REVIEW ARTICLE

AGROBIOLOGICAL RECORDS

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)

Open Access Journal

KIWIFRUIT: A REVIEW ON NUTRITIONAL COMPOSITION AND ITS ASSOCIATED HEALTH BENEFITS, MEDICINAL IMPORTANCES, AND ADVANCEMENT OF FOOD TECHNOLOGY

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ABSTRACT

The Kiwifruit is a worldwide-renowned fruit for its unique flavor, varied fruit flesh colors, and rich health-promoting properties. It is rich in vitamins, minerals, dietary fiber, and bioactive compounds, offering a broad spectrum of nutritional benefits. It is renowned for being an abundant source of vitamin C & K, folate, and potassium, along with phytochemicals such as polyphenols and carotenoids. The kiwifruit is rich in antioxidants that significantly contribute to reducing the risk of various chronic diseases in humans, including specific types of cancer, diabetes, and cardiovascular disorders, by combating oxidative stress. It has also been associated with its potential to improve digestive health, thanks to its natural enzyme actinidin, which aids in protein digestion. Moreover, kiwifruit has demonstrated its abundant medicinal importance, including anti-inflammatory, immunomodulatory, and antimicrobial properties. It supports immune system function, regulates blood pressure, and promotes skin health. Moreover, the potential of kiwifruit in managing metabolic syndromes and improving sleep quality due to its serotonin content is a promising area of research. Recent advancements in food technology, such as innovative processing techniques like freeze-drying, vacuum drying, and encapsulation, which are employed to preserve kiwifruit's nutrients and extend its shelf life, paint an optimistic picture for the future of kiwifruit research. Recent globally renowned kiwifruit-derived food products, including juices, purees, powders, and dietary supplements, are proof of the widespread use of kiwifruit and its global popularity. Biotechnology approaches, including genetic modification and controlled cultivation practices, are also being explored to enhance fruit yield, quality, and resistance to environmental stresses. This review offers a comprehensive understanding of the nutritional composition of Kiwifruit, its associated health benefits, medicinal properties, and benefits for human health, as well as the latest advancements in food technology.

Keywords: Kiwifruit, Nutritional composition, Health benefits, Medicinal importance, Processing, Drying, and preservation.

Article History (ABR-25-068) || Received: 02-Aug-2025 || Revised: 11-Sep-2025 || Accepted: 25-Sep-2025 || Published Online: 03-Oct-2025

1. INTRODUCTION

Kiwifruit (*Actinidia spp*.) is considered a relatively renowned horticultural crop with a concise history of cultivation (Sui et al. 2013). It is a fruit which is globally well known for its flavor and sweet-sour taste. It is believed that this fruit originated in China, specifically in the hilly regions of southwestern China; however, most *Actinidia* species are widely distributed throughout Asia (Lorenzo et al. 2006; Huang & Ferguson 2006; James et al. 2021). It is well known by various names, including “Chinese gooseberry,” “the horticultural wonder of New Zealand,” and “China's miracle fruit” (Tyagi et al., 2015). Botanically, kiwifruit is a berry with an outer layer of rough and soft, hairy, brown color when touched and a green color in its inner pericarp, covering numerous small and soft black seeds. It was found traditionally in China as wild native forms, later introduced to New Zealand as the national fruit, from where it has gained global recognition (Huang & Ferguson 2006; Zhang et al. 2010; James et al. 2021). The kiwifruit is a climbing vine fruit, which belongs to the genus *Actinidia* under the family *Actinidiaceae*, in which 76 and 125 genera and species (respectively) are found worldwide. However, out of these, only two species viz. *Actinidia deliciosa* (fuzzy kiwi fruit) and *Actinidia chinensis* (golden kiwi fruit) have been farmed commercially (Tyagi et al. 2015; Afiya 2023). However, *Actinidia arguta* (baby kiwifruit) and *Actinidia melanandra* (red kiwi), under the genus *Actinidia*, are also expected to emerge as alternatives to *Actinidia deliciosa* (green-fleshed kiwi) and *Actinidia chinensis* (yellow-fleshed kiwi) (Guroo et al. 2017).

Due to the recent emergence of global trade networks and their direct impact on changes in consumer preferences

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and choices, building the foundation for creating new demand for novel cultivars with distinct types of fruits, flavors, and nutritional properties. From the perspective of taste and nutritional properties, *Actinidia arguta* (hardy kiwifruit), also known as a mini kiwi, is gaining popularity (Nishiyama et al. 2008; Leontowicz et al. 2016; Pinto et al. 2020; Silva et al. 2021).

