EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 10
Issue: 12
75-86
Year: 2023

ACTINIDIA CHINENSIS VAR. DELICIOSA: A STUDY OF THE CULTIVATION, NUTRITION, AND PHARMACOLOGICAL USES OF KIWIFRUIT

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Article Received on 08/10/2023 **Article Revised on 29/10/2023** **Article Accepted on 19/11/2023**

ABSTRACT
Kiwi fruit, belonging to the Actinidiaceae family and Actinidia genus, is a highly commercialized fruit loaded with numerous nutrients such as vitamins, minerals, and phytochemicals. It has medicinal and therapeutic properties that are beneficial for various diseases, including those related to the cardiovascular system, diabetes, kidney problems, cancer, digestive disorders, bone, and eye problems. Kiwi fruit is a significant source of phytochemicals, such as caffeic acid, gallic acid, syringic acid, salicylic acid, ferulic acid, and protocatechuic acid, which contribute to its major flavonoid and phenolic contents. Kiwi fruit and its components exhibit numerous pharmacological properties, including antidiabetic, anti-tumour, anti-inflammatory, anti-ulcer, antioxidant, hypoglycaemic, and hypolipidemic effects. It also finds traditional applications in treating oedema, hepatitis, kidney problems, rheumatoid arthralgia, and microbial infections. The fiber present in kiwi fruit aids in water retention and promotes gastrointestinal health. Research is also being conducted on the insulin and glucose balance, weight maintenance, and homeostatic balance related to kiwi fruit consumption. This review aims to provide a better understanding of kiwi fruit's nutritional composition, pharmacological properties, health benefits, traditional utilization, and commercialization, offering scientific evidence-based recommendations to consumers.

KEYWORDS: Actinidia chinensis, Cultivation, Phytochemistry, Pharmacological uses.

INTRODUCTION
For many centuries, herbal medicines have played a significant role in the healthcare system. These remedies contain a variety of bioactive molecules, such as alkaloids, glycosides, flavonoids, terpenes, and phenolic moieties, that have been shown to provide health benefits. Plant species that are rich in phenolic compounds have been the focus of much research due to their potent antioxidant properties. Among these plant species, berries have emerged as particularly promising sources of health benefits. Berries are known for their high levels of phenolic compounds, which give them strong antioxidant properties. As a result, they have been associated with a range of health benefits, for example, they have been shown to have anti-inflammatory, anti-cancer, and neuroprotective effects. They may also help improve cardiovascular health, reduce the risk of diabetes, and promote weight loss.[1]

Actinidia chinensis var. deliciosa (A. Chev)
History
The history of Actinidia deliciosa, commonly known as kiwifruit, dates back to 1847 when plant specimens were collected by an agent for the Royal Horticultural Society in London. The plant's cultivation spread from China to other parts of the world in the early 20th century. In 1904, Isabel Fraser, the principal of Wanganui Girls' College in New Zealand, obtained kiwifruit seeds during her visit to mission schools in Yichang, China. She brought the seeds back to New Zealand and gave them to a local nurseryman named Alexander Allison, who planted them in 1906. The vines first fruited in 1910, and in 1924, Hayward Wright developed the familiar cultivar Actinidia deliciosa 'Hayward' in Avondale, New Zealand. This cultivar is now the most widely grown variety of kiwifruit in the world.[2]

Initially, Chinese Gooseberry (as it was called at the time) was produced in domestic gardens, but commercial planting began in the 1940s. In 1959, Turners and Growers, a New Zealand produce company, renamed the fruit "kiwifruit" after New Zealand's national bird, the kiwi, which is also brown and furry. Today, kiwifruit is grown in many parts of the world, including Italy, Chile, France, Greece, and the United States. It is a popular fruit that is known for its unique flavour, bright green flesh, and nutritional benefits.[3]

The Actinidia genus is made up of 76 different species, but only two of these species, Actinidia chinensis (golden kiwifruit) and Actinidia deliciosa (fuzzy kiwifruit), are produced on a commercial scale. Other species of the Actinidia genus include *Actinidia arguta* (baby kiwifruit), *Actinidia purpurea* (purple kiwifruit), *Actinidia kolomikta* (arctic kiwifruit), *Actinidia eriantha* (velvet vine), *Actinidia polygama* (silver kiwifruit), and *Actinidia melanandra* (red kiwi).[4]

The classification of kiwifruit has been updated, and it is now considered to be a variety of *Actinidia chinensis*, specifically Actinidia chinensis var. deliciosa (A. Chev.) A. Chev. Previously, it had been classified as *Actinidia deliciosa* (A. Chev.) Liang and Ferguson var. deliciosa.[5] Kiwifruit, also referred to as Chinese gooseberry, originally comes from the Yangtze region of China. It was later introduced to New Zealand where it became a popular fruit crop. Despite being a tropical fruit, kiwifruit is a relatively new commercial crop that has been widely cultivated for just over five decades.[6]

Table 1: Taxonomical classification.[7]

BOTANICAL NAME	*Actinidia chinensis var. deliciosa* (A.Chev) A. Chev
COMMAN NAME	Chinese-gooseberry, kiwi, kiwifruit, strawberry-peach
KINGDOM	Plantae
DIVISION	Magnoliophyta
CLASS	Magnoliopsida
SUBCLASS	Magnoliidae
ORDER	Ericales
FAMILY	Actinidiaceae
GENUS	Actinidia
SPECIES	*Actinidia chinensis*
VARIETY	*deliciosa*

