Review Article

Review on Major Bioactive Agents Along with Traditional and Medicinal Uses of *Malus domestica*

Prakash Awasthi, Rashmita Thakuri[1]

Department of Horticulture, Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, [1]Diploma in Pharmacy, Nepal Institute of Health Science, Stupa College, Purbanchal University, CTEVT, Kathmandu, Nepal

Abstract

Because they have fewer negative effects than chemical medications, fruit-derived bioactive compounds have gained attention as a regulator against a variety of diseases. Apple is one of the most popular fruits, a rich source of nutritional components, and has high amounts of bioactive substances. Pentacyclic triterpenes, phytosterols, polysaccharides (pectin), and polyphenols are the main structural classes of apple components. The nutritional benefits of apples are completed by vitamins and trace elements. These bioactive compounds found in apples and their peels can promote human health by reducing the risk of cancer, diabetes, inflammation, and cardiovascular disease. This is supported by a growing body of scientific research. The present understanding of apple bioactive compounds and their potential medical benefits for people's health will be the main emphasis of this review.

Keywords: Antidiabetic, anti-inflammatory antioxidant, apple, human health

Introduction

One of the most commercially and culturally significant, nutrient-rich fruits growing in all temperate zones is the apple *(Malus domestica)* belonging to the family Rosaceae.[1] The seeds of the fruit are not edible, but various products, such as ciders and juices, jams, compotes, tea, wine, or dried apples, can be made from them. They are vital to human nutrition because they improve stress resistance, boost immunity, and contain a variety of bioactive compounds that are healthy for people. Apples are undoubtedly healthful and offer several health benefits, but contemporary medicine had to demonstrate their value for preserving human health using data rather than experience.[2] Overall, a variety of bioactive compounds have been identified in apples, including polyphenols, polysaccharides, plant sterols, pentacyclic triterpenes, and organic acids. It has been demonstrated that the presence of these compounds greatly varies between apple pulp and peel. Polyphenols, polysaccharides, plant sterols, and triterpenes in particular together contribute to the bulk of favorable impacts on human health, including antioxidants, anticancer, and anti-inflammatory properties [Table 1].[7]

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Traditional Uses

Since antiquity, whole fruit has been used to make jams and cakes and, except for the seeds, is edible. Apples, on the other hand, are at least largely responsible for the proverb "An apple a day keeps the doctor away." Asthma, acidity, arthritis, diarrhea, fever, obesity, headache, stomach aches, skin illnesses, and respiratory issues are just a few of the maladies that apples can treat.[8] Because it includes iron in a very well-digestible form, as well as Vitamin B12 and folic acid, the usage of apple vinegar aids in the treatment of anemia. In addition, apple cider vinegar is excellent for treating skin conditions, kidney stones, arthritis, and asthma.

Medicinal Uses

The chemical elements found in apples have numerous medical applications. The apple has several medical benefits,

Address for correspondence: Dr. Prakash Awasthi, Institute of Agriculture and Animal Science, Tribhuvan University, Kirtipur, Nepal.
E-mail: prakashawasthi82@gmail.com

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Table 1: Major bioactive agents found in apple fruit

Bioactive agents	Found in	Citations
Cinnamic acid species	Peel	[3]
Chlorogenic acid	Peel, pulp, kernel, leaf	[4]
Caffeic acid	Peel, pulp	[4]
Ferulic acid	Pulp, leaf	[5]
P-coumaric acid	Pulp	[5]
Caffeoylquinic acid	Pulp and skin	[3]
P-coumarylquinic acid	Pulp and skin	[3]
Cinnamic acid	Leaf	[5]
(+)-Catechin	Peel, pulp, kernel	[6]
(−)-Epicatechin	Peel, pulp, kernel	[6]
Proantho Cyanidins	Peel, pulp, leaf	[6]

The major traditional and medicinal uses of apples will be outlined in this review

as does the vinegar made from apple juice.[9] Many human disorders can be effectively treated with apple cider vinegar, which also normalizes nervous system activity and increases blood coagulation, which reduces the effects of blood loss and enhances the performance of blood vessels. It is also regarded as a source of essential nutrients and energy. It helps the heart's muscles and gums to become stronger, and the vascular walls help the digestive system to return to normal. The apple's cysteine, malic acid, and arginine are thought to be suitable for flushing the body's toxic reserves. In addition, these ingredients are beneficial in treating kidney-related disorders, gout, uric acid, urticarial, and gouty arthritis.[10] Applying a stable water-in-oil emulsion with apple juice extract at a concentration of 3% to hyperpigmented human skin is thought to help reduce sebum production, melanin levels, greasiness, and acne-causing erythema while also improving the appearance of oily face skin.[11]

Pharmacological Studies

From apple fruit, various kinds of bioactive substances have been discovered. The peel and fruit juice extract analysis reveals numerous pharmacological actions that are regarded as advantageous for human health. These bioactive chemicals also exhibit exceptional medicinal efficacy in animal models.