Among the kiwifruit-producing countries, China is a leading country, followed by Italy. In terms of exports, kiwifruit is led by Italy and New Zealand (Testolin & Ferguson 2009). New Zealand produces approximately 3.7 billion kiwifruit per year, with around 2,500 farmers engaged in kiwi production, and exports to around 55 countries. In total, 247,109 hectares of land are used to grow kiwifruit globally, and kiwifruit production yields around 40,22,650 tons annually (FAOSTAT 2018). Among most of the varieties, Acitinida deliciosa has good productivity, fruit size, low respiration rate, and ethylene sensitivity; it is also hairy and fuzzier but has most extended storage, whereas the *Actinidia chinensis* is more attractive by shape and is smoother with intense yellow color, sweeter by taste and can be eaten with without peeling the outer layer (pericarp) causes high market price but have short storage which affect the market reach; the distinguishing traits of the cultivar is red 'iris' around the center of the fruit, and it's periphery, and yellow flesh outside, is one of the most attractive variety of this species. The commercial cultivar of *Actinidia chinensis*, viz, Hort16A, is a variety, marketed globally in decreasing volumes, from 2010 to 2013, due to the infestation of the PSA (*Pseudomonas syringae pv. Actinidiae*) bacterium in New Zealand. Then, after 'Gold3', a new cultivar of golden kiwifruit, marketed by Zespri under the trade name "Sun Gold", is more disease-resistant but not sweeter in comparison with Hort16A, with a hint of tanginess (Zhang et al. 2010). The Kiwifruits are enriched in flavor, abundant nutritional properties, and there are a lot of value-added products in the markets, but only a few are accepted globally. The flavor of kiwifruit is representative of its taste, texture, and aroma (Harker et al. 2009; Cozzolino et al. 2020). The kiwifruit is considered a unique fruit due to its rich nutritional properties, including anthocyanins, vitamin C, flavonoids, antioxidants, and polyphenols (Garcia et al. 2012; Li et al. 2018; Richardson et al. 2018; Ma et al. 2019; Saeed et al. 2019; Peng et al. 2020). Numerous studies have investigated the medicinal profile of kiwifruit, and its consumption has been reported to exhibit a range of biological activities, including anti-asthmatic, anti-carcinogenic, anti-constipation, anti-diabetic, anti-fungal, anti-hypertensive, anti-HIV, anti-inflammatory, anti-nociceptive, antioxidant, anti-platelet, anti-tumor, anti-thrombin, cytotoxic, and hepatoprotective effects.

The abundant nutritional profile of kiwifruit has numerous purposes and health benefits for humans (Tyagi et al. 2015; López-Sobaler et al. 2016; Guroo et al. 2017; Ma et al. 2019; Zhang et al. 2020; Yuan et al. 2022; Khutare & Deshmukh 2023). Some of these benefits include the treatment of asthma, reduction of blood pressure, and a decrease in the risk of cancer, diabetes and heart disease, as well as many other diseases (Al-Naimy et al. 2012; Duttaroy, 2013; Lippi & Mattiuzzi 2020; Hakami et al. 2021).

2. NUTRITIONAL PROFILE OF KIWIFRUIT

Kiwifruit is considered a 'superfood' as it is abundant in necessary nutrients; it is a powerhouse of numerous health benefits for human beings. It comprises a rich profile of nutrients and minerals, including calcium, copper, iron, phosphorus, potassium, magnesium, manganese, selenium, and Zinc (Fig. 1; Asker Mohsen & Habiba 2018; He et al. 2019). The Kiwifruit, also known as the king of fruits, is widely recognized for its high pulp content, thick flesh, delicious taste, and abundant nutritional value (Chawla et al., 2019, 2020). Similarly, it is an abundant source of various vitamins, including C, E, and K, dietary fiber, folate, potassium, and various phytochemicals (Tyagi et al. 2015; Afiya 2023; Khutare & Deshmukhs 2023). The kiwifruit possesses a rich profile in numerous phytochemicals, including vitamins, minerals, saponins, triterpenoids, and various phenolic compounds, including flavonoids, polyphenols, anthraquinones, and coumarins (López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al. 2022). Because it is rich in carotenoids, ascorbic acid, and folic acid, it helps regulate iron and support maternal health, particularly in women with iron deficiency. Kiwifruit contains various health-promoting compounds with significant nutritional value (Tyagi et al. 2015). It contains various phytochemicals, although many of the phenols and flavonoids, as constituents of kiwifruit, have not been identified yet, as they have not been extracted (Tarascou et al. 2010). As is known to date, the kiwifruit consists of approximately 2-3% dietary fiber, which consists of 1/3rd soluble fiber and 2/3rd insoluble fiber (Mishra and Monro 2012). The various nutrient contents of different kiwifruit species are given in Table 1.

The various nutritional composition of the kiwifruit varies with the cultivars of the genus *Actinidia* and its species (Table 2). Furthermore, variation in the organic acid content varied with the cultivars of the different species of the genus *Actinidia* (Table 3).

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Table 1: Various Nutritional compositions of Kiwifruit (Actinidia species) for 100g fresh fruit