Geographical Condition

Kiwifruit plants thrive in areas with full sun or light shade, and they require slightly acidic soil with a pH between 6.0 and 6.5 for optimal growth.[8] Actinidia deliciosa trees bear fruit successfully in sub-temperate and tropical climates that have warm and humid conditions at elevations ranging from 900 to 1800 meters. However, kiwi trees cannot withstand sub-freezing temperatures, and very high temperatures and low humidity can hinder their growth. The best temperature range for the successful cultivation of kiwi trees is between 25 and 30 °C. Additionally, a well-distributed rainfall of around 150 cm per year is sufficient for their growth. Kiwifruit plants produce fruits on mature growth that is at least one year old, and fruiting slows down on old wood that is over three years old. These plants are either male or female, and cross-pollination is necessary for fruit set. In backyard cultivation, it is common to grow several vines together in a clump to ensure the presence of both sexes. The sex of a kiwifruit plant can be determined once it matures and starts flowering.[9]

Morphological Characteristics[10]

Foliage: The leaves of Actinidia deliciosa are large, deep green, and leathery, and they have an oval to nearly circular shape. The leaves are alternate, deciduous, and long-petioled, with a cordate base and a length of 7.5-12.5 cm. While young leaves are covered with red hairs, mature leaves are hairless on the upper surface and dark green. The underside of mature leaves is downy-white, with prominent, light-coloured veins.

Flowers: The fragrant flowers of Actinidia deliciosa are either dioecious or bisexual, and they are borne singly or in groups of three in the leaf axils. They have five to six petals that are white at first, but change to buff-yellow and measure 2.5-5 cm in diameter. Both sexes have central tufts of many stamens, although the female flowers do not have viable pollen, and the flowers lack nectar. The tree flowers in November, and male and female flowers appear on different plants, so both sexes need to be planted in close proximity for fruit set. Commercial orchards typically use bees for pollination, but hand pollination can also be used, although it is more labour-intensive. [Fig.1]

Fruit: The fruit is oval, ovoid, or oblong in shape and can grow up to 2-2½ inches long. It has russet-brown skin that is covered in short, stiff brown hairs. The flesh is firm when unripe but becomes glistening and bright green or yellow, brownish, or off-white when fully ripe, except for the white centre that is juicy and succulent. The flesh is lined with many fine, pale lines, and scattered between them are tiny dark-purple or nearly black seeds that are not noticeable when eaten. The fruit has a sweet and tart to acidic flavour. [Fig.2]

Fig. 1: Flower of Acv.

Fig. 2: Fruit of Acv.

Table 2: Actinidia Species and Cultivators.

Actinidia Species	Cultivator	Colour of flesh
A. deliciosa	Hayward	Green
A. deliciosa	Koryoku	Deep green
A. deliciosa	Sanryoku	Yellow green
A. chinensis	Hort16Af	Yellow
A. chinensis	Sanuki Goldd	Deep yellow
A. rufa	Nagano	Deep green
A. arguta	Hirano	Green

Table 3: Phytochemistry of different parts of *A. deliciosa cv* 'Hayward' plant.[11-15]

PLANT PARTS	CONSTITUENTS
PULP	FLAVONOIDS (Quercetin, kaempferol, catechin and epicatechin), PHENOLIC ACIDS (p-hydroxybenzoic, p-coumaric, ferulic, gallic, and caffeic acids), (ANTHOCYANIN (cyanidin-3-O-sambubioside), PHENOLS (procyanidin B1 and B2, gallic acid, chlorogenic acid and quercetin-3-O-rhamnoside.), SUGARS (Fructose, glucose, sucrose and trehalose), SATURATED AND UNSATURATED FATTY ACIDS (palmitic acid and α-linoleic acid), α-TOCOPHEROL (α- and γ-tocopherol), VITAMIN C (92.7g), ORGANIC ACIDS (quinic, malic, citric and ascorbic acids), actinidic acid, triterpenoids
ROOTS	β-sitosterol, *n*-stearic acid, isoscopoletin, 2, 2-dimethyl-6-chromancarboxylic acid, fraxetin, aesculetin, umbelliferone, vanillic acid, protocatechuic acid, vanillic acid 4-*O*-β-D-glucopyranoside, 5, 7-dihydroxychromone, and tachioside
PEEL	gallic, protocatechuic, gentisic, catechin, rosmarinic, chlorogenic, cinnamic, caffeic, syringic, ellagic, vanillic, ferulic and sinapic acids as well as coumarin, chrysin, pyrogallol, quercetin, rutin, pectin
LEAVES	Quercetin, rutin, isoferulic acid, carotenoids, oxalic acid, essential oils, microelements and chlorophyll a, b.
SEEDS	62% alpha linolenic acid, omega-3 fatty acid

