

## **Traditional Uses in Food Products and Health Benefits of Hawthorn**

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**Abstract:** Hawthorn (*Crataegus monogyna*) is a plant of the Rosaceae family and is widely grown throughout the world as one of the medicinal and edible plants, known as the “nutritious fruit” due to its richness in bioactive substances. Extracts derived from it are used in the formulation of dietary supplements, functional foods, and pharmaceutical products. Rich in amino acids, minerals, pectin, vitamin C, chlorogenic acid, epicatechol, and choline, hawthorn has a high therapeutic and health value. Many studies have shown that hawthorn has antioxidant, anti-inflammatory, anticancer, anti-cardiovascular disease, and digestive enhancing properties. This study briefly reviews the chemical composition, nutritional value, food applications, and the important biological and pharmacological activities of hawthorn. This will contribute to the development of functional foods or obtain a natural additive with high conservation value from hawthorn.

**Keywords:** chemical composition, *Crataegus monogyna*, flavonoids, health benefits, polyphenols.

### **Introduction**

*Crataegus monogyna* species are commonly used in traditional medicine. This medicinal plant constitutes a valuable source of bioactive phytochemicals or bio-nutrients (Ma et al., 2016).

Hawthorn is a plant of the *Rosaceae* family. Its is spread all over Romania. It is often found at the edge of the forest or in the form of a shrub on mountain slopes, mostly growing to 15 m. Its wood is

hard and durable. In the 2020 edition of *Pharmacopeia of the People Republic of China*, hawthorn is a wrinkled, uneven, round piece sliced shrub, and dried in autumn after the fruit has ripened. Hawthorn is widely distributed in the world, with over 1000 species (Li et al., 2022; Ma et al., 2016).

The chemical composition of its flowers is diverse and consist a of various biologicaly active substances hyperoside, acetylcholine, quercetin, essential oil, organic acids and tannins, flavonoids, careotenoids. Its berries ripen in the period September - October and also contain a number of biologicaly active components such as flavonoids, citric acid, tannins, pectin and others (Li et al., 2022).

Hawthorn is widely used as a wild fruit for food and medical research. The fresh or dried fruits of hawthorn are used to make preserves, teas and food supplements (Dimitrov et al., 2020). Extracts of hawthorn berries, leaves and flowers are used to prevent hypertension and heart failure (Li et al., 2022).

Hawthorn berries, leaves and flowers are used in Europe for the treatment of heart disease, in North America for the same purpose and in China, mainly for commercial products. In recent years hawthorn is no longer restricted to the processing of some jams and snack foods. A growing number or functional hawthorn products are appearing on the market, such as hawthorn functional drinks, food additives, flavonoid injections and hawthorn enzymes (Hakima et al., 2019).

This review summarizes the nutritional and chemical composition, food products and health benefits of hawthorn.

### **Nutrient composition of Hawthorn**

Approved as a medicinal fruit by the Chinese National Health and Wellness Commission, hawthorn has higher dietary fiber, pectin, ascorbic acid, minerals in high quantities compared with other fruits (Lou et al., 2020). It also presents antioxidant activity. Studies have confirmed that hawthorn is rich in amino acids (8 essential amino acids and 3–8 times more amino acids than fruit), proteins (17 times more protein than apple fruit), sugars, minerals, vitamins (vitamins A, C, B1, B2, about 10 times more vitamins), and has a high nutritional value. Hawthorn is also rich in calcium, vitamin C, and carotene, with the highest calcium content and 890 mg/kg of vitamin, and rich in organic acids, which prevent vitamin C from

being completely destroyed even when heated (Lou et al., 2020; Zhang et al., 2021).

### **Chemical compositions of Hawthorn**

Hawthorn fruit, leaves, and flowers are rich in biologically active ingredients. It contains compounds with bioactive components such as organic acids, flavonoids, mucoxanthin, polyphenols, triterpenoids, and trace elements. Flavonoids range from 0.1 to 1.0% in the hawthorn fruit, 1 to 2% in the leaves and flowers, organic acids are second only to the flavonoids at 4.1% and proanthocyanidins range from 1 to 3% in the hawthorn fruit or leaves. Of these, total flavonoids and organic acids are the most abundant chemical constituents in hawthorn, while proanthocyanidins and total flavonoids are the two main categories of bioactive constituents in hawthorn (Jurikova et al., 2012).

Hawthorn pericarp and pulp are also rich in pectin. Pectin extracted from hawthorn contains approximately 67% glyoxalate has a high galacturonic acid and methyl esterification content and has a high viscosity compared to other food pectins such as lemon and apple pectin (Li et al., 2021).

As a fruit rich in organic and phenolic acids, the organic acids in hawthorn are mainly malic, citric, succinic, ascorbic, quinic, oxalic, linolenic, and lauric acid. The amount of organic acids varies depending on the variety of hawthorn. Citric and malic acids are the highest in hawthorn fruit, with malic acid averaging 1128.68 mg/100g (Nabavi et al., 2015).

