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Therapeutic potential of kiwi fruit

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Abstract
The kiwi fruit known as *Actinidia deliciosa* is a member of the *Actinidiaceae* family and the genus *Actinidia*. It is one of the fruits with the highest level of commercialization on the world market, and various portions of it are known for their medicinal and therapeutic properties against diseases of the cardiovascular system, diabetes, kidney problems, cancer, digestive disorders, bone, and eye issues. By being a significant source of phytochemicals such caffeic acid, gallic acid, syringic acid, salicylic acid, ferulic acid, and protocatechuic acid, it increases the primary flavonoid and phenolic contents of kiwi fruit. Numerous biological properties of the kiwi fruit and its constituent parts have been demonstrated, including anti-diabetic, anti-tumor, anti-inflammatory, anti-ulcer, antioxidant activity, hypoglycemic, and hypolipidemic effects. Aside from these, the kiwi fruit has a long history of usage in the treatment of edoema, hepatitis, kidney problems, rheumatoid arthritis, and microbiological infections. Kiwi fruit's fibre helps it retain water, which reduces transit time and boosts gastrointestinal health. Additionally, kiwi fruit consumption is being studied in relation to homeostasis, weight maintenance, and insulin and glucose balance. As a result, kiwifruit is high in fibre and vitamin C and bioactive compounds with diverse biological functions.

Keywords: Kiwi, nutritional profile, bioactive compounds, health benefits, biological activities

Introduction
The term "kiwifruit" refers to plants in the genus *Actinidia lindl.* as well as the fruit they produce. Kiwifruit, also known as Chinese gooseberry, is a berry found on woody vine species. *Actinidia* species are mostly found in southwestern China, however, a few are also found in neighboring countries (Siddique *et al*., 2021) [45]. Although more than 50 species are now recognized, just three have been domesticated, and this is within the past century. The kiwi fruit is a member of the *Actinidiaceae* family and genus *Actinidia*. According to Wang *et al*. (2014) [52], the kiwi fruit is also known by the names Macaque peach, Mihoutau, and Chinese gooseberry. *Actinidia* is a genus of 76 species, but only two are farmed commercially: *Actinidia chinensis* (golden kiwifruit) and *Actinidia deliciosa* (fuzzy kiwifruit). The genus *Actinidia* includes the *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) (Siddique *et al*., 2021; Park *et al*., 2014) [45, 34]. It measures approximately 3 inches long and has a brown hairy peel with green flesh and white pulp in the core, as well as numerous minute black edible seeds. China tops all countries in kiwi fruit output, followed by Italy. The world's two largest kiwi exporters are Italy and New Zealand. According to Soquetta *et al*. (2016) [49], it is one of the newest fruit crops to reach significant levels of global economic production. Of the 8.5 thousand tonnes of kiwi fruit produced in India, Arunachal Pradesh and Nagaland account for 56.5% of the total output. The plant thrives in both full sun and moderate shade, and it favours slightly acidic soil with a pH between 6.0 and 6.5. Although kiwi is typically eaten fresh, it is also used to make juices, purees, desserts, fortified beverages, dried, frozen, and lyophilized products, as well as leather, spirits, and syrups (Richardson *et al*., 2018) [40]. Extensive research investigations have shown that it includes an abundance of nutrients that provide health benefits to those who consume it by boosting an individual's digestive, immunological, and metabolic health. Vitamins A, B, C, E, and K are present in large concentrations, as well as dietary fibre, folate, potassium, and other minerals (Mishra and Monro, 2012) [31]. Numerous phytochemicals, such as carotenoids, flavonoids, anthocyanins, and lutein, are present in it. Vitamin C, an antioxidant with skin- texturing benefits found in abundance in kiwis. As a result of preventing skin damage brought on by damaging UV rays, it also helps to produce the protein collagen, which supports healthy, flexible skin (Garcia *et al*., 2012) [14]. Besides having immunomodulatory characteristics, vitamin C also contains anti-oxidant, anti-atherogenic, and

anti-carcinogenic capabilities. However, kiwifruit also contains dietary fibre, phytochemicals, folate, potassium, and magnesium, which may help to further contribute to any potential health benefits (Richardson *et al*., 2018; Mishra and Monro, 2012) [40, 31]. It has actinidin, a proteolytic enzyme that helps the stomach and small intestine break down intricate protein structures. Kiwi fruit contains bioactive substances that alter human colonic bacteria in a positive way, alter faeces' consistency, ease discomfort in the abdomen, and alleviate constipation symptoms by speeding up intestinal transit time (Tyagi *et al*., 2015) [50]. Xanthophyll and lutein, two phytochemicals found in kiwis, support eye health and stave off macular degeneration. Other notable health advantages associated with kiwi consumption include enhanced blood coagulation, better sleep, vitamin D and iron absorption, lowered risk of kidney stone formation, and cytotoxic and antibacterial effects. It is used to treat and prevent many cancers, such as cancer of the stomach, lung, and liver (Tyagi *et al*., 2015; Mishra and Monro, 2012) [50, 31]. Research and development of natural compounds with bioactive properties that might potentially replace synthetic additives have also been sparked in recent years by consumer desire for healthier and more natural products. One of the major trends addressing food production sustainability is the utilization of fruit byproducts (Costa *et al*., 2017) [6]. The demand for these unique natural additives with bioactive capacities has developed as a result of society's growing understanding of the value of preventive health measures including a healthy and balanced diet and the use of helpful food supplements. These new natural substances must be unique, add value, and have fewer negative effects than synthetic components (Sanz *et al*., 2021) [43]. Thus, the current trend is to combine the ideas of agriculture, industrial production, and circular economy from a sustainable approach by using agricultural leftovers as matrices to create bioactive compounds of interest to industry. Its pharmacological actions include those that are anti-cancer, anti-diabetic, anti-fertility, hepatoprotective, anti-ulcer, cataract prevention, and macular degeneration. The kiwi fruit has gained enormous popularity over the past 20 years as a result of its many health advantages. Overall kiwi fruit is an enriched source of bioactive compounds and has therapeutic potential (Richardson *et al*., 2018; Mishra and Monro, 2012) [40, 31]. This review majorly focuses on the nutritional profile, composition, bioactive compounds, health benefits, and biological activities of the kiwi fruit.