Nutritional Composition of *A. deliciosa cv* 'Hayward' plant

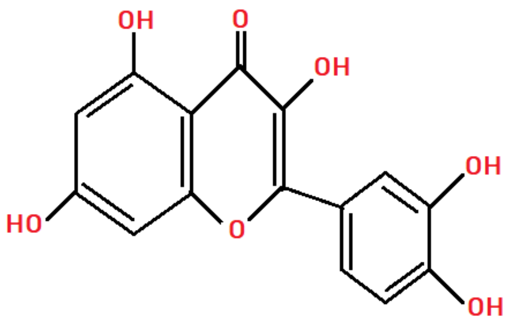
Kiwi fruit is known for its rich nutrient profile and potential health benefits. Its chemical composition includes various nutritive components such as protein, lipids, carbohydrates, vitamins (such as vitamin A, vitamin C, vitamin E, and folic acid), minerals, polyphenols, antioxidants, and dietary fiber. These components play a crucial role in maintaining good health and preventing various diseases.[16-17] Protein is essential for building and repairing tissues, while lipids (fats) provide energy and play a role in hormone production. Carbohydrates provide energy to the body, and vitamins, such as vitamin A, vitamin C, vitamin E, and folic acid, are essential for various bodily functions, including maintaining healthy skin, eyes, and immune system.[18]

Kiwi fruit is also rich in minerals such as potassium, calcium, magnesium, and phosphorus, which are necessary for maintaining healthy bones and teeth. Polyphenols and antioxidants found in kiwi fruit help to neutralize harmful free radicals in the body and may help reduce the risk of chronic diseases such as cancer, heart disease, and stroke.[19] Finally, dietary fiber found in kiwi fruit is important for maintaining digestive health, preventing constipation, and regulating blood sugar levels. Overall, the unique combination of these various components makes kiwi fruit a highly nutritious and beneficial food for human consumption.[20]

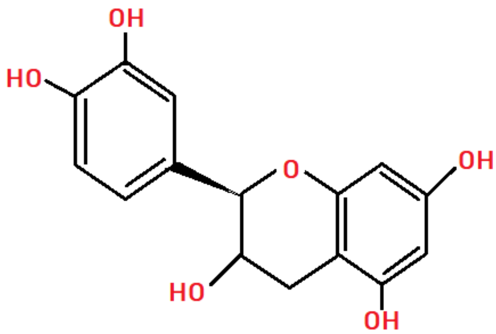
Table 4: Nutritional Composition of *A. deliciosa cv.*

Nutrient	*A. deliciosa cv value per 100g*
Water (g)	*83.07*
Total protein (g)	*1.14*
Energy (kcal/KJ)	*61/255*
Fat (g)	*0.52*
Carbohydrate (g)	*14.66*
Fiber (g)	*3.0*
Sugar (g)	*8.99*
Calcium	*34*
Iron	*0.31*
Magnesium	*17*

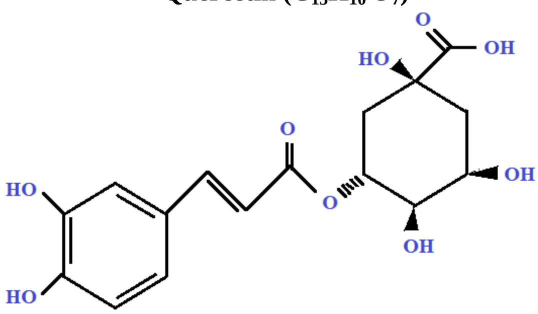
Chemical constituents and its pharmacological activity



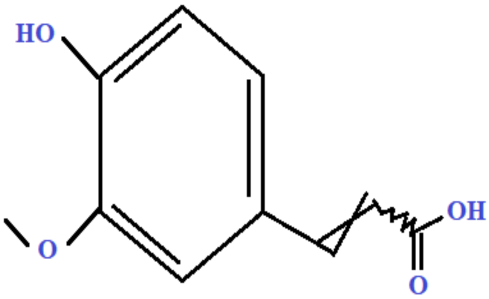
Quercetin ($C_{15}H_{10}O_7$)



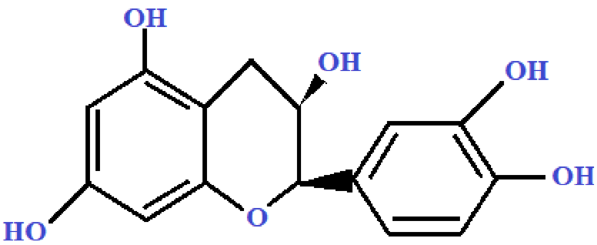
Catechin ($C_{15}H_{14}O_6$)



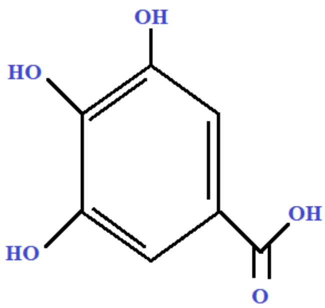
Chlorogenic Acid ($C_{16}H_{18}O_9$))



Ferulic Acid ($C_{10}H_{10}O_4$)



Epicatechin ($C_{15}H_{14}O_6$)



Gallic acid ($C_7H_6O_5$)

Fig. 3: Chemical constituents of *Acv.*

Quercetin ($C_{15}H_{10}O_7$)