In addition, apart from organic acids, hawthorn is also rich in phenolic acids. The main phenolic acid in hawthorn is chlorogenic acid, accounting for more than 80% of the total phenolic acid. Flavonoids are the most abundant and wide-ranging class of compounds in hawthorn. Currently, more than 60 flavonoids have been isolated from hawthorn including the oxidized (chrysin, rutin, and quercetin) and reduced (proanthocyanidins, catechin derivatives) types (Li et al., 2015; Sagaradze et al., 2019).

Secondly, triterpenoids and their derivatives in hawthorn were isolated and identified in the first studies on hawthorn in the 1960. Triterpenoids are a wide range of structurally diverse compounds found in plants, consisting mainly of three terpene or isoprene units.

(Song et al., 2011). Hawthorn is a group of plants rich in triterpenoids, and some pharmacological studies have shown that these components have important effects such as cardiac strengthening, increasing coronary flow and improving circulation. And the presence of triterpenoids in the fruit may be the main reason for their anticancer activity (Tohtahon et al., 2017; Nabavi et al., 2015; Zhang et al., 2022).

Hawthorn seeds have been reported to contain high levels of lignan content. Lignans are natural components synthesized by bimolecular polymerization of phenylpropanoids, which have antioxidant and anti-inflammatory activities and could be a new, inexpensive source of antioxidants, and inflammation inhibitors (Gao et al., 2010).

Sugars are mainly produced in the leaves and are transported to the fruit and other parts of the fruit as they develop. Sugar alcohols, mainly sorbitol and inositol, are mainly found in hawthorn varieties that are more commonly consumed as food (Nabavi et al., 2015).

### **Hawthorn applications in food products**

Fresh hawthorn fruit can be eaten directly without any fumigation or washing. To meet the high quality standards expected by consumers, hawthorn fruit has been processed into many types of products. With the continued development of science and technology, such as the enzyme industry, homogenizer products and membrane technology, a new phase in the processing of hawthorn has been introduced and its product range is becoming more and more diverse (Zhang et al., 2022).

Hawthorn is rich in nutritional value, stimulating appetite and digestion, and is widely used in the food industry. There are many products made from hawthorn on the market, with more than 150 types of products sold. Traditional hawthorn products in China mainly include sugar gourd, hawthorn cakes, hawthorn preserves, canned hawthorn, hawthorn chips, and hawthorn roll (Zhang et al., 2022).

In the production of hawthorn bakery products, it is most important to use effective methods to retain its effective active ingredients and increase the absorption and dissolution properties of hawthorn in bakery products. Wang et al. (2012), used ultra-fine

grinding technology to produce hawthorn bread with 3% hawthorn powder addition, 0.6% salt, 18% sugar, and 0.5% bread amendment as a formula to improve its health benefits and special flavor (Wang et al., 2012). The addition of hawthorn to the whole wheat flour bread has the effect of promoting the normal function of the digestive and circulatory system and also has an antihyperglycemia effect, this raw material is inexpensive and can be consumed by people with type 2 diabetes (Sixt and Strube, 2018).

Hawthorn is so rich in vitamins, minerals, and active substances that can meet people's nutritional requirements for fruit wines. The sales of fruit wines in China are increasing at a rate of 15% and the development prospects are very promising. Beers produced from the North American shrub, star-spotted hawthorn, not only have a higher antioxidant capacity and higher polyphenol concentration, but also have a greater degree of improvement in taste, aroma, clarity, and overall impression (Gasiński et al., 2020).

Treatment of hawthorn wine with pectinase facilitated the reduction of pH and the release of methanol in the wine and accelerated the clarification of hawthorn wine (Jiang et al., 2021).

With the widespread use of hawthorn, vinegar has become more than a simple flavoring agent, and its health maintenance and wellness benefits are receiving more and more attention. The production of hawthorn vinegar from hawthorn berries not only has good characteristics of volatile aromatic compounds that enrich the taste of the vinegar, but also has highly bioactive phenolic compounds that exert a nutritional and health value, increasing the area of use and consumption of hawthorn berries. The use of hawthorn for the production of hawthorn vinegar is a more efficient way to produce innovative and healthy products (Özdemir et al., 2022).

Zhou et al. (2020), incorporated hawthorn into traditional sausages, giving them a new taste and flavor, and solving the food safety problem of nitrite in traditional cured sausages. The antioxidant and antibacterial effects of phenolics in hawthorn have also been investigated in a variety of commercial foods such as lamb burgers, frankfurters, and pork liver (Zhou et al., 2020).

As the perfect companion to bread and other pastries, the consumer demand for jam is gradually increasing. According to China Industry Research Network, the consumption of jam in China has been growing at a rate of around 15%. Hawthorn jams on the

market at present are broadly divided into two types: an ordinary hawthorn jam and compound jam with hawthorn flavor, such as hawthorn leaf flavonoid jam and hawthorn passion fruit jam (Lu et al., 2022). Li et al. (2022), used 1.15% hawthorn leaf flavonoids, 45% white sugar, 0.30% pectin, 0.20% xylitol and 0.16% citric acid as the formula to develop hawthorn leaf flavonoid jam with flavonoid flavor. The composite hawthorn jam not only meets the need for a safe and healthy jam, but also further enhances the use of hawthorn and hawthorn by products (Wang et al., 2012).

