects, as well as prevention of cardiovascular diseases	Khoo et al., 2017
Quercetin	Quercetin has antioxidant and anti-inflammatory effects that might help reduce swelling, kill cancer cells, control blood sugar, and help prevent heart disease.	
Phloretin	Phloretin has been clinically observed to possess skin-soothing, antioxidative properties. Antioxidant protection helps to neutralize free-radicals present in the environment.	Shin et al., 2014

8. Gerhauser C. Cancer chemopreventive potential of apples, apple juice, and apple components. *Planta Med.* 2008; 74: 1608–1624.
9. He X, Liu RH. Triterpenoids isolated from apple peels have potent antiproliferative activity and may be partially responsible for apple's anticancer activity. *J Agric Food Chem.* 2007; 55: 4366–4370.
10. Song Y, Manson JE, Buring JE, Sesso HD, Liu S. Associations of dietary flavonoids with risk of type 2 diabetes, and markers of insulin resistance and systemic inflammation in women: a prospective study and cross-sectional analysis. *J Am Coll Nutr.* 2005; 24: 376–384.
11. Liu J-R, Dong H-W, Chen B-Q, Zhao P, Liu R. Fresh apples suppress mammary carcinogenesis and proliferative activity and induce apoptosis in mammary tumors of the Sprague Dawley rat. *J Agric Food Chem.* 2009; 57: 297–304.
12. Chan A, Shea T. Dietary supplementation with apple juice decreases endogenous amyloid-beta levels in murine brain. *J Alzheimers Dis.* 2009; 16: 176–171.
13. Sampson L, Rimm E, Hollman P, deVries J, Katan M. Flavonol and flavone intakes in US health professionals. *J Am Diet Assoc.* 2002; 102: 1414–1420.
14. Woffram S, Block M, Ader P. Quercetin-3-glucoside is transported by the glucose carrier SGLT1 across the brush border membrane of rat small intestines. *J Nutr.* 2002; 132: 630–635.
15. Hollman P, Arts I. Flavonols, flavones, and flavanols-nature, occurrence and dietary burden. *J Sci Food Agri.* 2000; 80: 1081–1093.
16. Wolfe K, Liu RH. Apple peels as a value-added food ingredient. *J Agric Food Chem.* 2003; 51: 1676–1683.
17. Lu Y, Foo L. Antioxidant and radical scavenging activities of polyphenols from apple pomace. *Food Chem.* 2000; 68: 81–85.
18. Chan A, Shea TB. Supplementation with apple juice attenuates presenilin-1 overexpression during dietary and genetically-induced oxidative stress. *J Alzheimers Dis.* 2006; 10: 353–358.
19. Veeriah S, Kautenburger T, Habermann N, Sauer J, Dietrich H, Will F, et al. Apple flavonoids inhibit growth of HT29 human colon cancer cells and modulate expression of genes involved in the biotransformation of xenobiotics. *Mol Carcinog.* 2006; 45: 164–174.
20. Boyer, Jeanelle, and Rui Hai Liu. "Apple phytochemicals and their health benefits." *Nutrition journal.* 2004; 3: 5.
21. Rodgers AL, Webber D, de Charmoy R, Jackson GE, Ravenscroft N. Malic acid supplementation increases urinary citrate excretion and urinary pH: implications for the potential treatment of calcium oxalate stone disease. *J Endourol.* 2014; 28: 229–236.
22. Kneepkens CMF, Jakobs C, Douwes AC. Apple juice, fructose, and chronic nonspecific diarrhoea. *European Journal of Pediatrics.* 1989; 148: 571–573.
23. Alam MA, Subhan N, Hossain H, et al. Hydroxycinnamic acid derivatives: a potential class of natural compounds for the management of lipid metabolism and obesity. *Nutr Metab (Lond).* 2016; 13: 27.
24. Wang LN, Wang W, Hattori M, Daneshtalab M, Ma CM. "Synthesis, anti-HCV, antioxidant and reduction of intracellular reactive oxygen species generation of a chlorogenic acid analogue with an amide bond replacing the ester bond." *Molecules.* 2016; 21: 737.
25. Boo YC. p-Coumaric Acid as An Active Ingredient in Cosmetics: A Review Focusing on its Antimelanogenic Effects. *Antioxidants.* 2019; 8: 275.
26. Rauf A, Imran M, Abu-Izneid T, Ihtisham-Ul-Haq, Patel S, Pan X, et al. Proanthocyanidins: A comprehensive review, *Biomedicine & Pharmacotherapy.* 2019; 116: 108999.
27. Perumalla and Hettiarachchy. *Phenols such as epicatechin and caffeic acid influence the osmotic potential of a cell, damaging the membrane and ultimately causing cell constituents to leak. Second Edition 2021.*
28. Jepson RG, Williams G, Craig JC. "Cranberries for preventing urinary tract infections". *Cochrane Database of Systematic Reviews.* 2012; 10: CD0011321.
29. Lin CC, Chu CL, Ng CS, Lin CY, Chen DY, Pan IH, et al. Immunomodulation of phloretin by impairing dendritic cell activation and function. *Food Funct.* 2014; 5: 997–1006.
30. Khoo HE, Azlan A, Tang ST, Lim SM. Anthocyanidins and anthocyanins: colored pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food Nutr Res.* 2017; 61: 1361779.
31. Shin S. Protective Effects of a New Phloretin Derivative against UVB-Induced Damage in Skin Cell Model and Human Volunteers. *IJMS International Journal of Molecular Sciences.* 2014; 15: 18919–8940.
32. Sampath C, Rashid MR, Sang S, Ahmedna M. Specific bio active compounds in ginger and apple all evia tehyp ergly cemia in mice with high fat diet-induced obesity via Nrf2 media tepoch way. *Food Chem.* 2017; 226: 79–88.