Quercetin is a polyphenol-flavanol found in kiwi fruit, belonging to the flavonoid subclass. Its IUPAC name is 3,3′,4′,5 7-pentahydroxy flavanone. Quercetin acts as a calmodulin inhibitor and inhibits cyclooxygenase and lipoxygenase with Quercitrinase. It has been shown to prevent DNA damage from free radicals, as demonstrated in experiments with TBARS and DPPH. Traditionally, quercetin has been used to treat various conditions such as cancer, cardiovascular diseases, PCOS, obesity, chronic diseases, and reproductive dysfunctions. Studies have shown that quercetin is an effective antioxidant, anti-inflammatory, anti-apoptotic, and anticancer drug.[21] However, its use in the pharmaceutical industry is limited due to poor bioavailability, solubility, permeability, and instability. Quercetin has been found to inhibit both 2- hydroxy estradiol and 4- hydroxy estradiol with IC50 values of 0.9 to 1.5 µM and 0.5 to 1.2 µM, respectively. In DPPH scavenging assay, quercetin showed an IC50 value of 0.55 µM, while in ABTS+ assay, the IC50 values were found to be 1.17 ± 0.23 µM.[22]

Catechin ($C_{15}H_{14}O_6$)

Catechin is a polyphenolic flavanol, specifically a flavan-3-ol, with the IUPAC name 3,3',4',5,7-pentahydroxy flavan. It is a secondary metabolite of plants and is found in Acacia, also known as mimosa catechu or black catechu, which belongs to the Fabaceae family. Catechin can cross the blood-brain barrier and regulate gene and protein expressions in neurons. It also influences angiogenesis, extracellular matrix degradation, cell death regulation, and multiple drug resistance in diseases such as cancer. Catechin scavenges reactive oxygen species (ROS) and chelates metal ions. It works synergistically with vitamin C and E and antioxidant enzymes like catalase and superoxide dismutase, while inhibiting pro-oxidant enzymes. Catechin has therapeutic properties such as anti-cancer, anti-cardiovascular, hepato-protective, and neuroprotective effects. It is also effective in treating diabetes and obesity. Studies using in vitro, in-vivo, and other physical methods have shown the antioxidant property of catechin. Catechin inhibits 4-hydroxy estradiol and α-glucosidase with IC50 values of 5-7 µM and 239.27 µg/mL, respectively.[23]

Chlorogenic Acid ($C_{16}H_{18}O_9$)

Chlorogenic acid, also known as 3-(3,4 dihydroxy cinnamoyl) quinin acid or 3-caffeoyl quinin acid, belongs to the polyphenol family of esters. Despite its name, chlorogenic acid does not contain any chlorine. It has been found to improve lipid and glucose metabolism in both metabolic and genetic disorders. In addition, chlorogenic acid possesses a range of pharmacological activities such as antioxidant, antibacterial, hepatoprotective, cardioprotective, anti-obesity, antiviral, antimicrobial, antihypertensive, free radical scavenging, and CNS stimulating properties. The exact mechanism of its antioxidant effects is not yet fully understood. Chlorogenic acid has also been shown to affect key enzyme activities involved in lipid metabolism.[24-25]

Ferulic Acid ($C_{10}H_{10}O_4$)

Ferulic acid, a plant-based antioxidant, has been used for skincare and anti-aging purposes due to its ability to combat free radicals and increase the antioxidant activity of vitamins C and E. It is available as a serum and supplement for various conditions like diabetes and pulmonary hypertension. Ferulic acid's antioxidant properties make it beneficial for age-related factors, skin problems like age spots and wrinkles, and as a preservative. It has been studied for its potential to treat Alzheimer's and cardiovascular diseases due to its ability to inhibit the formation of reactive oxygen species (ROS) and form stable phenoxy radicals. When combined with vitamins C and E, ferulic acid increases photo-protective activity. It inhibits the enzymes α-amylase, α-glucosidase, and neuraminidase, with IC50 values of 0.622 mg/mL, 0.866 mg/mL, and 50 µM, respectively. These reactions are catalysed by the enzyme's xanthine oxidase and cyclooxygenase-2.[26-27]

Epicatechin ($C_{15}H_{14}O_6$)

Epicatechin is a type of catechin, which is a polyphenolic compound with various effects on the body. One of its benefits is that it can lower blood pressure and act as an antioxidant, preventing oxidative damage. However, it can also induce endothelial dysfunction, which can lead to hypertension and brain disorders. Epicatechin can modify metabolic rate, blood content, and cross the blood-brain barrier. Epicatechin has a unique feature in that it can neutralize reactive oxygen species (ROS) and also modify cell signalling pathways, including the mitogen-activated protein kinase (MAP kinase) pathway. It is a preventive agent that is sometimes given with chemotherapy and radiation therapy to enhance their effects. The direct mechanism of epicatechin is that it acts as a free radical scavenger, while the indirect mechanism is that it modulates the activity of superoxide dismutase and glutathione peroxidase. Epicatechin has an IC50 value of 10 to 18 µM when inhibiting the 4-hydroxy estradiol enzyme and 44 to 65 µM when inhibiting the 2-hydroxy estradiol enzyme.[28]

Rutin ($C_{27}H_{30}O_{16}$)