Nutritional value of kiwi fruit

The nutritional composition of the Kiwi is distinguished by a low contribution of energy, carbs, proteins, and lipids and a high contribution of water, fiber, minerals, and vitamins, as well as intriguing biomolecules. The skin of kiwifruit (*A. deliciosa* and *A. chinensis* "green" and "gold" cultivars, respectively) is often peeled before eating (Satpal *et al*., 2021; Drummond, 2013) [44, 11]. Kiwi's chemical composition is of tremendous interest to people to understand its nutritional value and potential health benefits. The fruit's nutritional components, which include protein, lipids, carbohydrates, vitamins (including vitamins A, C, and E as well as folic acid), minerals, polyphenols, antioxidants, and dietary fibre, have received the majority of research attention. Due to their low sugar content, kiwis are a desirable addition to a diet low in fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAP) (Richardson *et al*., 2018) [40]. Fructose, glucose, and sucrose stand out among the sugars in kiwi in *A. deliciosa*, *A. chinensis*, and *A. arguta*, respectively. Kiwi has a modest protein consumption, however, the most abundant ones, actinidin, and kiwellin, which are both high in cysteine, have been shown to have bioactive potential (Satpal *et al*., 2021) [44]. Kiwi pulp contains a minimal amount of fattyacids. However, polyunsaturated fatty acids account for 75% of its total fatty acids, primarily linoleic and linoleic acids, which are known to be beneficial lipids. Consuming the entire SunGold kiwifruit (with the skin) boosts fiber, vitamin E, and folate content by 50, 32, and 34%, respectively (Richardson *et al*., 2018) [40]. The protein content of kiwifruit flesh varies from 0.810 to 1.52 g/100 g fresh weight (FW), depending on the species and cultivar. Similarly, the amino acid content of the fruit is modest, and the protein content of the seeds accounts for just 150-200 g/kg of seed weight. Actinidin, kiwellin, and thaumatin-like proteins were the three primary proteins found in kiwifruit species using SDS-PAGE and Western analysis (TLP). Actinidin is a cysteine protease enzyme that catalyzes peptide bond hydrolysis and is the major allergen in kiwifruit (Satpal *et al*., 2021; Henare, 2016) [44, 17]. The majority of the lipid in kiwifruit is found in the seed oils, with minor levels of membrane-associated lipids present within the flesh. The oil content of green kiwifruit seeds is roughly 27-29% of the seed weight. The fatty acids in kiwifruit seed oils are composed of approximately 76% polyunsaturated fatty acids, 15% monounsaturated fatty acids, and 9% saturated fatty acids (Ma *et al*., 2019) [29]. In terms of fiber content, the green kiwi (*A. deliciosa*) contributes more soluble and insoluble fiber than other fruits such as oranges and apples. Fiber is prone to fermentation and can provide benefits by producing short-chain fatty acids (Di Francesco *et al*., 2018) [9]. Furthermore, it considerably slows the mixing and diffusion of glucose at the gut level. Fiber is well renowned for its prebiotic effects, since it stimulates intestinal motility, enhances satiety, and helps to maintain the health of the digestive and intestinal bacteria. Kiwifruit contains a variety of carotenoid molecules, including lutein, carotene, violaxanthin, zeaxanthin, and 9'cis-neoxanthin (Ma *et al*., 2019; Di Francesco *et al*., 2018) [29, 9]. Depending on the species and cultivar, kiwifruit contains both chlorophylls a and b in variable levels and ratios. Chloroplasts that contain chlorophyll are preserved in the flesh of green-colored kiwifruit as they age and ripen, but they convert into chromoplasts with a loss of chlorophyll in the flesh of gold-colored kiwifruit. According to Zhang *et al*. (2020) [54], the total chlorophyll content of kiwifruit can range from insignificant levels to 4.4 mg/100 g FW. A. chinensis cultivars' chlorophyll content ranges from less than 0.05 to 0.73mg/100 g FW, while that of A. deliciosa cultivars ranges from 1.33 to 2.74mg/100 g FW. Kiwi contains a variety of minerals, including calcium, iron, potassium, magnesium, manganese, copper, phosphorus, zinc, and selenium. These minerals are vital for the body's many metabolic processes, and their bioavailability varies depending on how quickly each element is absorbed (Pérez-Burillo *et al*., 2018) [37]. The calcium content of *A. deliciosa* is 34 mg/100 g, while *A. chinensis* contains 20 mg/100 g. Calcium is actively carried through the enterocytes of the intestine by either of the two transport channels. It binds to Calbindin Dak, a transport protein, and is expelled through the basolateral membrane (Sanz *et al*., 2021) [43]. The Na-Ca exchanger or the enzyme