### **Health Benefits**

The active ingredients in hawthorn are the basis for the wide range of health benefits it exerts. For example, polyphenolic compounds are good antioxidants and immunomodulators, flavonoids have anti-inflammatory and antithrombotic activity, lignans have antibacterial and antioxidant activity, while triterpenoids have anticancer, anti-inflammatory and anti-proliferative activities. It is therefore essential to advocate the exploitation of the therapeutic potential of hawthorn in new food products to improve and maintain the nutritional and health indices of the population (Jurikova et al., 2012; Salmanian et al., 2014).

At present, there is little information and research on hawthorn's anticancer effects. However, the bioactive substances contained in hawthorn are believed to have beneficial effects on human cancer cells. The anticancer effects of hawthorn can be divided into two main areas: hawthorn extract and hawthorn isolated compounds. Qiao et al. (2015) found that triterpenoids extracted from hawthorn with acetone had significant inhibitory effects on the proliferation of human breast and hepatocellular carcinoma cells.

The proanthocyanidins, total flavonoids, and other extracts contained in the fruits, leaves, and flowers of hawthorn are commonly used in the treatment of cardiovascular disease due to their significant in vitro effects and apparent safety profile (Hakima et al., 2019).

The diastole of the peripheral blood vessels is the main cause of the fall in blood pressure. Hawthorn fruit extract confers antioxidant effect on high-salt induced hypertension and it may be used as a nutritional supplemental therapeutic drug to protect against high-salt induced hypertension in renal medulla. A

randomized controlled trial of type 2 diabetes showed that patients given hawthorn extract (1200 mg per day) had a significantly greater reduction in mean diastolic blood pressure than those given placebo (the prescribed drug). The hydroalcoholic extract of hawthorn flower heads was shown to inhibit thromboxane A<sub>2</sub> (TXA<sub>2</sub>) activity and promote peripheral vasodilation, thereby lowering blood pressure (Ravikumar and Chua, 2022).

A dried extract of Hawthorn with flowering leaves, has been shown to have positive inotropic and anti-arrhythmic properties (Kirakosyan et al., 2003). Hawthorn ethanol extract can increase the activity of glutathione peroxidase and decrease the content of malonaldehyde (MDA) in the myocardium, alleviating inflammatory cell infiltration, and myofibrillar disorders in the myocardial structure. Hawthorn leaf flavonoids protect against diabetes-induced cardiomyopathy by reducing oxidative stress and inflammation. The citric acid, caffeic acid, chlorogenic acid, and quercetin in hawthorn also have a protective effect against myocardial ischemia. Dried hawthorn berries treated with honey can increase the content of organic acids, phenylpropanoids, and flavonoids in hawthorn, thus further enhancing the anti-myocardial ischemia effect of hawthorn (Zhang et al., 2022).

The phenolic and flavonoid compounds in hawthorn are considered to be important active substances in the fight against diabetes. Hawthorn is able to improve hyperlipidemia by lowering blood sugar and triglyceride levels caused by a high-fat diet. The quercetin in hawthorn can effectively inhibit the activity of alpha-glucosidase enzyme, resulting in a reduction in the release and absorption of glucose thereby lowering blood sugar levels (Dai and Mumper, 2010).

Hawthorn has hypolipidemic and vascular protective effect, which is mainly attributed to its high antioxidant effect. Phenolic compounds, flavonoids, and triterpenoids are important components of natural antioxidant substances. In hawthorn fruits, free phenolic compounds accounted for 35.3–37.8% of the antioxidant activity, followed by insoluble bound phenolic compounds accounting for 25.0–27.0% of the antioxidant activity (Alizeralu et al., 2020).

Hawthorn is a common herbal remedy for indigestion, and its herbal tonics and extracts have been shown to improve gastrointestinal motility. The phenolic substances in hawthorn, especially phenolic acids, play an important role in the digestive

system due to their stable structure (Zheng et al., 2018).

Hawthorn extract protects the gastrointestinal tract mainly by altering disorders of lipid, energy, and amino acid metabolism. In the atropine gastrointestinal motility disorder model, the ethanolic extract of hawthorn modulates the metabolism of bile acids and promotes the excretion of lipids to some extent (Babiker et al., 2020).

## Conclusions

Hawthorn is a good source of proteins, amino acids, sugars, minerals, vitamins and phytochemicals including terpenoids, phenols, and flavonoids. As a medical herb, hawthorn contains a large number of naturally occurring bioactive substance with therapeutic properties and is therefore a highly marketable source of medicines worldwide.

Dozens of bioactive substances in hawthorn can be extracted as a health product. At present, the processing technology of hawthorn food has been widely emphasized, both traditional processing technology and modern technology. Hawthorn has been processed into many products, such as hawthorn drinks, hawthorn paste, hawthorn vinegar, hawthorn wine and bread.

The rich nutrients in hawthorn seeds and leaves should not be overlooked. It is important to look at hawthorn composition as a whole. In the future, it is important to continue to explore the nutritional and health benefits of hawthorn and to develop value added foods and supplements based on the functional components of hawthorn, based on extracts and active substances from other parts of hawthorn.

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