Nutritional Value/100g	Units	*Actinidia deliciosa*	*Actinidia chinensis*	*Actinidia arguta*
Energy	kcal	61 (Stan et al. 2021)	63 (Stan et al. 2021)	32 (Jo et al. 2006)
Water	g	83.1 (Stan et al. 2021)	82.4 (Stan et al. 2021)	88.0 (Jo et al. 2006)
Carbohydrates	g	14.66 (Stan et al. 2021)	14.23 (Stan et al. 2021)	9.20 (Jo et al. 2006)
Sugars	g	8.99 (Stonehouse et al. 2013)	10.99 (Stonehouse et al. 2013)	3.9-9.6 (Boyes et al. 1991; Nishiyama 2007; Bieniek 2012a; 2012b; Wojdyło et al. 2017)
Protein	g	1.14 (Drummond 2013)	1.23 (Drummond 2013)	1.70 (Jo et al. 2006)
Fiber	g	2.13-3.39 (Lintas et al. 1991, Spiller 2001)	2.0 (Spiller 2001)	2.9-4.1 (Latocha 2017)
Saturated fats	g	0.029 (Henare 2016)	0.149 (Henare 2016)	13.90-30.50 (Latocha 2017; Stan et al. 2021)
Vitamins				
Vitamin A	μg	87.0 (Stan et al. 2021)	23.0 (Stan et al. 2021)	37.3-84.5 (Stan et al. 2021)
Vitamin B1(Thiamine)	mg	0.027 (Stan et al. 2021)	0.01 (Stan et al. 2021)	0.01-0.05 (Gan et al. 1982; Nishiyama 2007; Jiang 2011; Stan et al. 2021)
Vitamin B2(Riboflavin)	mg	0.025 (Stan et al. 2021)	0.074 (Stan et al. 2021)	0.02-0.11 (Gan et al. 1982; Nishiyama 2007; Jiang 2011; Stan et al. 2021)
Vitamin B3(Niacin)	mg	0.341 (Stan et al. 2021)	0.231 (Stan et al. 2021)	0.50-1.55 (Gan et al. 1982; Nishiyama 2007; Jiang 2011; Stan et al. 2021)
Vitamin B6	mg	0.63 (Stan et al. 2021)	0.079 (Stan et al. 2021)	1.10-1.90 (Gan et al. 1982; Nishiyama 2007; Jiang 2011; Stan et al. 2021)
Vitamin C	mg	92.7 (Nishiyama et al. 2004; Chew et al. 2012; Stonehouse et al. 2013; Scaeteanu et al. 2019)	105.4 (Gan et al.1982; Nishiyama 2007; Jiang 2011; Stan et al. 2021)	22.8-43.0 (Xiao 1999; Nishiyama et al. 2004; Nishiyama 2007)
Vitamin E	mg	1.46 (Chew et al. 2012; Stonehouse et al. 2013; Scaeteanu et al. 2019)	1.49 (Chew et al. 2012; Stonehouse et al. 2013; Scaeteanu et al. 2019)	4.6-5.3 (Ferguson and Ferguson 2002)
Vitamin B9(Folic acid)	μg	25(39)-29 (Chew et al. 2012; Stonehouse et al. 2013; Scaeteanu et al. 2019)	34 (Stan et al. 2021)	-
Minerals				
Magnesium, Mg	mg	17 (Stan et al. 2021)	12.0 (Stan et al. 2021)	10.0-23.2 (Drummond 2013; Sivakumaran et al. 2018)
Phosphorus, P	mg	34 (Stan et al. 2021)	25 (Stan et al. 2021)	31.7-80.2 (Drummond 2013; Sivakumaran et al. 2018)
Potassium, K	mg	300 (Drummond 2013; Stonehouse et al. 2013)	250-400 (Samadi-Maybodi & Shariat 2003)	162.7-382 (Drummond 2013; Sivakumaran et al. 2018)
Calcium, Ca	mg	34 (Stan et al. 2021)	17.0 (Stan et al. 2021)	51.5-120.1 (Drummond 2013; Sivakumaran et al. 2018)
Copper, Cu	mg	0.13 (Stan et al. 2021)	0.15 (Stan et al. 2021)	0.05-0.16 (Bieniek 2012a; 2012b; Latocha et al. 2014)
Iron,Fe	mg	0.31 (Stan et al. 2021)	0.21 (Stan et al. 2021)	0.31-1.15 (Bieniek 2012a; 2012b; Latocha et al. 2014)
Zinc,Zn	mg	0.14 (Stan et al. 2021)	0.08 (Stan et al. 2021)	0.18-1.45 (Bieniek 2012a; 2012b; Latocha et al. 2014)

Table 2: Composition of nine different cultivars of kiwifruit (g/100g FW)

Cultivars	Water	Total Sugar	Total Acid	Dietary fibre	Pectin*(mg)	Vit.C"
Abbott	82.05	11.58	1.99	2.64	564	38.2
Bruno	82.95	10.47	2.34	3.05	552	132.7
Fatma	79.58	13.29	3.05	3.12	602	26.3
Gracle	83.6	11.43	2.21	2.67	377	98.3
Elmwood	84.8	8.05	2.16	2.5	462	125.4
Hayward cl.Priori	83.25	11.92	2.11	2.25	410	93
Hayward cl.Tenna	86.5	11.53	2.61	2.13	462	66.2
Hayward	84.05	10.51	1.92	2.6	392	59.1
Monty	84.83	9.72	1.95	2.74	397	70.7

Adapted from Guroo et al. (2017). *As galacturonic acid equivalents."(mg/100g FW).