Ca-ATPase catalyses this reaction. Additionally, 1,25-dihydroxyvitamin D, which is the active form of vitamin D, encourages the body's active absorption of calcium and is linked to the development of the transport protein calbindin dak. *A. deliciosa* has a magnesium concentration of 17 mg/100 g, whereas *A. chinensis* has a magnesium value of 14 mg/100 g (Sanz *et al*., 2021; Pérez-Burillo *et al*., 2018) [43, 37]. Its passive absorption has been seen to occur in the small intestine. Magnesium is absorbed to a lesser amount in the human intestine due to its lower permeability compared to Calcium. Caffeic acid and other chlorogenic derivatives, procyanidins, syringic acid, ferulic acid, gallic acid, salicylic acid, protocatechuic acid, quercetin, glycosides, gallic acid, and salicylic acid are a few of the bioactive substances that can be found in kiwi fruit (López-Sobaler and RM, 2016) [28]. In addition, the absorption of magnesium is inhibited by antinutrient elements like phytic acid and other medications, including antibiotics. The Cu-binding transport proteins CTR1 and ATOX1 are assumed to be responsible for the human small intestine's ability to absorb copper, which is present in *A. deliciosa* and *A. chinensis* at 0.13 and 0.147 mg/100 g and 0.13 and 0.147 mg/100 g, respectively (Singletary, 2012) [46]. Researchers have also reported that chloride ions influence copper uptake, but the particular process has not yet been thoroughly identified. Another important mineral present in kiwi is potassium, which has concentrations of 312 and 316 mg/100 g in *A.* deliciosa and *A.* chinensis, respectively. In the intestine, potassium is absorbed both actively and passively. Enterocytes utilise sodium-dependent H+/K+ ATPase to actively absorb potassium (Li and Zhu, 2019) [25]. Additionally, a number of hormones, including aldosterone, affect how well it is absorbed. Kiwi is a good source of a few trace minerals, including manganese, chromium, zinc, and selenium, in addition to the aforementioned nutrients. Vitamin and mineral bioavailability in the human body is influenced by a number of variables, including concentration, health status, excretory losses, drug-nutrient interaction, and nutrient-nutrient interaction (Li and Zhu, 2019; López-Sobaler and RM, 2016) [25, 28]. Antinutrients such phytates, oxalates, and tannins can reduce the bioavailability and mineral absorption of kiwi fruit. Despite having very low quantities of oxalates and tannic acid, kiwi has been shown in studies to have no substantial antinutritive activity. Although antinutritionalelements in food decrease mineral bioavailability, some bioactive compounds encourage and enhance mineral absorption in the human body (Liang *et al*., 2021) [26]. Ascorbic acid, or vitamin C, is well recognised to enhance the absorption of iron. The treatment of iron deficiency has been associated with the consumption of kiwi fruit because of its high ascorbic acid content (Liang *et al*., 2021; Li and Zhu, 2019) [26, 25]. A study was also done to find out how eating kiwi affected how much iron was absorbed, and it was found that kiwi not only helped to regulate how much iron was absorbed but also helped to dramatically enhance how much calcium was absorbed (Lan *et al*., 2021) [23]. In order for white blood cells to operate properly and to help the body fight off hazardous microbes, ascorbic acid is also necessary. White blood cell activity and the immune system have been found to be strengthened by kiwi fruit, which is high in vitamin C. In addition, it helps with mood issues like weariness, sorrow, and depression (López-Sobaler and RM, 2016) [28]. The nutritional composition of two varieties of kiwi fruit, viz. *deliciosa* and *A. chinensis*, is compared in Table 1.

Table 1: Nutritional profile of kiwi fruit varieties

Nutrients	*Actinidia deliciosa*	*Actinidia chinensis*	References
Water (g)	83.07	83.22	Satpal *et al*., 2021; Sivakumaran *et al*., 2018; Costa *et al*., 2017; Henare, 2016 [44, 47, 6, 17]
Total protein (g)	1.14	1.23	
Energy (kcal/KJ)	61	60	
Ash (g)	0.61	0.76	
Fat (g)	0.52	0.56	
Carbohydrate (g)	14.66	14.23	
Fiber (g)	3.0	2.0	
Sugar (g)	8.99	10.98	
Sucrose (g)	0.15	0.05	
Glucose (g)	4.11	5.20	
Fructose (g)	4.35	5.68	
Maltose (g)	0.19	0.05	
Galactose (g)	0.17	ND	
Vitamin C	92.7	105.4	Dias *et al*., 2020; Ma *et al*., 2019; López-Sobaler and RM, 2016 [29, 10, 28]
Vitamin B1	0.027	0.024	
Vitamin B2	0.025	0.046	
Vitamin B3	0.341	0.28	
Vitamin B5	0.183	0.5	
Vitamin B6	0.063	0.057	
Vitamin B9	25	34	
Vitamin B12	0	0	
Vitamin K (µg)	40.3	5.5	
Vitamin A (IU)	87	72	
Vitamin B3	0.341	0.28	
Vitamin B5	0.183	0.5	
Vitamin B6	0.063	0.057	
Vitamin B9	25	34	
Vitamin B12	0	0	
Vitamin K (µg)	40.3	5.5	
Vitamin A (IU)	87	72	
Calcium	34	20	
Magnesium	17	14	
Iron	0.31	0.29	
Phosphorus	34	29	
Potassium	312	316	
Sodium	3	3	
Zinc	0.14	0.1	
Copper	0.13	0.147	
Manganese	0.098	0.058	
Selenium	0.2	3.1	
Threonine	0.047	0.042	
Tryptophan	0.015	0.044	
Isoleucine	0.051	0.037	
Glycine	0.060	0.046	
Proline	0.044	0.028	
Leucine	0.066	0.056	
Methionine	0.024	0.016	
Serine	0.053	0.040	
Histidine	0.027	0.020	
Cystine	0.031	0.025	
Phenylalanine	0.044	0.030	