Rutin is a polyphenolic flavonoid that is also known as rutinoside, vitamin, or quercetin-3-rutinoside. It is derived from the plant Ruta graveolens and contains the flavonoid quercetin along with the disaccharide rutinose. Rutin inhibits the transcription of various enzymes such as HMG-CoA reductase, glycerol-3-phosphate acyltransferase (GPAT), fas, and ACC, and it has an antioxidant effect by inhibiting cellular oxidase enzymes. Rutin has various effects on different body systems, including the central nervous, endocrine, cardiovascular, respiratory, reproductive, and gastrointestinal systems. It also has various pharmacological activities, including antioxidant, cytoprotective, vaso-protective, anti-neoplastic, neuroprotective, and cardioprotective activities. However, rutin is poorly absorbed in the intestine due to the presence of intestinal microflora in the lower gut. It gets hydrolyzed in the gut and absorbed in the walls of the small intestine as aglycone, quercetin, and sugar. The IC50 value of rutin was found to be 4.708 to 19.377 µM. In the DPPH assay and ABTS+ assay, the IC50 value of rutin was found to be 5.56 ± 0.05 µg/mL and 17.16 ± 0.05 µg/mL, respectively.[29]

Gallic acid ($C_7H_6O_5$)

Gallic acid is a polyphenolic compound found in various plants and has several pharmacological activities including antioxidant, cytoprotective, vaso-protective, anti-neoplastic, neuroprotective, and cardioprotective activities. The IC50 (half maximal inhibitory concentration) value of gallic acid can vary depending on the specific assay and the target molecule being studied. However, some reported IC50 values for gallic acid include IC50 value of gallic acid for inhibiting 5-lipoxygenase (5-LOX) enzyme is 25.4 µM. IC50 value of gallic acid for inhibiting α-glucosidase is 13.04 µM. IC50 value of gallic acid for inhibiting tyrosinase enzyme activity is 19.83 µM.[30]

Table 5: Chemical constituents and its pharmacological activity.

S.no	Chemical constituents/ structure	Pharmacological activity	Mode of action	Ref
1.	Quercetin	• Antioxidant activity • Anti-inflammatory activity • Inhibition of histamine release	1.Potent antioxidant by scavenging free radicals and preventing oxidative damage to cells. 2. Inhibit the activity of several enzymes involved in inflammation and cancer development, including cyclooxygenase (COX) and lipoxygenase (LOX).	[21] [22]
2.	Catechin	• Anti-diabetic activity • Neuroprotective activity • Anti-cancer effect	1. Catechin has been found to chelate (bind) metal ions, which can help prevent their accumulation in the body and reduce oxidative stress. 2. Catechin has been shown to modulate various cell signalling pathways, including those involved in cell growth and differentiation, apoptosis (programmed cell death), and DNA repair.	[23]
3.	Chlorogenic acid	• Antimicrobial activity • Neuroprotective activity • Antioxidant activity	1. CGA is a potent antioxidant, meaning it can neutralize harmful free radicals in the body that can damage cells and contribute to chronic diseases like cancer, heart disease, and diabetes. 2. CGA has been shown to inhibit glucose absorption in the intestine and reduce glucose production in the liver, which can help regulate blood sugar levels and prevent or manage type 2 diabetes.	[24-25]
4.	Ferulic acid	• Skin protection • Cardiovascular activity • Anti-diabetic activity	Ferulic acid reduce the synthesis of cholesterol in the liver, which may help reduce the risk of developing heart disease.	[26-27]
5.	Epicatechin	• improve cognitive function. • anti-aging properties. • protect against oxidative stress caused by free radicals.	Epicatechin has potent antioxidant activity, which helps to neutralize free radicals and reactive oxygen species (ROS) that can damage cells and cause inflammation. This activity is thought to be due to its ability to scavenge free radicals, chelate transition metals, and upregulate endogenous antioxidant enzymes.	[28]
6.	Rutin	• Cardiovascular effects • Anti-cancer effects • Anti-diabetic effects	Rutin has been shown to improve cardiovascular function by reducing oxidative stress, improving endothelial function, and reducing blood pressure. This effect is thought to be due to its ability to activate endothelial nitric oxide synthase (eNOS), an enzyme that produces nitric oxide (NO) in the endothelium.	[29]
7.	Gallic acid	• Anti-inflammatory activity • Anti-microbial activity	Anti-microbial effect is thought to be due to its ability to disrupt microbial membranes and inhibit microbial enzymes.	[30]

Table 6: Patent of kiwifruit species.

S.NO	INVENTOR	PATENT NO	TITLE	REFERENCE
1.	S. Pellegrino	MO 2005000211	Monitoring of the maturation and ripening evolution of the cultivar 'Hayward' fruits	[31]
2.	J.D. Spiers	22,191	AU Golden Dragon	[32]
3.	Costa G	22,159	AU Golden Sunshine	[33]

Reported Pharmacological Applications

Antioxidant activity

Kiwifruit is a rich source of antioxidants; antioxidant compounds are essential for protecting the body from damage caused by oxidative stress. Oxidative stress is a process that occurs when there is an imbalance between free radicals, which are highly reactive molecules that can damage cells and tissues, and the body's antioxidant defences.[34] The antioxidant activity of kiwifruit is mainly attributed to its high content of vitamin C and polyphenolic compounds. Antioxidant activity involves the prevention of oxidation of various molecules, such as proteins, lipids, and DNA, by interfering with the propagation stage of oxidative chain reactions.[35] This is achieved by scavenging free radicals directly or by preventing the formation of free radicals through the Fenton's reaction. Primary antioxidants directly scavenge free radicals, while secondary antioxidants indirectly prevent the formation of free radicals. Both primary and secondary antioxidants are important for protecting the body from oxidative stress and reducing the risk of chronic diseases associated with oxidative damage, such as cancer, cardiovascular disease, and neurodegenerative disorders.[36]

