RESEARCH PAPER

Comparative Analysis of Actinidia (A.) deliciosa Fruit Cultivated at Hilly Region of Uttarakhand: A Morphological, Physicochemical, Biochemical and Antioxidant Potential Investigation

Harsahay Meena[1,2], Ankit Kumar[1,2], Devakanta Pahad Singh[1], Rajeshwar Kamal Kant Arya[2*]

[1]Department of Pharmacology and Toxicology, Defence Institute of Bio-Energy Research (DIBER), Defence R & D Organization (DRDO), Goraparao P.O. - Arjunpur, Haldwani - 232139, Nainital (Uttarakhand), India

[2]Department of Pharmaceutical Sciences, Sir JC Bose Bhimtal Campus, Kumaon University, Nainital, Uttarakhand, India

Address for correspondence: Rajeshwar Kamal Kant Arya, Department of Pharmaceutical Sciences, Sir JC Bose Bhimtal Campus, Kumaun University, Nainital, Uttarakhand, India

Email: rajeshwararya@gmail.com

Mobile: +91-9758008496

Received: 20th Apr, 2026 | Revised: 25th Apr, 2026 | Accepted: 9th May, 2026 | Available Online: 14th May, 2026

ABSTRACT

Objectives: This study compares the morphological, physicochemical, biochemical and antioxidant attributes of three kiwifruit varieties Hayward Old (OH), Hayward New (NH), and Allison (All).

Results: Morphological analysis revealed that OH had the highest average fruit weight (50.0 g) and the largest edible portion (41.46 g), whereas All exhibited the longest but narrowest fruit (63.23 mm × 34.82 mm). Color variations range from dark brownish green (OH) to greenish yellow (NH) and brownish green (All), with all varieties exhibiting a sour taste. Physicochemical analysis showed that All had the highest moisture content (76.05±1.739%), while OH had the highest ash content (7.74±0.578%), suggesting superior mineral composition. Acidity was highest in All (pH 2.9±0.1), aligning with its tangier flavor, while NH exhibited the highest carbohydrate content (28.755±0.590 g/100g). Biochemical analysis highlighted that All contained the highest phenolic (751.3±83.478 mg/100g) and flavonoid (74.12±3.113 mg/100g) levels, along with the highest ascorbic acid content (442.91±21.090 mg/100g), contributing to its strong antioxidant potential. The All extract exhibited the highest antioxidant potential, with 79.90% and 75.12% inhibition in the DPPH and ABTS assays, respectively (IC_{50} = 2.993 mg/mL and 3.613 mg/mL). The OH extract showed moderate activity, with 57.21% (DPPH, IC_{50} = 3.743 mg/mL) and 53.71% (ABTS, IC_{50} = 4.154 mg/mL). The NH extract demonstrated the lowest activity, with 44.03% (DPPH, IC_{50} = 4.561 mg/mL) and 42.08% (ABTS, IC_{50} = 5.294 mg/mL). The fat content remained low across all varieties.

Conclusion: These findings underscore the distinct nutritional and antioxidant profiles of each variety, with OH being optimal for yield and dietary fiber, NH for carbohydrate-rich consumption, and All for antioxidant-rich dietary applications.

Keywords: Kiwi, antioxidant activity, phytochemicals and antioxidant compounds.

How to cite this article: Meena H, Kumar A, Singh DP, Arya RKK., Comparative Analysis of Actinidia (A.) deliciosa Fruit Cultivated at Hilly Region of Uttarakhand: A Morphological, Physicochemical, Biochemical and Antioxidant Potential Investigation. Int J Drug Deliv Technol. 2026;16(44s): 1368-1377; DOI: 10.25258/ijddt.16.44s.147

Introduction

Free radicals or Reactive oxygen species (ROS) are produced because of the metabolic process occurring inside the human body or by exogenous chemicals, which oxidize biomolecules such as cell membranes, DNA, nucleic acids, and proteins [1]. Oxidative stress is generated due to the interaction between biomolecules and chemicals, which is the main cause of various diseases e.g., cancer, diabetes, cirrhosis, arthritis, and atherosclerosis [2,3].