Bioactive compounds from kiwi fruit

Bioactive chemicals are important for human health because of their numerous biological effects, including reduced risk factors for cardiovascular disease, as well as antioxidant, antimutagenic, anticarcinogenic, antiallergenic, anti-inflammatory, and antibacterial properties (Park *et al*., 2014) [34]. Kiwi fruit is composed of different bioactive and phytochemicals that defined their health benefits. The antioxidant and cell-protective properties of phytochemicals are well recognised, and their immunomodulatory properties are increasingly gaining recognition (Wang *et al*., 2018) [52]. On the other hand, the phytochemical composition of kiwifruit might differ significantly depending on the health advantages of a certain *Actinidia* species 241 species or genotype (Park *et al*., 2014) [34]. The chlorophylls a and b, as well as carotenoids like carotene, lutein, violaxanthin, and 9'-cis-neoxanthin, are frequently found in green-fleshed kiwifruit (A. *deliciosa*). When ripe, kiwifruits with yellow meat (A. *chinensis* or A. *macrosperma*) have carotenoids but little to no chlorophyll, and those with red flesh (A. chinensis 'Hongyang') contain anthocyanins. Additionally, A. *deliciosa* 'Hayward' leaf tissue and fruit juice have both been discovered to contain polyphenolics, particularly flavonols (Wang *et al*., 2018; Soquetta *et al*., 2016) [52, 49]. The major constituents of kiwis are phenols and flavonoids, which have anticancer and antioxidant activities. The total phenolic concentration of kiwifruit has been reported to be 87mg gallic acid equivalent/100g FW using the Folin- Ciocalteu method; however, after accounting for the ascorbic acid contribution, this value reduces to 28mg/100g FW (Vallespir *et al*., 2019) [51]. Furthermore, the antioxidant capacity of kiwi fruit has been associated with polyphenols, and studies have linked the flavonoids quercetin, kaempferol, epicatechin, and hesperidin to antibacterial and antiviral effects. Soquetta *et al*. (2016) [49] and Vallespi *et al*. (2019) both cite kiwi as a valuable source of phenolic compounds with applications in the food industry and health prevention. The flavonoids in kiwifruit have not been extensively studied. There have been discovered flavan-3-ols (catechin and epicatechin), flavonols (quercetin and kampferol glycosides), and several anthocyanins. Cyanidin and delphinidin, two aglycone anthocyanidin bases, and their derivatives are what give some varieties of kiwifruit its red and purple meat and skin (Saleh *et al*., 2021) [42]. Several glycosylated forms of cyanidin and delphinidin have been found in kiwifruit, including delphinidin 3-[2-(xylosyl)-galactoside], delphinidin 3-galactoside, cyanidin 3-galactoside, and cyanidin 3-glucoside. Cyanidin derivatives have been found in all kiwifruit species that contain anthocyanins, however only *Actinidia melanandra* Franch. and *A. arguta* 'Purpurea' have delphinidin derivatives (Maheshwari *et al*., 2022) [30]. The different volatile compounds evaluated from kiwi fruit are terpenes, benzenoids, esters, aldehydes, ketones, alcohols, acids, hydrocarbons, furans, and sulphur compounds. According to a study that identified up to 80 volatile compounds in kiwi fruit extracts, monoterpenes (such as menthol) can be obscured by esters including ethyl butanoate, hexanoate, 2-methylbutanoate, and 2-methylpropanoate, as well as the aldehydes hexanal and hex-E2-enal (Leontowicz *et al*., 2016) [24]. Anthocyanins, carotenoids, and chlorophylls are only a few of the pigments found in kiwi. A. chinensis gets its yellow colour from the abundance of carotenoids, whereas A. deliciosa, a green kiwi, has more chlorophyll. However, the amount in A. arguta may be double that. The carotenoids violaxanthin, neoxanthin, lutein, and carotene are among those found in kiwi. Red-fleshed kiwis also contain 9′-cis-neoxanthin, anthraxanthin, zeaxanthin, and cryptoxanthin (Wang *et al*., 2018; Soquetta *et al*., 2016) [52, 49]. The amount of lutein varies between 0.1 and 1.0 mg/100 g of FW, with *A. deliciosa* and *A. arguta* often having greater levels than *A. chinensis*. These pigments, which include carotenoids and anthocyanins, are frequently used as vegetable colours and colourants in food products (Soquetta *et al*., 2016) [49]. Both carotenoids and anthocyanins are pigments that are often employed in food goods as colouring agents and vegetable dyes. The flesh of the kiwi fruit, in particular, contains a variety of bioactive molecules, including a wide spectrum of carotenoids, including lutein and beta-carotene, anthocyanins, chlorophyll, phenolic compounds, flavonoids, and even volatile chemicals (Maheshwari *et al*., 2022; Leontowicz *et al*., 2016) [30, 24].

Health uses of kiwi fruit

Kiwi fruit is enriched with nutrients and phytochemicals and protects against diseases. Table 2 represented the health benefits associated with activities and key findings of kiwi fruit and Figure 1 depicted the different health benefits of kiwi fruit and some of them are defined below:

Digestive health

Kiwifruit contains a high concentration of the proteolytic enzyme actinidin, a protein- dissolving enzyme that promotes protein digestion and can aid in the digestion of a meal, similar to papain in papaya and bromelain in pineapple (Singletary, 2012) [46]. It promotes easy passage through the digestive tract (Eady *et al*., 2019) [12].

Skin health

Kiwifruit contains vitamin C, a vital component that acts as an antioxidant in our bodies to help prevent damage caused by the sun, pollution, and smoke, smooth wrinkles, keep the skin young and vibrant, and enhance overall skin texture (Skinner *et al*., 2013) [48]. It is also high in vitamin E, which keeps the skin supple and moist and protects it from deterioration. Vitamins also help with cell regeneration, which keeps the skin youthful and flexible. Collagen is formed due to the presence of vitamin C. A connective protein called collagen keeps skin tight and supple while also promoting skin healing (Mishra and Monro, 2012) [31]. It helps prevent rough and dry skin and speeds up the healing of cuts and wounds. Antioxidants and Vitamin E, both of which are necessary for healthy, radiant skin, are also abundant in it. Amino acids found in kiwis shield skin from UV damage (Eady *et al*., 2019) [12].

Bone health

Kiwifruit is high in folate, magnesium, and vitamin E, all of which have health advantages ranging from bone building to heart health. Vitamin K may play a role in bone mass formation by boosting osteotrophic activity in the bone (Moughan *et al*., 2013; Parkar *et al*., 2010) [32, 35].

Heart health

Kiwis' fiber and potassium content benefit heart health. Fiber can help lower cholesterol levels, lowering the risk of heart disease and heart attack. Heart disease, myocardial infarction,

and hypertension are all linked to low magnesium levels (Hussain *et al*., 2021) [19]. Fresh kiwi fruit is high in the heart-healthy electrolyte "potassium." 100 g contains 312 mg, or 7% electrolyte. The most essential dietary modification a person can do to lower their risk of cardiovascular disease is to increase potassium intake while decreasing sodium intake. Potassium is an important component of cells and body fluids that helps control heart rhythm by counteracting sodium's negative effects (Eady *et al*., 2019) [12]. Omega-3 fatty acids are highly concentrated in kiwifruit seeds. According to a number of studies, consuming meals high in omega-3 fatty acids may reduce the risk of coronary heart disease and stroke. The risk of heart disease was also found to be reduced by vitamin E, magnesium, and folate (Mishra and Monro, 2012; Parkar *et al*., 2010) [31, 35].