The antioxidant activity of kiwifruit has been studied using various in-vitro and in-vivo assays. Antioxidant properties of kiwi fruit flesh, using methods such as DPPH and ABTS radical scavenging, Hydroxyl ion reducing ability, Iron chelating capacity, Ferric reducing antioxidant power, and Oxygen radical absorbance capacity assays. These assays are crucial in evaluating the ability of various plant extracts to prevent the harmful effects of free radicals in diseases like cancer and Alzheimer's. DPPH is an important method for screening the antioxidant activity of different plant constituents, while hydroxyl scavenging activity is assessed to determine the protective effect of extracts against free radicals, which can cause DNA damage and mutations leading to cancer.[37-38]

Anti-inflammatory Activity

Several studies have reported on the anti-inflammatory properties of kiwifruit in both in vitro and in vivo models. In one study, kiwifruit extract was found to reduce the production of pro-inflammatory cytokines in human white blood cells, indicating its potential to alleviate inflammation. Another study showed that kiwifruit extract was able to suppress the expression of inflammatory genes in mice with induced colitis.[39] Kiwifruit can inhibit the synthesis of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2) enzymes, which are involved in reactions that can lead to ischemic brain injury. Inhibition of these enzymes may have a protective effect on the brain by reducing inflammation and oxidative stress. iNOS is responsible for producing nitric oxide, which can cause damage to brain tissue when produced in excess. COX-2, on the other hand, produces prostaglandins that contribute to inflammation and tissue damage in the brain. By inhibiting these enzymes, kiwifruit may help to reduce the risk of ischemic brain injury, which occurs when blood flow to the brain is restricted and can lead to stroke or other neurological damage.[40]

Antidiabetic activity

Kiwifruit has been found to have potential antidiabetic activity due to its high fiber and antioxidant content, which may help to regulate blood sugar levels and improve insulin sensitivity. One study found that consuming kiwifruit for four weeks resulted in a significant decrease in fasting blood glucose levels and HbA1c levels, which are markers of long-term blood sugar control. Another study showed that kiwifruit extract improved glucose uptake and insulin sensitivity in human fat cells.[41]

Kiwifruit has also been found to have a low glycemic index, meaning that it causes a slower and more gradual rise in blood sugar levels compared to high glycemic index foods. This is likely due to its fiber content, which can slow down the absorption of carbohydrates. Furthermore, kiwifruit contains bioactive compounds such as catechins and quercetin, which have been found to have antidiabetic effects in animal studies. These compounds may help to improve insulin sensitivity and reduce inflammation, which can contribute to the development of type 2 diabetes.[42]

Hepatoprotective activity

Kiwi fruit extract had a protective effect on liver cells in rats with liver damage induced by a toxic chemical. The study showed that kiwi fruit extract reduced oxidative stress and inflammation in the liver, and improved liver function.[43]

Another study published that the effects of kiwi fruit on liver function in healthy human volunteers. The study found that consuming kiwi fruit for 4 weeks improved liver function markers, including alanine transaminase (ALT) and gamma-glutamyltransferase (GGT), which are commonly used to assess liver function.[44]

Antimicrobial and Antiviral activity

According to a study on kiwi fruit peel, its acetone and ethanol extracts showed significant antimicrobial activity against various bacterial strains, fungi, and yeast at concentrations of 400-600 ppm. The acetone extract was found to be more effective than the ethanol extract in inhibiting the growth of these microorganisms. These findings suggest that kiwi fruit peel, with its high nutritional value, could be a valuable ingredient for functional food production. However, further research is needed to isolate the specific bioactive compounds responsible for this antimicrobial activity.[45]

Another study found that polyphenolic compounds in kiwi fruit were more effective against gram-positive bacteria than gram-negative bacteria, which may be due to the hindrance posed by lipopolysaccharide molecules in the outer membrane of gram-negative bacteria. These studies suggest the potential use of kiwi fruit peel and its constituents for antimicrobial applications, but more research is required to determine their effectiveness and safety for various applications.[46]

Neurodegenerative disorder

The study showed that kiwifruit extract has anti-inflammatory and neuroprotective effects in vitro, suggesting its potential for treating neurodegenerative disorders such as Alzheimer's. Another study showed that the effects of kiwifruit on cognitive function in healthy adults. The results showed that consumption of kiwifruit improved cognitive performance, including attention, memory, and executive function, suggesting its potential for improving cognitive function in individuals with Alzheimer's disease. Furthermore, kiwifruit is rich in polyphenols, which are known to have antioxidant and anti-inflammatory properties that can protect against neurodegenerative diseases. These findings suggest that kiwifruit may have potential as a therapeutic agent for Alzheimer's disease, although further research is needed to determine its efficacy and safety in humans.[47]