Antioxidants are crucial in mitigating these effects by neutralizing free radicals and reducing disease risks [4,5]. Recently, natural antioxidants have garnered significant attention for their protective roles, particularly those derived from medicinal plants, which have demonstrated effectiveness in traditional treatments [1]. Natural antioxidants have significant role in improving insulin sensitivity, anti-inflammatory effects, improving lipid metabolism and maintaining body weight and gut health etc. [6] For example, patients with diabetes are encouraged to incorporate medicinal plants into their treatment to alleviate symptoms.

Actinidia deliciosa (kiwi), a nutrient-dense fruit, offers numerous health benefits when consumed regularly. Indigenous to the mountainous regions of China, it is widely distributed across Asia and cultivated globally, with approximately 55–60 species of *Actinidia* reported [7]. Among these, *A. deliciosa* is the most commercially valuable and extensively marketed species. In the Chinese traditional medicine system, it is used for treating rheumatoid arthritis, inflammation, hepatitis, gastric and breast cancer. Its nutrient profile includes vitamins C, E, B12, folate, dietary fiber, and various bioactive constituents such as phenols, tannins, proteins, and carbohydrates. Furthermore, the fruit, stems, and roots of *A. deliciosa* exhibit diuretic, febrifuge, and sedative properties, and *A. deliciosa* seeds has a natural anticoagulating property [8,9].

Various phytochemicals have been identified in *A. deliciosa* include triterpenoids, phenols, flavonoids, phenylpropanoids, ascorbic acid, quinones, and steroids. These compounds contribute to kiwi's total antioxidant capacity, enabling effective scavenging of reactive oxygen species (ROS). A study shows that roots contain β-sitosterol, fraxetin, umbelliferone, and vanillic acid derivatives as main phytoconstituents [10]. Kiwi stimulates bone marrow function, improves immunity, and enhances iron and vitamin D absorption [11]. These attributes may make Kiwi beneficial for addressing thrombocytopenia by promoting platelet production. *Actinidia deliciosa* are also recognized for diuretic, antipyretic, sedative, and mild anticoagulant properties, supporting its broader therapeutic relevance. Our study aims to make a comparison between different strains of Kiwi fruit as well as age of the orchard based on the morphological, physicochemical, compositional, and antioxidant properties of two strains of *Actinidia deliciosa* (Allison and Hayward). The comparison of two kiwifruit varieties, Hayward and Allision (All), and the effect of the age of the orchard (Old Hayward (OH), New Hayward (NH) was performed to underscore kiwi fruit's significance in promoting health and combating oxidative stress.

Material and Methods

Plant material and fruit powder preparation*:* Two strains of *Actinidia deliciosa* (Allison, and Hayward New and Hayward Old) have been collected from the IVRI Centre at Mukteshwar, a medium-hilly region in Uttarakhand. was performed to underscore the significance of kiwi fruit in promoting health and combating oxidative stress. The outer peel of the fruit was discarded, and the remaining inner part was chopped and dried in an oven at temperatures below 50°C. and dried fruit was ground using a grinder. The freshly powdered fruit was stored in an airtight container (air replaced by nitrogen) at -4° C temp for experimental use.

Chemicals*:* Methanol, $AlCl_3$, CH_3COOK, 2, 6, -dichloro-phenolindophenol, Folin–Ciocalteau solution, DPPH, Catechol, ABTS, Oxalic acid, Tannic acid, D-glucose, Ascorbic acid, Bovine serum albumin, and Quercetin were procured from Merck Life Sciences Pvt. Ltd.

Macroscopic and organoleptic examination: A morphological and organoleptic study of the fruit of both strains was performed using standard protocol. The morphological and organoleptic properties, including size, shape, taste, odour, and colour, were investigated [12,13].

Qualitative detection of phytochemicals*:* The phytochemical content in kiwi fruit samples was quantitatively assessed using various standard methods. Alkaloids were detected through Mayer's and Wagner's reagent tests, while Glycosides were analyzed with the Keller-Killani test and carbohydrates were identified using Fehling's test and Molisch's test, and triterpenes and sterols were confirmed using the chloroform method. Saponins were evaluated via the foam test, and proteins along with amino acids were tested using the Biuret method. Tannins were determined using the gelatin test, phenols were identified by the ferric chloride test, and flavonoids were assessed using the NaOH and sulfuric acid methods [14].