Gut health

Food is processed by the gastrointestinal system from the time it is ingested until it is digested, absorbed, or expelled as faeces. As we understand more about the tasks the gut microbiota performs that directly affect health, its roles are becoming more well recognised (Moughan *et al*., 2013) [32]. Kiwifruit has long been used as a digestive aid. There isn't any solid proof that green kiwifruit (also known as "Hayward") and the enzyme actinidin it contains can enhance the upper-tract digestion of a variety of dietary proteins, especially stomach digestion. *In vitro* digestion of proteins in yoghurt, cheese, salmon, and raw eggs in the presence of 'Hayward' kiwifruit was demonstrated to result in significantly more digestion of intact protein and distinct peptide patterns when compared to mammalian digestive enzymes (Moughan *et al*., 2013; Parkar *et al*., 2010) [32, 35]. Actinidin was conclusively shown to be responsible for better gastric hydrolysis of dietary proteins in pigs during an *in vivo* experiment that included a positive control of extra actinidin and a negative control in which the actinidin in 'Hayward' kiwifruit was inactivated. Consumption of kiwifruit may also alter food component absorption (Hunter *et al*., 2016) [18]. Minerals are necessary nutrients that are absorbed in the intestines. Kiwifruits have a lot of vitamin C compared to other foods, which helps nonheme iron become more bioavailable and may affect how calcium is absorbed. kiwifruit, particularly the cultivar "Hort16A," can increase iron, calcium, phosphorus, and magnesium intake as well as retention, according to recent research in cells, animals, and people (Siddique *et al*., 2021) [45].

Wound healing and skin

A growing body of research is showing how effective kiwifruit is as a dermatological and wound-healing agent. Debridement, or the removal of dead tissue from wounds, can be done medically, mechanically, autolytically, biologically, or enzymatically. It is a crucial step in the healing process (Lippi and Mattiuzzi, 2020) [27]. It has been proven that placing slices of kiwifruit flesh to burns speeds up the healing process. as the lesion was covered with kiwifruit flesh slices, the average duration of debridement of necrotic tissue from full-thickness burns was significantly reduced as compared to wounds treated with no treatment agent or fibrinolysin (Hunter *et al*., 2016) [18]. Deep second-degree burns treated with kiwifruit have improved on the surface, and it also takes considerably less time for the wounds to heal completely (Siddique *et al*. 2021) [45].

Hair health

Fruit contains elements such as zinc, magnesium, and phosphorus, which promote hair development and blood circulation. It also contains vitamins C and E, which aid in hair growth. Kiwi seed oil includes omega-3 fatty acids, which help to keep hair moisturized (Billows *et al*., 2022) [3]. Copper, which is abundant in kiwis, keeps hair from becoming grey too soon and helpsit maintain its original colour. The iron in fruit nourishes the hair and encourages healthy bloodflow to the scalp. It strengthens the hair from the roots up as a consequence (Rasheed *et al*., 2021) [39].

Eye health/Macular degeneration

Kiwifruit is high in phytochemicals óxanthophylls and, in particular, lutein. Lutein has been shown to build up in the retina of the eye. The phytochemical lutein is found in kiwifruit (Billows *et al*., 2022) [3]. Lutein is a carotenoid vitamin that can help prevent macular degeneration. Because the body cannot synthesize lutein, it is critical to consume sufficient lutein-containing foods such as kiwi (Baranowska-Wójcik and Szwajgier, 2019) [2].

Cardiovascular disease

Dietary changes that include more fruits and vegetables have been linked to a lower risk of cardiovascular disease. As a result, cardiovascular disease mortality is lower, as is the risk of ischemic stroke. Carotenoids, flavonoids, polyphenols, and other antioxidants found in fruits and vegetables have been linked to this (Hussain *et al*., 2021) [19]. Kiwifruit's antioxidant capacityshows that they may help minimize the risk of cardiovascular disease. Kiwifruit may also helpprevent arteriosclerosis, a complicated condition marked by cholesterol oxidation, intracellularbuildup of oxidised cholesterol, elevated blood pressure, and platelet aggregation (Baranowska-Wójcik & Szwajgier, 2019) [2]. Crude ethanolic and aqueous extracts of kiwifruit (likely 'Hayward') were shown to exhibit antioxidant, antihypertensive, and to a lesser extent hypocholesterolemic and fibrinolytic effect in *in vitro* tests. The confirmation of kiwifruit's antioxidant activity shows that eating it may minimize cholesterol oxidation, minimizing the growth of atherosclerotic plaques (Rasheed *et al*., 2021) [39].

Cancer

Kiwifruit consumption helps to fight cancer by being cytotoxic to cancer cells while having no effect on normal, healthy cells. Kiwi fruit's high fibre content lowers colorectal cancer risk (Lippi and Mattiuzzi, 2020) [27]. It has been proven that kiwis contain an antimutagenic substance that assists in preventing gene changes that might cause cancer. By promoting bone marrow development, the phytochemical catechin lessens the toxicity of anti-cancer medications (Billows *et al*., 2022) [3]. Kiwifruit contain the phytochemical lutein, which has been linked to protection against prostate and lung cancer. The reduction could be explained by glutathione's presence. In order to prevent or treat cancer, kiwi fruit's biochemical composition, which contains a variety of antioxidants, carotenoids, vitamins, and fibres, is beneficial (Hussain *et al*., 2021) [19].

Table 2: Health benefits associated with activities and key findings of kiwi fruit