Anticancer activity

Kiwifruit consumption has been found to have beneficial effects against cancer due to its ability to selectively target and kill cancer cells without harming healthy cells. This is partly due to the high levels of dietary fiber in kiwifruit, which can help reduce the risk of colon cancer. Kiwifruit also contains an antimutagenic component that can help prevent genetic mutations that can lead to cancer.[48]

Another important phytochemical found in kiwifruit is catechin, which can reduce the toxicity of anticancer agents by stimulating bone marrow proliferation. Additionally, lutein, another phytochemical found in kiwifruit, has been linked to the prevention of prostate and lung cancer. The presence of glutathione in kiwifruit may also contribute to a reduction in breast cancer risk. Kiwifruit's biochemical composition, including antioxidants, carotenoids, vitamins, and fibers, has been found to be effective in preventing or treating cancer. Extracts of kiwifruit or its individual constituents have also been shown to have antimutagenic or antiproliferative properties that can counteract the cancer process.[49]

Cardioprotective activity

Kiwi is a potent source of polyphenols and antioxidants, which have been shown to have a positive impact on heart health. One of the ways that kiwi can help maintain heart health is by regulating blood pressure and platelet aggregation.[50]

Several studies have suggested that consuming kiwi can lead to a reduction in blood pressure levels. For example, a study published in the British Journal of Nutrition found that consuming three kiwis per day for eight weeks led to a reduction in both systolic and diastolic blood pressure levels in individuals with mild hypertension. Another study published in the Journal of Nutritional Biochemistry found that consuming two kiwis per day for eight weeks led to a reduction in platelet aggregation in smokers, which is a risk factor for heart disease.[51]

Dermatological activity

Kiwifruit is a rich source of nutrients that can benefit the health and appearance of the skin. Ascorbic acid, also known as vitamin C, is particularly important for skin health as it plays a role in the formation of collagen, which is a protein that gives skin its strength and elasticity. In addition to vitamin C, kiwifruit contains other antioxidants and vitamin E, which can help to protect the skin from damage caused by free radicals and environmental factors such as UV radiation. The amino acids present in kiwifruit can also help to protect the skin from sun damage. Kiwifruit has also been used in traditional medicine for its wound-healing properties. The proteolytic enzymes such as actinidin present in kiwifruit can help to break down and remove dead tissue from wounds, which promotes faster healing.[52]

Digestive tract health

Kiwifruit contains actinidin, an enzyme that can enhance the absorption of certain proteins, such as whey and zein. This can be beneficial for individuals who are looking to increase their protein intake. In addition, there is some evidence to suggest that kiwifruit may have anti-inflammatory properties that could be helpful for individuals with inflammatory bowel disease (IBD). One study found that consuming kiwifruit inhibited the synthesis of pro-inflammatory cytokine tumour necrosis factor α (TNF-α), which is involved in the development of IBD. Kiwifruit has also been studied for its potential benefits in individuals with irritable bowel syndrome (IBS). One clinical trial found that consumption of kiwifruit increased the frequency of defecation and decreased colon transit time in individuals with IBS.[52] Fibre is another important component of kiwifruit that can promote digestive health. The fibre in kiwifruit can increase faecal bulk and soften stool, which can help to prevent constipation. Additionally, an animal study conducted and found that ingestion of kiwifruit led to changes in gut microflora, which may have further benefits for digestive health.[53]

Kiwifruit also contains quinic acid, which has been shown to have beneficial effects on the gastrointestinal tract. Quinic acid has been found to enhance DNA repair and, during digestion, is broken down into tryptophan and nicotinamide, which can stimulate antioxidant metabolism. Nicotinamide is a naturally occurring compound and a derivative of vitamin B3. It is an important component of NADH, which is essential for maintaining cellular processes. NADH can undergo oxidation in the presence of free radicals, thereby protecting other cellular machinery from oxidative stress.

Studies have found that nicotinamide is more effective against protein oxidation than lipid peroxidation.[54]

Antidepressant activity

Inositol is present in kiwifruit and acts as a precursor for the production of an intracellular second messenger system called inositol triphosphate (IP3). Although some studies have suggested that inositol supplements may offer some benefits for people with depression, the evidence is currently insufficient to recommend it as a primary treatment.[55]

Macular degeneration

The kiwifruit is a highly beneficial fruit due to its rich content of oxanthophylls, specifically lutein, which has the ability to accumulate in the eye's retina. Lutein, a carotenoid vitamin, is essential for preventing age-related blindness. As the human body cannot produce lutein on its own, it is vital to consume foods that are rich in this nutrient, such as kiwifruit.[56]