Determination of Physicochemical Properties:

***Loss on drying*:** The Loss on drying of powdered samples was estimated by using a Moisture analyzer. 1 g of root powder was weighed carefully and then placed in a sample pan at 105° C for the analysis [13].

Total ash: The total ash is the carbon-free ash obtained after burning at high temperatures. For this, a 500 mg sample was put down in a pre-weighed porcelain dish, and then it was ignited at 500° C using a muffle furnace to convert the sample into ash. After converting the sample into ash, it was placed in a desiccator to cool it, and the process continued till a constant weight was obtained. The total ash content was estimated using the formula given below [15].

$$\% \text{ Ash} = \frac{W3 - W1}{W2 - W1} 100$$

Where W1=weight of a porcelain dish without ash, W2= weight of the (porcelain dish + sample before ash, W3=weight of porcelain dish+ ash,

Water-soluble ash: For determining the water-soluble ash, the ash was dissolved in 25 mL water and boiled for 5 min. The boiled ash was then filtered through ashless filter paper. The residue obtained on the paper was washed with hot water and dried, after drying the residue was combusted at 600^0 C. The percentage of water-soluble ash was determined from the obtained ash [13]

Acid-insoluble ash: The total ash was dissolved in 100 mL of diluted hydrochloric acid in a 250 mL beaker. After dissolving the ash into acid, the mixture was boiled, and after boiling, the mixture was filtered through ashless paper, and the residue on the paper was collected. The residue was washed many times to neutralize the residue. The residue was then transferred to a pre-weighed porcelain dish. The dish was combusted in a muffle furnace at 600° C. After combusting the sample, it was cooled in a desiccator and weighed. The percentage of acid-insoluble ash was then estimated [13]

Determination of pH: First, a 1% aqueous solution of kiwi powder was prepared by dissolving 500 mg of kiwi powder in 50 mL of distilled water. The prepared sample was then placed in a pH apparatus, and the pH was estimated to use a standard glass electrode [13]

Biochemical analysis: The analysis of phytochemicals like carbohydrates, reducing sugar, proteins, crude fiber, fat, flavonoid, total phenols, ascorbic acids, and tannins in fine powder of kiwi samples were carried out.

Total carbohydrates: Carbohydrates are the stored structural unit of plants. The quantification of carbohydrates can be performed by hydrolyzing the polysaccharides into monosaccharides using the acid hydrolysis process, and monosaccharides are estimated using the Anthrone method [16]. D-glucose was used as the standard for estimating monosaccharides.

Total protein: Proteins are building blocks for all living organisms, their detection in plant materials is requisite. Generally, Lowry's protein detection method is performed to estimate the protein content [16]. The Folin-Ciocalteau reagent is used to detect the presence of protein in the plant sample. The amino acid present in the protein reduces the phosphomolybdic–phosphotungstic agent, and the blue color is developed. The protein is estimated using the standard graph. Bovine serum albumin (BSA) was used as standard.

***Total phenols* (TP):** A modified Folin-Ciocalteu method was used for determining the total phenols (TP). First, the prepared extracts (100 μL) were dissolved in water, and then Folin-Ciocalteu reagent (0.5 mL) was mixed in it. The solution was put aside for 3 min, after that 20% Na_2CO_3 (2 mL) was mixed to it with vigorous shaking, the mixture was boiled for 1min and the formation of blue color was observed, and absorbance was observed at 650 nm, and the TP was estimated with respect to catechol (standard) [16].

Total flavonoids: $AlCl_3$ colorimetric method was employed to estimate the Total flavonoid (TF) [17]. A standard curve was plotted by using Quercetin as standard. First, the extracts were mixed in 80% ethanol and then 95% ethanol, then $AlCl_3$ and was potassium acetate solution was added to it. The resultant solution was then thoroughly stirred and incubated for half hr. The absorbance of the solution observed spectrophotometrically against blank at 415 nm. The TF estimated with respect to quercetin and represented as quercetin equivalent (QE) in mg/100g on a dry weight basis.