Health uses	Activities defined by fruit health uses	Key findings	References
Bone health	Antioxidant, Anti-inflammatory, Antimicrobial, Antitumor	• It has bone metabolism protecting benefits in overiectimized rats when combined with daidzein • It aids in the prevention of overiectomy-induced BMD (bone mineral density) decrease	Siddique *et al*., 2021; Baranowska-Wójcikand Szwajgier, 2019 [45, 2]
Skin health	Antitumor, Antioxidant	• It has a lot of vitamin K, which is essential for having healthy, attractive skin • It also contains a lot of vitamin C, which works as an antioxidant to protect skin from UV radiation, pollution, and smoking; and it contains a lot of vitamin E	Siddique *et al*., 2021; Zehra *et al*.,2020; Tyagi *et al*., 2015 [45, 53, 50]
Digestive health	Antioxidant, Anti-inflammatory, Antimicrobial, Antitumor, Antiviral	• The fruit is known for maintaining excellent digestive health since it contains laxative properties that help alleviate constipation • It contains actinidin, a proteolytic enzyme that positively affects the stomach and intestinal digestion of proteins	Tyagi *et al*., 2015; Singletary,2012 [50, 46]
Maintains immunity	Lipid-lowering activity, Antioxidant, Antimicrobial	• It could encourage the innate and adaptive immune functions of human blood cells	Dias *et al*., 2020; Ma *et al*., 2019; López-Sobaler and RM, 2016 [29, 10, 28]
Improves cardiovascular health	Antioxidant, Antimicrobial, Anti-inflammatory	• Kiwi has been demonstrated to be helpful in the preservation of heart health as a rich source of polyphenols and antioxidants • It helps smokers control their blood pressure (B.P.) and platelet aggregation • Systolic and diastolic blood pressure have been demonstrated to decrease by 10 and 9 mm Hg, respectively.	Rasheed *et al*., 2021; Dias *et al*.,2020; Singletary, 2012 [39, 10, 46]
Avoid diabetes	Antidiabetic	• It is an excellent choice for patients with type 2 diabetes because the entire fruit has a low glycemic impact	Siddique *et al*., 2021; Zehra *et al*.,2020; Tyagi *et al*., 2015 [45, 53, 50]
Prevent cancer	Antioxidant, Anti-inflammatory, Antimicrobial, Antitumor, Antiviral	• The biological components of kiwis, such as their carotenoids, vitamins, antioxidants, and fibre, are beneficial for preventing cancer • Instead of harming the healthy body cells, it works as a cytotoxic agent on malignant cancer cells • It is high in fibre, it lowers the risk of colon cancer	Siddique *et al*., 2021; Zehra *et al*.,2020; Tyagi *et al*., 2015 [45, 53, 50]

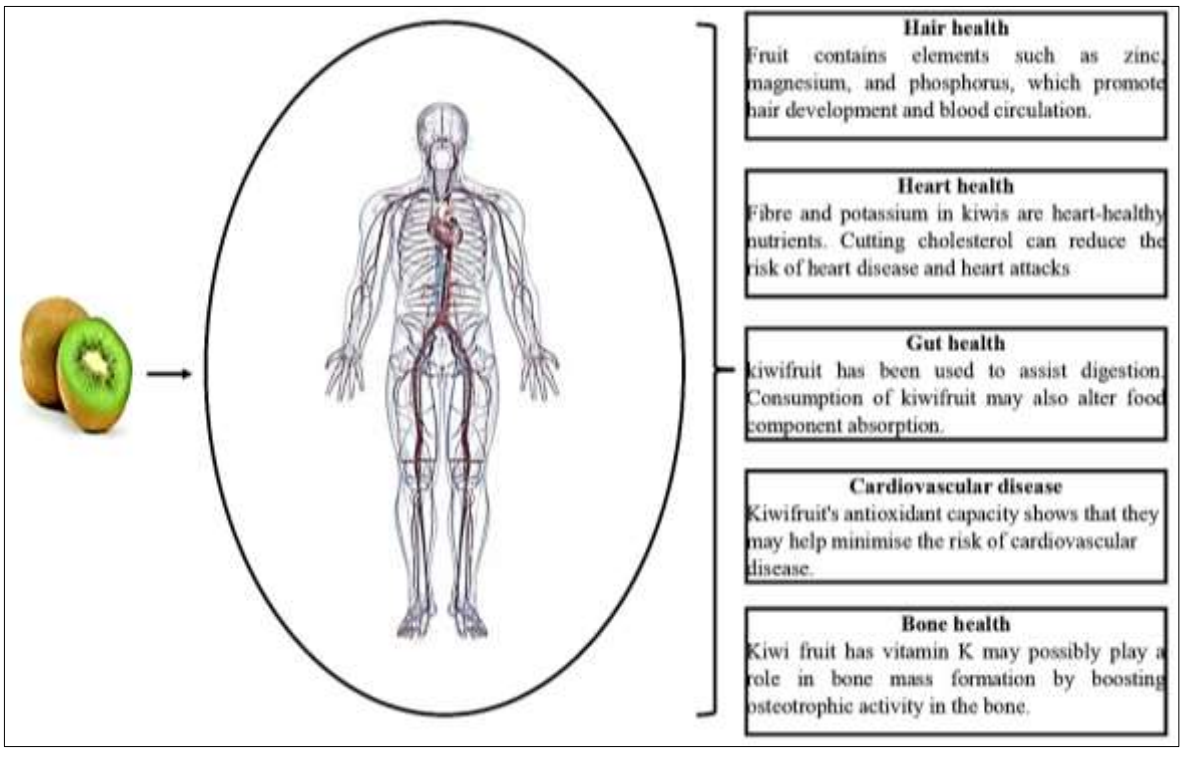

Fig 1: Different health benefits of kiwi fruits and their remarks

Therapeutic activities of kiwi fruit

Various experts have conducted several studies on the therapeutic characteristics and health benefits of kiwi. Anti-oxidant, anti-diabetic, anti-inflammatory, anti-hypertensive, anti- carcinogenic, anti-fungal, antiviral, anti-asthmatic, hepatoprotective, anti-platelet, anti- nociceptive, anti-HIV, anti-microbial, anti-constipation, cytotoxic, anti-tumor, and anti- thrombin properties have all been reported (D'Eliseo *et al*., 2019) [7]. Because of its extensive biological profile, it provides numerous health benefits. It helps to prevent cancer, diabetes, asthma, HIV/AIDS, and cardiovascular disease. It helps to cure metabolic diseases such dyslipidemia, low-density lipoprotein (LDL) cholesterol, triglycerides, hypertension, incorrect glucose metabolism, vascular inflammation, and hemostatic illness. The oxalates are the only irritating component in kiwi (Hunter *et al*., 2011) [5]. Some people may get oral mucosal irritation as a result of these oxalates. It helps to prevent cancer, diabetes, asthma, HIV/AIDS, and cardiovascular disease (D'Eliseo *et al*., 2019; Hunter *et al*., 2011) [7, 5]. The oxalates are the only irritating component in kiwi. Some people may get oral mucosal irritation as a result of these oxalates. Patients with nephrolithiasis and urolithiasis should avoid eating kiwi fruit due to its high oxalate concentration (7.8 to 45 mg/100 g in golden kiwi fruit and 12.7 to 84.3 mg/100 g in green kiwi fruit). High levels of oxalate can also affect the bioavailability of calcium, magnesium, and iron in the body (Guroo *et al*., 2017) [15]. Figure 2 represented the different therapeutic activities and are explained below:

Antioxidant activity

The abundance of biomolecules found in kiwis, including ascorbic acid (vitamin C), vitamin E, phenolic compounds, and carotenoids (lutein and zeaxanthin), are excellent anti-inflammatory and antioxidant substances. Their primary mode of action is the neutralization of reactive species, including both oxygen and nitrogen (Pal *et al*., 2015) [33]. These free radicals have a role in the development of oxidative damage linked to numerous illnesses, including cancer and cardiovascular ailments (Bursal and Gülçin, 2011) [4]. As a result, these chemicals may avoid oxidation and boost oxidative defenses by upregulating genes involved in deoxyribonucleic acid (DNA) repair. According to Bursal and Gülçin (2011) [4], the antioxidant potency of natural extracts is frequently expressed in terms of 6-hydroxy-2,5,7,8-tetramethylchroman-2- carboxylic acid, a potent antioxidant derived from vitamin E and commonly referred to as Trolox. It can be measured using different assays, including the oxygen radical (ORAC), the ferric reducing antioxidant power (FRAP) based on metal ions, and those based on organic radical producers like 2,2′-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) [ABTS] and 2,2- difenil-1- picrylhydrazyl [DPPH], it is assessed the ability of the antioxidants to scavenge the radical (Bursal and Gülçin, 2011) [4].

Antitumor activity

Cancer is a complicated illness with several interrelated causes and challenging therapeutic options. Numerous research has concentrated on the preventative and/or palliative benefits of diet in conjunction with other medications, as well as the prevention and/or palliative effects of this illness through a healthy lifestyle (He *et al*., 2019) [16]. In this regard, one research predicted that 20,000 cases of cancer may be avoided if half of the American population increased their intake of fruits and vegetables. Fruits' beneficial effects are linked to their high levels of micronutrients and bioactive compounds (Jin-Tao *et al*., 2021) [21]. The research indicates that thermolabile and water-soluble phenolic compounds are the components of antimutagenicity. Kiwi can therefore be viewed as a dual-action preventative antitumor agent. On the one hand, it can help develop chemoprevention strategies by preventing or reducing DNA damage and mutagenesis processes. Kiwi intake paired with a balanced diet may reduce DNA damage (Jin- Tao *et al*., 2021; He *et al*., 2019) [21, 16].

Anti-inflammatory activity

The body's natural reaction to the presence of invasive foreign substances is inflammation; however, several metabolic or autoimmune diseases might alter this process. For instance, in the case of kiwi, both *in vivo* and *in vitro* models have been used to examine the anti-inflammatory effects of the A. *chinesis* variety (He *et al*., 2019; Deng *et al*., 2016) [16, 8]. In RAW 264.7 cells activated by LPS, the phenolic acids protocatechuic, p-hydroxybenzoic, p- coumaric, caffeic, and ferulic identified in the oil of *A. chinensis* seeds decreased the production of the pro-inflammatory cytokines IL-1 and TNF (Jin-Tao *et al*., 2021) [21]. Similar findings were made using a mouse animal model in a prior study, which connected kiwi seed oil consumption for 12 weeks to a decrease in fat accumulation, body weight, blood glucose, and the production of inflammatory cytokines (Saeed *et al*., 2019) [41]. Kiwi skin has a potent anti-inflammatory action and can be used in cosmetic, pharmaceutical, or nutraceutical formulations as a preventive or therapeutic natural ingredient. Additionally, human alveolar epithelial cells (A549) were treated *in vitro* with polyphenolic extract from several varieties of kiwis, and the results revealed that chemokine levels were reduced (Kim *et al*., 2019) [22].

Antimicrobial and antiviral activity

Research into the antibacterial and antiviral effectiveness of food items is necessary in light of the growth of drug-resistant microbiological strains of bacteria, viruses, fungus, and yeast. In addition, kiwi fruit has many of phytochemicals, which give it its antibacterial and antiviral properties (El Azab and Mostafa, 2021) [13]. The bioactive components of kiwi fruit may have antibacterial properties in addition to other therapeutic properties. Kiwi extracts (skin, pulp, seeds, and stems) were effective in killing *Salmonella typhi*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Enterococcus faecalis*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, and *Escherichia coli* (Kim *et al*., 2019) [22]. Asker Mohsen and Habiba, (2018) [1] conducted a study to explore the antioxidant, antibacterial, and antiviral properties of *A. deliciosa* peel. The antioxidant activity of kiwi fruit peel extracts in aqueous, acetone, methanol, and ethanol was assessed, and it was found that kiwi is rich in many potent antioxidant compounds, including lutein, vitamin C, phenolics, carotenoids, chlorophyll, and flavonoids, which contribute to the fruit's high antioxidant potential. For instance, kiwi skin and pulp extracts exhibit inhibitory action against *S. aureus* and *S. pyogenes*, with respective MIC values of 8 and 4 g/mL, as well as against *E. faecalis*, *S. typhi*, *P. mirabilis*, *P. aeruginosa*, *E. coli*, and *K. pneumonia*, with MIC values ranging from 16 to 128 g/mL (Bursal and Gülçin, 2011) [4].

The MIC values of kiwi seeds ranged from 1 to 8 g/mL and shown bactericidal action against *S. pyogenes* and *P. aeruginosa*. The inclusion of flavonoids and phenolic acids in kiwi leaf extracts, which showed strong antibacterial action against *S. aureus*, was also a contributing factor (D'Eliseo *et al*., 2019) [7].