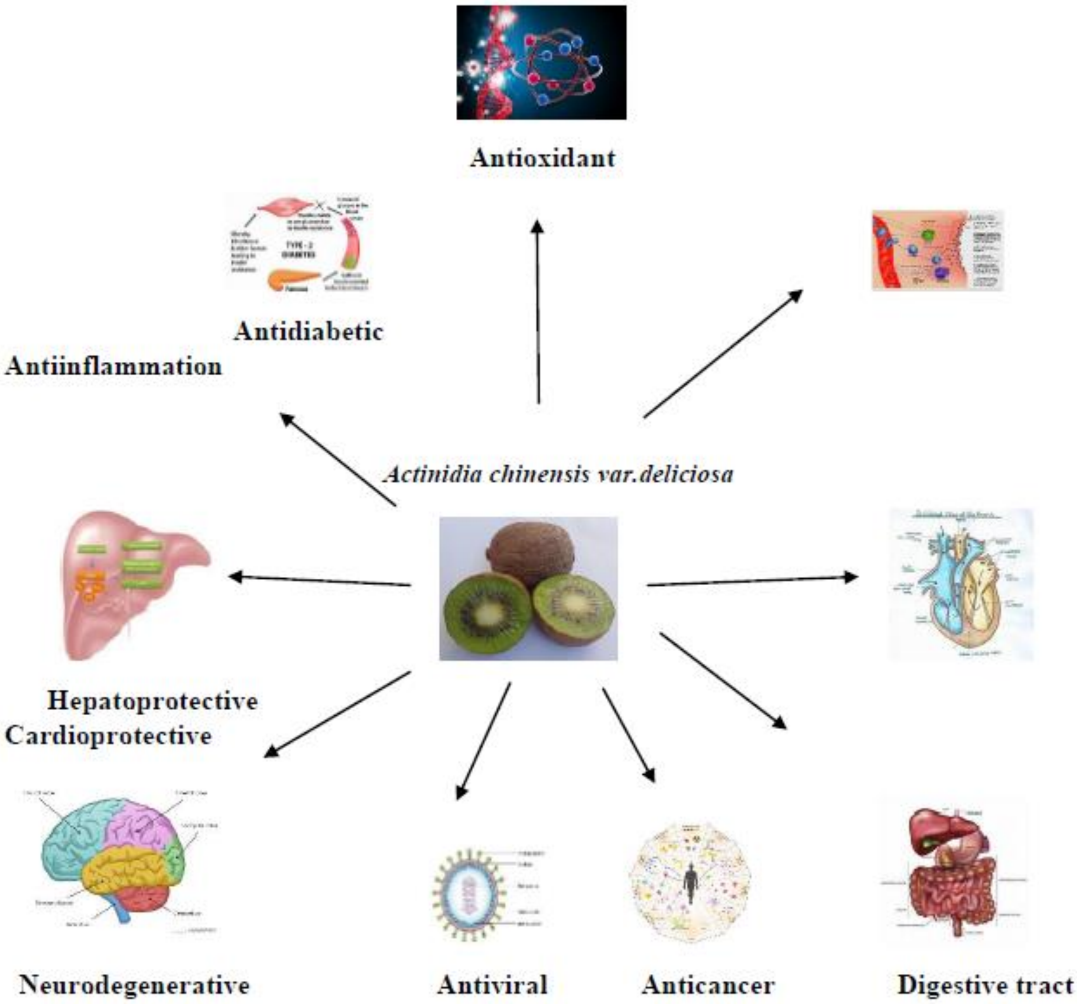


Fig. 4: Pharmacological Application.

Table 7: Traditional uses of different parts of kiwi plant.

Plant Part	Extract	Active Constituents	Traditional Uses	Reference
Leaves	Aqueous	flavonoids, phenolic compounds	The leaves extract exhibit anti-inflammatory, anti-hypercholesterolaemia, anti-acetylcholinesterase properties.	[57-58]
Seed	Aqueous	Vitamin E and omega-3 fatty acids	The seeds of kiwi fruit may have potential blood-thinning effects.	[59]
Stem	Aqueous	flavonoids, phenolic compounds	Stem of the kiwi plant have been found to potentially exhibit sedative effects, as well as being used as a diuretic and febrifuge. Additionally, the root and stem may have	[60]

			potential medicinal uses in treating conditions such as urinary tract stones, liver and oesophageal cancer, and rheumatoid arthralgia.	
Pulp	Ethanolic	Vitamin C, E and K	The peel extract of kiwi fruit has been found to potentially exhibit anti-microbial, anti-inflammatory, antioxidant cytotoxic activities.	[61-62]
Peel	Ethanolic	Phenolic Compounds	The peel extract of kiwi fruit has been found to potentially exhibit anti-microbial and anti-viral, antioxidant and anti-cancer properties.	[63-64]
Root	Ethanolic	Phenolic Compounds	The root of the kiwi plant has been found to potentially exhibit anti-hepatotoxic effects, which could be useful in the treatment of liver disease. The root may also have anti-pyorrheal effects, which may help treat gum disease, and anti-inflammatory effects, which could be beneficial in reducing gingival inflammation. Additionally, the root of the kiwi plant is traditionally used for treating conditions such as hepatitis, edema, gastric carcinoma, and breast carcinoma	[65-66]

CONCLUSION

In developing countries, access to modern healthcare facilities and costly medicines is often limited for the rural population. As a result, there is a growing need to explore alternative options, such as herbal drugs. Ethnomedical studies have gained attention for their ability to uncover the medical benefits of plants, both known and unknown, through modern scientific methods such as phytochemical analysis, pharmacological screening, and clinical studies.

Actinidia deliciosa, also known as kiwi fruit, has been found to possess various pharmacological activities, as discussed in this review. However, further pre-clinical and clinical studies are necessary to fully understand the potential of this fruit. Additionally, it is important to establish better quality control methods to ensure the safety and efficacy of kiwi-based products. By exploring the unexplored potential of kiwi fruit, researchers can develop new and innovative herbal drugs that may be more accessible to the rural population, providing a cost-effective and sustainable solution for their healthcare needs.

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