Antioxidant Functions

Apples include flavonoids and phenolic compounds that have biological activity as antioxidants, antimicrobials, and enzyme inhibitors (against cholinesterase, tyrosinase, amylase, and glucosidase). Studies revealed that apple peels exhibit better activity than apple pulp.[12] According to research, the food, pharmaceutical, and cosmetics industries could benefit from using water, alcohol, and polyphenol extracts of *M. domestica* fruit to combat Gram +ve and Gram-ve bacteria such as *Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Klebsiella pneumonia, E. coli,* and *Pseudomonas aeuroginosa,* respectively.[13] According to research, the antioxidant quercetin compound is widely distributed in apple peel and functions as an antioxidant. The apple's potential antioxidant activity was found to be around 83 mol equivalents of Vitamin C, which means that 100 g of apples has the antioxidant activity of about 1500 mg of Vitamin C.[14]

Anti-inflammatory Effect

Numerous triterpene acids, including maslinic acid and chlorogenic acid, have been identified to have anti-inflammatory properties. Through the inactivation of nuclear factor kappa B, maslinic and pomolic acids have anti-inflammatory and anti-arthritic actions. Many substantial sources of these chemicals, according to some experts, have the potential to have anti-inflammatory and glycemic control effects. In addition, according to, apple polyphenol extracts shield rat stomach mucosa from injury *in vivo* and *in vitro*.[15]

Antidiabetic Activity

Diabetes, often known as diabetes mellitus, is a metabolic condition primarily characterized by high blood sugar levels, insulin resistance, and a relative insulin shortage. There is a dearth of knowledge about the possible impact of apple polyphenol extracts on controlling blood glucose levels and other diabetes-related indicators. Two inhibitors at concentrations 10 times dilution (I^2) demonstrated minimal absorbance in apple extract, which was found to reduce browning at a glucose concentration. *M. domestica* is hence useful and efficient in lowering the degree of glycation in diseases such as diabetes.[16] Consuming apples may reduce the risk of diabetes because they contain a larger quantity of quercetin, and eating apple peels was also linked to a lower risk of type II diabetes. Researchers discovered that phenolic substances, such as flavonoids found in apple juices, significantly affected plasma glucose concentrations, insulin, and the hormones glucose-dependent insulinotropic polypeptide and glucagon-like peptide-1 in volunteers. The findings were consistent with delayed intestinal absorption of glucose. *In vivo* and *in vitro* pharmacological activities were significantly influenced by flavonoids.[17] In addition, they have health-promoting properties and are useful in pharmaceutical, nutraceutical, and cosmetic applications.

Conclusion

Experimental data from *in vitro* and *in vivo* research suggest that apples and their peel have a beneficial role in the prevention and treatment of diseases, and apple and their peel are linked to excellent human health. All of the earlier investigations that have been described find support in this review. However, the literature is woefully inadequate in many reported review articles. The effectiveness of nutrients found in apples against illnesses was assessed in both *in vivo* and *in vitro* research. Currently, there is still a lot of potential for the development and application of apples' bioactive compounds. Consuming processed apple products or extracts rich in polyphenols has been related to a lower risk of developing

asthma, cardiovascular disease, cancer, and other chronic diseases. These positive impacts on health are produced by polyphenols' antioxidant and anti-inflammatory properties as well as their modulation of biomarkers in multiple cell signaling pathways. Many of the positive benefits of health still need more research, even though some of them have enough support. The extraction of more apple bioactive compounds and the creation of pharmaceuticals and functional foods that can fight tumors, inflammation, and cardiovascular disease should be the main areas of future study. It will bring about benefits for the economy in addition to protecting human health.

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Conflicts of interest

There are no conflicts of interest.

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