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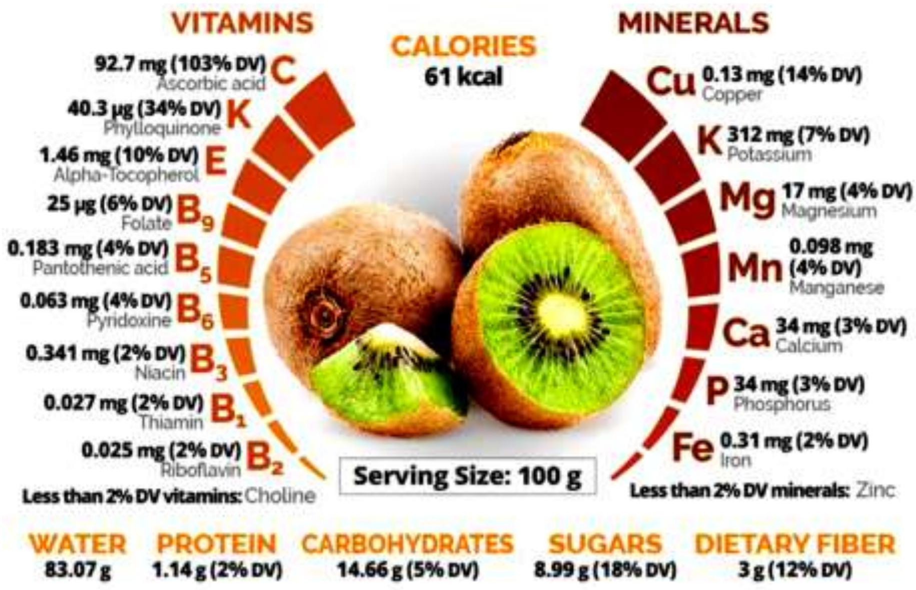

Fig. 1: Nutritional value of kiwi (Rasheed et al. 2021).

Table 3: Organic acid contents of the nine different cultivars of the different species

Cultivars	Quinic	Malic	Citric
Abbott	0.45	0.41	1.06
Bruno	0.51	0.36	1.42
Fatma	0.71	0.34	1.95
Gracle	0.30	0.29	1.56
Elmwood	0.45	0.34	1.30
Hayward cl.Priori	0.40	0.28	1.35
Hayward cl.Tenna	0.53	0.36	1.68
Hayward	0.39	0.24	1.20
Monty	0.43	0.37	1.10

Adopted from Lintas et al. (1991).

The daily intake of golden kiwifruit is safe and beneficial for human health. It helps reduce body fat and lower blood pressure, particularly in overweight young individuals. After ingestion, the concentration of circulating TNF-α significantly decreased. In patients with high baseline SBP, angiotensin II concentrations also decreased. An important finding is that there is no dropout or adverse effects were found during the research, reinforcing the safety of kiwifruit consumption. The study also highlighted a significant increase in dietary fiber and vitamin intake, with no notable changes in body weight. These findings support the use of kiwifruit in dietary management for overweight individuals (Yang et al. 2020).

While kiwifruit intake has been associated to potential health benefits for human beings, it is crucial to be aware of the potential risks. The intake of kiwifruit has been associated with a potential reduction in cancer risk, with evidence supporting both direct and indirect anticancer effects. Research, including in vitro studies and human intervention trials, has identified various methods by which kiwifruit may help prevent cancer. Kiwifruit is believed to encourage the growth of lactic acid bacteria and improve bowel movements, potentially lowering the risk of colon cancer. Its high ascorbic acid content helps to reduce DNA oxidative damage caused by hazardous chemicals. However, it's crucial to note that at extremely high doses, kiwifruit may have mutagenic effects, and caution should be exercised in such cases (Lippi & Mattiuzzi 2020).

3. KIWIFRUIT: ASSOCIATED HEALTH BENEFITS AND MEDICINAL IMPORTANCE

Kiwifruit is rich in abundant phytonutrients, minerals, and vitamins that promote overall health. Similarly, it comprised a significant amount of fructose and glucose, as well as a small amount of sucrose. It represents excessive levels of vitamin A, E, and K, as well as various types of flavonoid antioxidants, including xanthin, lutein, and beta-carotene (Tyagi et al. 2015). Kiwifruit contains various significant anti-cancer bioactive compounds, including antioxidants, cytotoxicity, pro-oxidant activity, antimicrobial properties, and tumor selectivity (Motohashi et al., 2002). The associated health benefits, along with the medicinal importance of Kiwifruit, are listed and discussed below.

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ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

3.1. Digestive Health

Kiwifruit contains an excessive amount of the proteolytic enzyme actinidin, which improves protein digestion through breaking down complex proteins into simpler forms, aiding in the digestion of a meal. It induces smooth traffic in the human digestive system (Boland 2013; Jayawardana et al. 2021; Ishida et al. 2021; Bayer et al. 2022). Gearry et al. (2023) concluded daily intake of 2 green kiwifruit is associated with relief from constipation and improvements in gastrointestinal comfort. Similarly, regular consumption of kiwifruit is associated with safe and may have a considerable improvement of increasing the frequency of bowel movements in the human body (Cokro et al. 2024).

3.2. Skin Health

Kiwifruit supplies an abundance of vitamin C, which is an antioxidant that works excellently in the human body to carry out various functions, such as keeping the skin young and vibrant, helping to prevent sun damage, pollution, and smoke, smoothing wrinkles, and improving skin texture. It supplies abundant vitamin E, which helps to make the skin soft and retain moisture and overall protects it from degeneration. Furthermore, vitamins also assist in the regeneration of cells in the human body, thereby making the skin look and feel young and flexible. Vitamin C plays a crucial role in the formation of a connective protein, specifically collagen, which is essential for repairing the skin and maintaining its firmness and suppleness. Furthermore, it functions to recover from various cuts, and wounds in the human body, besides preventing rough and dry skin as well. The kiwifruit contains amino acids, which protect the skin from sun damage (Tyagi et al. 2015; López-Sobaler et al. 2016; Ma et al. 2019; Ishida et al. 2021; Yuan et al. 2022; Khutare & Deshmukh 2023).