Lipid-lowering and antidiabetic activities

Consumers who consume kiwis are shielded against cardiovascular problems, which are greatly impacted by elements like diet and exercise (Bursal and Gülçin, 2011) [4] because to the fruit's vitamin C content, carotenoids, and phenolic compounds. In one study of male smokers, participants who increased their intake of three kiwis per day while maintaining a healthy diet and engaging in regular exercise saw reductions in their systolic and diastolic blood pressure of 10 and 9 mm Hg, respectively (Patel *et al*., 2015) [36]. The effect was stronger in those who had hypertension. It has been shown that kiwi seed oil consumption reduces weight gain, inguinal fat tissue, and the buildup of total cholesterol triacylglycerides (TAG) and low-density lipoprotein (LDL) in an experimental model of mice fed a high-fat diet. Like this, kiwi seed oil lowers the HOMA-IR (homeostatic model for evaluating insulin resistance) score, which lowers insulin and glucose resistance (Qu *et al*., 2019) [38]. These outcomes could result from increased lipolysis in adipocytes or fat cells and reduced lipid absorption brought on by pancreatic lipase inhibition. According to Baranowska-Wójcik and Szwajgier (2019) [2], more authors have validated the lipid-reduction properties of A. chinensis seeds in this regard. Kiwis' fibre content also slows down the digestion of carbohydrates since it reduces the rate of glucose diffusion during digestion due to their swelling activity. The phenolic compounds have been suggested to have a role in the hypoglycemic action of kiwis. The -glucosidase enzyme is shown to be inhibited by kiwi stems, which lowers high levels of postprandial blood glucose in diabetics (Iwasawa *et al*., 2011) [20]. In conclusion, kiwi consumption is a healthy habit that may help to control blood sugar and insulin levels as well as prevent the onset of cardiovascular illnesses (Baranowska-Wójcik and Szwajgier, 2019) [2].

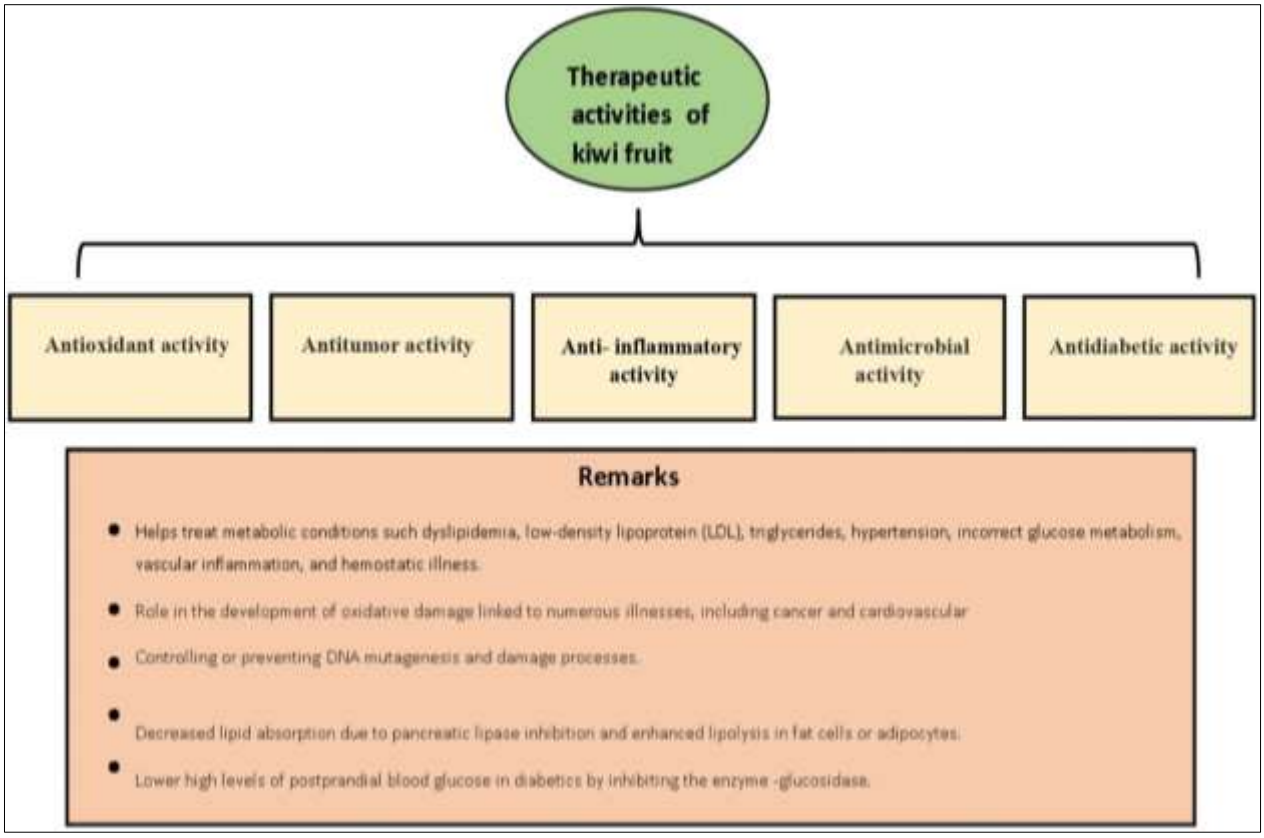

Fig 2: Different therapeutic activities of kiwi fruit

Conclusion and future perspective

Consumers should get scientifically sound information from dietitians and other healthcare experts to help them make informed dietary decisions. The body of scientific research demonstrating the unique health advantages of kiwifruit is rapidly growing. Since kiwi fruit is seasonal, there have been attempts to produce processed dishes with kiwi as an ingredient. Its processing and preservation can be utilised as a tool to improve rural residents' job opportunities. Several investigations have demonstrated that the kiwi fruit has an outstanding pharmacological profile. Vitamins C, E, K, and folate as well as PAs and their derivatives, flavonoids (flavanols, flavonols, and anthocyanins), carotenoids, chlorophylls, minerals, and organic acids are among the bioactive phytochemicals present in kiwifruit. Antioxidant, anti-inflammatory, anti-cancer, anti-bacterial, neuroprotective, anti-obesity, and pro-gut health qualities are all present in kiwis. The kiwi fruit provides a wide range of health advantages because of its bioactive and nutritional diversity. As a result, kiwi fruit may be utilised in a variety of ways, including as a valuable source of natural ingredients for the creation of useful goods. As the possible health benefits of kiwifruit eating are investigated further, we can anticipate other ways that kiwifruit will enhance our health in the future.

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