3.3. Bone Health

The Kiwifruit is also considered a powerhouse of nutrients which are friendly to bone of human being. From vitamin E, magnesium, and Folate that aid in bone formation, to vitamin K that plays a crucial role in bone mass building through promoting osteotropic activity, kiwifruit is a key player in maintaining strong and healthy bones (Tyagi et al. 2015; Khutare & Deshmukhs 2023).

3.4. Cardiovascular Health

The kiwifruit is an abundant source of various polyphenols, containing combined potassium, vitamins C, and E. These components are effective in maintaining and protecting the health of the cardiovascular system in humans. The kiwifruit exhibits various inhibitory activities in human beings that aid in reducing triglycerides in the blood (Tyagi et al. 2015; López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al. 2022; Khutare & Deshmukhs 2023).

Kiwifruit consists of potassium and fiber, which are beneficial for heart health. Fiber helps reduce the risk of various heart-related diseases, including heart attacks, by lowering high levels of cholesterol in the human body (Pam et al., 2024). The fresh kiwifruit is an abundant source of potassium, which are helpful for human beings to reduce the chances of cardiovascular disease. It helps reduce sodium intake, thereby increasing potassium intake. Potassium is a key constituent of cells and body fluids, which, through counteracting the negative impact of sodium, assists in regulating heart rate. Additionally, the seeds of kiwifruits contain abundant fatty acids, such as Omega-3, which are beneficial for reducing the risk of heart disease and stroke. Similarly, vitamins, Magnesium, and Folate are also helpful in reducing the chances of heart disease (Tyagi et al. 2015; López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al., 2022; Khutare & Deshmukh 2023).

The high potassium content of kiwifruit is beneficial in mitigating the adverse effects of sodium in the body. A low intake of potassium may mitigate the negative effects of sodium on high blood pressure. Similarly, another mineral, Copper, is involved in making red blood cells (RBC) and developing a strong immune system (Tyagi et al. 2015; Khutare and Deshmukhs 2023).

3.5. Hair Health

Kiwifruits are rich sources of various minerals, including magnesium, phosphorus, and zinc, which serve dual functions, such as improving hair growth and enhancing blood circulation in the human body. As kiwifruits contain both vitamin C and E, which help reduce hair fall. The omega-3 fatty acids in Kiwifruit are beneficial in preventing hair loss by retaining moisture. The kiwifruit also contains compounds that help preserve the hair's natural color and protect it from premature greying. The iron content of Kiwifruit helps nourish the hair and accelerate proper blood circulation in the scalp, thereby strengthening the hair from its roots (Tyagi et al. 2015; Khutare & Deshmukhs 2023).

3.6. Vision Improvement

Rich in phytochemicals and óxanthophylls, particularly Lutein, it helps prevent age-related blindness by accumulating in the retina. Including Kiwifruit in your diet is a proactive step towards maintaining good eye health (Tyagi et al. 2015; Khutare and Deshmukhs 2023).

3.7. Physical Fitness

The various types of minerals essential for replenishing energy that are lost during exercise, especially during hot environments, are also contained in kiwifruit. For example, in China, a kiwifruit-derived sports drink is designed to help athletes overcome the challenges of athletes. As during athletic training in a hot environment, where large amounts of minerals are lost through sweat (López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al. 2022; Khutare and Deshmukhs 2023).

3.8. Pregnant Women's Health

The kiwifruit is also considered an abundant source of vitamin B6, which is beneficial for pregnant women, as it helps in the development of the fetus and promotes its health. Additionally, it is beneficial for growing children, as it provides a sense of reassurance and confidence in their health and development (Tyagi et al., 2015; Khutare & Deshmukh, 2023).

3.9. Benefits for Blood Circulation

The Vitamin K components of the kiwifruit are helpful for blood clotting and absorption of vitamin D (Tyagi et al. 2015). It is a well-established fact that consuming kiwifruit facilitates the absorption of iron, which helps prevent anemia in the human body (Tyagi et al., 2015). Similarly, Ishida et al. (2021) in their study demonstrated the regular intake of green kiwifruit upto 4 consecutive weeks pinpointed the remarkable increase in blood flow.

3.10. For Better Sleep

The kiwifruit is considered to be a natural sleep aid. The serotonin content of kiwifruit, a neurotransmitter that regulates sleep, can improve sleep onset, reduce waking time after sleep onset, and provide relief from sleep disturbances. The peel of the Kiwifruit is also an important ingredient for the development of natural sleeping aids, offering a comforting solution for better sleep (Tyagi et al. 2015).

3.11. Reduce Depression

The other component of the Kiwifruit is Inositol, which is considered beneficial for treating depression, as it functions as a precursor to an intracellular second messenger system (Tyagi et al., 2015; Khutare & Deshmukh, 2023). Similarly, intake of sungold kiwifruit is beneficial for the maintenance of psychological wellbeing, thereby reducing the chances of depression in human being (Billows et al., 2025).

3.12. Reduce Kidney Stones

Kiwifruit contains excessive potassium, which is also associated with a reduction in the formation of kidney Stones in the human body. Additionally, the magnesium in fruit crops also reduces the risk of kidney stones. As Kiwifruit contains high amounts of both potassium and magnesium, it provides a sense of security and protection against the formation of kidney stones (Tyagi et al. 2015; López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al. 2022; Khutare and Deshmukhs 2023).

3.13. Anti-Cancer Benefits

The intake of Kiwifruit is beneficial against cancer; it is cytotoxic to cancer cells, meaning it works without affecting normal and healthy cells. Dietary fiber is abundant in kiwifruit, which helps reduce the risk of colon cancer. The antimutagenic components present in kiwifruits are beneficial in preventing gene mutations that may initiate the process of cancer cell formation. It contains a component named Catechin, a phytochemical that stimulates bone marrow proliferation, thereby reducing the toxicity of anticancer agents. Similarly, kiwifruit was found to contain another phytochemical named Lutein, which is believed to be associated with the dual function of preventing prostate and lung cancer in humans. The biochemical composition of kiwifruit, with an abundance of antioxidants, carotenoids, vitamins, and fiber, is effective in preventing or treating cancers (Tyagi et al. 2015; López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al. 2022; Khutare and Deshmukhs 2023).

3.14. Anti-Diabetic Effects

Kiwifruit is available with a low glycemic index, which helps reduce the risk of diabetes. Similarly, kiwifruit is a fiber-rich food that plays a key role in helping diabetic patients control their blood sugar levels. Due to some health-significant properties of kiwifruit, it a superior fruit, so the intake of this fruit may help prevent and treat many diseases. The kiwifruit is considered to be the most nutrient-dense fruit; we should eat it more frequently for better

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health (Tyagi et al. 2015; López-Sobaler et al. 2016; Ma et al. 2019; Yuan et al. 2022; Khutare and Deshmukhs 2023).

4. FOOD TECHNOLOGY ADVANCEMENT

The study focuses on novel methods for processing fruits and vegetables, with a particular emphasis on kiwi fruit. Concentrates on vitamin C stability and bioavailability during processing. Non-thermal procedures cause less nutritional loss than thermal treatments. High-pressure processing preserves more bioactive chemicals than conventional procedures. Compared to whole fruits and vegetables, fresh-cut produce contains less vitamin C, Washing and cutting dramatically reduce vitamin C levels (Mieszczakowska-Frąc et al. 2021). Effective post-harvest management is crucial for maintaining the quality of the product. Fruit and vegetable losses are reduced when harvested promptly. Cleaning, sorting, and pre-cooling are all examples of effective handling methods. Modified-atmosphere packaging can help decrease spoilage and increase shelf life. In this context, developing countries, including Nepal, are facing challenges due to a lack of access to fundamental post-harvest methods.

There is a direct impact of cold storage and processing methods on the quality and functionality of the kiwifruit. When stored at 0°C for 24 weeks, the kiwifruits demonstrated a gradual decrease in firmness, with organic types softening at a faster rate. Meanwhile, soluble solids increased, acidity declined, and reducing sugar levels increased substantially by 12 weeks (Park et al. 2015). Nevertheless, the deterioration caused by *Botrytis cinerea* was significant, especially in organic fruits. Cold storage improved overall quality and increased antioxidant activity (Zhuang et al. 2019). Ultra-micro kiwifruit powder (UKP) has been shown in studies to increase dietary fiber characteristics, promote intestinal peristalsis, and relieve constipation. Cold plasma treatment preserves bioactive compounds more effectively than thermal treatment. CP-optimized juice included more ascorbic acid than CP-extra. The study looks at hexaconazole residue in kiwifruit juice processing. Residue levels increase during homogenization and sterilization processes. Enantiomers show similar dissipation behaviors during processing. Research helps reduce pesticide risks in agriculture. Sensory attributes of CP-optimized juice were superior (Kumar et al. 2024).

PEF treatment increased the kiwifruit peel's ability by a factor of two. Under optimal conditions, the specific peeling force dropped by 100. PEF-treated bagasse showed 5.1% higher phenolic content. The antioxidant capacity rose by 260% in PEF-treated samples. PEF treatment reduced peeling loss when compared to control samples. Low energy levels did not improve peel ability. Higher specific energy enhanced peel ability and minimized peeling loss (Vaidya et al. 2006). Morton and Julia (1987), demonstrated the variation in the nutrient content (food value) of the fresh kiwifruit, canned, and frozen kiwifruit (Table 4).

Table 4: Nutrient content per 100g of the kiwifruit

Nutrient Content	Fresh	Canned	Frozen
Calories	66	-	66
Moisture (g)	81.2	73.0	80.7
Protein (g)	0.79	0.89	0.95
Fat (g)	0.07	0.06	0.08
Carbohydrates (g)	17.5	25.5	17.6
Ash (g)	0.45	0.45	0.53
Calcium (mg)	16.0	23.0	18.0
Iron (mg)	0.51	0.40	0.51
Magnesium (mg)	30.0	30.0	27.0
Phosphorus (mg)	64.0	48	67.0
Thiamine (mg)	0.02	0.02	0.01
Niacin (mg)	0.50	0.40	0.22
Riboflavin (mg)	0.05	0.02	0.03
Vitamin A (IU)	175	155	117
Ascorbic Acid (mg)	105	103	218

Adapted from Morton and Julia (1987).

4.1. Kiwifruit Processing

Although kiwifruit's ascorbic acid level can decrease with processing, it is renowned as an abundant constituent of vitamin C. The product, such as kiwifruit leather, retains more of this essential vitamin than other processed goods. Of the cultivars examined, "Bruno" is most suited for producing jam and candies, but "Hayward" and "Allison" are more suitable for producing butter and leather. Effective processing techniques for turning kiwifruit into a range of value-added goods, including jam, butter, leather, candies, and toffees, were successfully established by the study. These products offer a way to utilize kiwifruit grades that are not marketable, while also satisfying a variety of consumer preferences. In areas with ideal environmental conditions for kiwifruit farming, such as Himachal Pradesh in India, this is a significant advantage (Vaidya et al., 2006). Food technology developments for kiwifruit processing

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

encompass a range of procedures, including fermentation and drying, that enhance the fruit's value and shelf life, making it easier to produce a wide range of value-added products, including juices and dried snacks. Nowadays, non-thermal juice processing techniques are employed to retain both the nutrition and stability of juice. Kumar et al. (2024) concluded in their study, cold plasma-treated juice was found better alternative for processing of kiwifruit juice in comparison with thermal processing.

4.1.1. Processing Protocols: Kiwifruit are mostly eaten fresh, but also made into juices, jams, and sauces. Due to the inherently unstable properties of fresh Kiwifruit, it poses challenges for traditional processing technology. Recent advancements in fermentation technology have enhanced the safety and nutritional value of kiwifruit products, leading to the development of new options, including kiwifruit cider and liqueurs (Adebo et al., 2018). Similarly, Infrared-assisted drying has been proven to reduce drying time and energy consumption while maintaining vitamin C content and color quality in dried kiwifruit slices (Li et al. 2023). These days, non-thermal treatment of the juices is becoming an appropriate alternative to keep the juices intact with the aspects of both nutritional content and stability of juices (Kumar et al. 2024).

4.1.2 Preparation Method of Kiwi Products

Kiwifruit Jam: To prepare kiwifruit jam, first, the pulp is peeled from the kiwifruit, and sugar is combined in equal amounts, or in a 1:1 ratio. The blend should be heated on a gas stove upto 105°C until it attains a concentration of 68°Brix, verified through a sheet test. Due to the natural pectin found in kiwifruit, there is no need for artificial pectin. When the jam reaches the preferred consistency, it is hot-filled into containers for storage and distribution (Vaidya et al. 2006; Hassan et al. 2023).

Kiwifruit Butter: 1 kilogram of kiwifruit puree is mixed with 400g of sugar and cooked until it reaches a thick, creamy texture with a concentration of 45°B. The final product is then hot-filled into containers to preserve its freshness (Vaidya et al. 2006).

Kiwifruit Candy: To prepare kiwifruit candy, first prepare equal amounts of sugar and fruit. Then, the fruits are treated with a lye solution (15% NaOH at 90°C), cleaned thoroughly, and neutralized in a 0.5% citric acid solution. Following the pricking to improve absorption, the fruits undergo blanching to remove air and halt enzyme activity. The gradual candy-making procedure involves stacking the fruits with sugar and allowing them to rest for 24 hours, which facilitates slow sugar absorption. Finally, the candies are dried in a cabinet dryer at 55°C for 5 hours, then after cooled, and packaged (Vaidya et al. 2006).

Kiwifruit Leather: For the preparation of the kiwifruit leather, the fruit pulp is mixed with 15% sugar and preserved with 500 mg/kg of potassium metabisulfite to maintain its green hue. The pulp is laid out in a 2.5 cm thick layer on trays coated with fat and used to dry in a cabinet dryer at 45°C for approximately 15 hours (Iwansyah et al., 2020). After completion of drying to a thickness of 0.5 cm, the leather is sliced into sections, wrapped in butter paper, and prepared for sale (Vaidya et al., 2006).

Kiwifruit Wine: The distinct flavor and its associated health benefits of the kiwifruit wine are considered to be a novel beverage. Various fermentation methods, as well as different yeast strains, have been tested to enhance their quality, aroma, and nutritional value. The kiwifruit wine production primarily focuses on fermentation methods, aroma characteristics, and nutritional value (Huang et al. 2024; Zhou et al. 2024).

The conventional pear-kiwifruit wine possesses a dull and acidic flavor. Malolactic fermentation (MLF) enhances flavor by breaking down L-malic acid. Optimal MLF conditions: pH 3.4, inoculation 5; temperature 20°C. The reduced L-malic acid concentration by 98.3%. The conventional pear-kiwifruit wine has a dull and acidic flavor. The deacidification process enhances the wine's flavor. Malolactic fermentation influences L-malic acid conversion in wine. Sensory characteristics vary dramatically between treated and untreated wines. The deacidification procedure solely determines the concentration of aromatic compounds. The statistical research on this topic has demonstrated considerable variation in wine quality. Further investigation of MLF's impact on diverse fruit wines. Investigation of various *O. oeni* strains for flavor enhancement. A study regarding the preferences of consumers for pear and kiwi fruit wine had analyzed the impact of long-term aging on wine quality and development & and improved accordingly (Yang et al. 2022).

4.2. Fermentation Techniques

4.2.1. Yeast Strains: There are various yeast strains, viz. *Saccharomyces cerevisiae* and indigenous yeasts such as *Zygosaccharomyces rouxii* have been utilized to enhance fermentation outcomes. For example, found that successive fermentation with *Z. rouxii* dramatically improved antioxidant activity and fragrance complexity (Li et al. 2023; Xia et al. 2024). *L. brevis* and *L. plantarum* were optimized as strains for kiwifruit juice fermentation as these strains effectively enhance the functional and sensory qualities of kiwifruit juices and the aroma profile can be effectively improved (Lan et al., 2023).

4.2.2. Inoculation Procedures: There are several inoculation strategies, including sequential and mixed procedures, that have been employed. The sequential inoculation of Wicker hamomyces anomalous followed by *S. cerevisiae* produced the most significant sensory scores in low-alcohol kiwi wine (Huang et al. 2022).
4.2.3. Kiwifruit Toffee: It is made with 1 kilogram of pulp, 600 grams of sugar, 100 grams of glucose, 160 grams of skim milk powder, and 100 grams of edible (Huang et al. 2022).

5. CHALLENGES AND FUTURE PERSPECTIVE

Recently, kiwifruit farming has gained popularity in Nepal, with cultivation expanding in certain districts, including Ilam, Kavrepalanchowk, Dolakha, Makwanpur and Solukhumbu. It is increasing in terms of volume, value, and area (Rai 2025). Though for the commercial production of kiwifruit in mid hills of Nepal is still facing numerous challenges, marginalized smallholder farmers still focusing on agrobiodiversity for their income generation and livelihood options in rural areas (Nepal et al. 2025a), lack of appropriate plant protection measures as primates are emerging as a significant crop causes damages(Rai & Rai 2024a), lack of adoption of appropriate plant propagation techniques (Rai and Rai 2024b; Rai and Rai 2024c), lack of appropriate government policy (Nepal et al. 2025b; Rai et al. 2025) and research and development (Rai 2025). Besides these challenges, in Nepal, the present status of kiwifruit production is achieving momentum due to its suitability for the agroclimatic conditions in the Mid-hills of Nepal.

The shelf life of Kiwifruit is remarkably shortened due to degradation and increasing softness during storage. Although cold storage is widely used to extend the shelf life of fruits, it can compromise the physicochemical and nutritional properties of kiwifruits. The primary cause of kiwifruit rot, loss of quality, and waste is recognized as being due to the interaction of *Botrytis cinerea* (Park et al., 2015). The sensitivity of kiwifruit to ethylene exacerbates these issues, resulting in rapid spoilage and quality degradation during processing and storage (Göksel and Atak 2014). This would ensure farmers receive fair compensation for their produce, encouraging more growers to enter the market (Rai and Rai 2024b).

Further studies should focus on addressing these problems by investigating the long-term effects of cold storage on kiwifruit quality and nutritional composition, and follow a wide range of approaches. Comparative studies of antioxidant properties in different kiwifruit cultivars can help identify varieties with superior health benefits. Research findings on the effect of ethylene production on fruit quality could help develop better storage and processing techniques. Likewise, it is beneficial to investigate how storage conditions, such as temperature, humidity, and packaging, affect the preservation of nutritional value. Consumer preferences for organic and conventionally cultivated kiwifruit require further investigation to inform market-oriented development. To reduce post-harvest losses and increase profitability, efforts should be made to investigate creative value addition solutions for kiwifruit and its byproducts. It would always be better to prioritize breeding projects to develop new kiwifruit cultivars with superior storage properties, disease resistance, and nutritional value. Finally, research should focus on the impact of kiwifruit consumption on food allergies to improve its safety and acceptance across varied communities.

6. CONCLUSION

Kiwifruit, due to its climatic adaptability in the diverse temperate zones of the region, originated in China. It spread from its original place to Europe, America, New Zealand, and other parts of the Asian continent. Although it has been known to occur in shorter periods due to its nutrient-dense properties and numerous health benefits, it is gaining increasing popularity globally. Kiwifruit comprises important chemical components like vitamins, phenolic compounds, amino acids, proteolytic enzymes and antioxidant properties; it has demonstrated numerous pharmacological activities associated with it. Nevertheless, daily consumption of kiwifruit resulted in a reduction in various disease incidences. To address the issue of food security and sovereignty, kiwifruit could be a boon to the world, as it can be utilized in various processing forms while maintaining its nutrient content intact.

DECLARATIONS

Funding: No funding was available to support the conduct of this study.

Acknowledgement: The authors acknowledge the support provided by the Institute of Applied Sciences, Organic Agriculture Program, Madan Bhandari University of Science and Technology (MBUST), Chitlang, Thaha Municipality-9, Bagmati Province, Nepal, in creating a research environment.

Conflicts of Interest: All the authors declare that they have no conflicts of interest regarding this manuscript for authorship, content of the manuscript, and contribution provided by the authors.

Data Availability: Data will be available from the corresponding author upon request.

Ethics Statement: No animals or human subjects are involved in this experimentation; therefore, no ethical approval is required.

Author's Contributions: **RR-**Conceptualization, preparation of the preliminary draft of the manuscript, review of the manuscript and editing, and final writing of the manuscript. **AN-** Preparation of the first draft of the manuscript, writing the manuscript, revising the manuscript, and final editing of the manuscript. **SR-**Review and rewriting the draft of the manuscript, editing, and final writing of the manuscript.

Generative AI Statements: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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