Total tannins: To estimate tannin content using the Folin-Denis method [17]**.** The color intensity is measured at 750 nm using a spectrophotometer, and tannin concentration is determined by comparing the absorbance with a standard calibration curve made using tannic acid as standard. First, the prepared extracts (100 μL) were dissolved in water (30 mL), and then Folin-Ciocalteu reagent (0.5 mL) was mixed in it. The resultant solution was put aside for 3 min, after that 35% Na_2CO_3 (2 mL) was mixed to it with vigorous shaking, the mixture was heated for 30 min at 20-30^0C, and absorbance was recorded at 700 nm [16]. and the TT was estimated with respect to tannic acid (standard) and represented as tannic acid equivalent (TAE) in mg/g on a dry weight basis

Total ascorbic acid: Total amount of ascorbic acid has been determined by using 2, 6, - dichloro-phenolindophenol titrated method in the plant extracted [17]. A standard curve was plotted by using Ascorbic acid as standard. Total ascorbic acid (mg/100 g) was estimated using the formula:

$$\text{Ascorbic acid (mg/100g)} = \frac{0.5\, mg\ X\ titter\ vol\ against\ test\ X\ 100\, mL}{\text{Ascorbic acid (mg /100g)}} X100$$

Analysis of reducing sugars: Reducing Sugars was determined by 3, 5-Dinitrosalicylic Acid (DNSA Method) [16].

Analysis of crude fiber: Crude fibre was estimated by using acid and alkali-treated methods [16].

Analysis of fat: Total fat was determined by the Soxhlet extraction method [18]. It is also called the solvent extraction method.

Antioxidant activity*:* *In-vitro* antioxidant activity of both strains (Allison, New, and Old Hayward) of Kiwi were carried out by DPPH method and ABTS method:

DPPH method: The stable DPPH radical was used for evaluating the free radical neutralizing ability of both strains. The absorbance was observed at 517 nm. A standard graph of Ascorbic acid (standard) was prepared [19,20]. Percentage inhibition was calculated as

$$\%\, Radical\ Scavenging = \frac{\text{(Abs control − Abs sample)}}{\text{(Abs control)}} \text{X100}$$

ABTS method: The ABTS radical scavenging activity was assessed following the modified method of [21]. Butylated hydroxytoluene (BHT) was used as the standard. The percentage inhibition of ABTS+ was calculated using the following formula:

$$\%\, Radical\ Scavenging = \frac{\text{(Ao − Ast)}}{\text{(Ao)}} \text{X100}$$

where Ao is the absorbance of the control, and Ast is the absorbance of the test sample.

Statistical Analysis: The results of the study were expressed as Mean ± S.D. The post hoc test in one-way ANOVA statistical analysis was used for analysis of the results through Dunnett's t-test for all test groups compared vs. control group and Student – Newman - Keuls Test was used for compared all pairs of groups.

Results and Discussion

Macroscopical and organoleptic screening of kiwi fruit strains: Morphological characters such as colour, shape, size of the fruit of both strains (Allison and New & Old Hayward) of kiwi fruits were recorded as per the reported method [12,13] cited in table 1. The comparison of three kiwifruit varieties-Hayward Old, Hayward New, and Allision revealed several key differences. Hayward Old exhibited the highest average fruit weight (50.0 g), followed by Hayward New (38.9 g) and Allision (36.29 g), suggesting superior growth conditions or genetics for this variety. Allision had the longest fruit (63.23 mm), though it was the narrowest (34.82 mm), indicating a more elongated shape compared to the Hayward varieties, which were shorter and wider. In terms of color, the Hayward Old was dark brown-green, Hayward New was greenish-yellow, and Allision was brownish green, with all varieties sharing a sour taste typical of *Actinidia deliciosa*. Additionally, the Hayward Old showed the highest proportion of edible inner fruit (41.46 g), outperforming Hayward New (30.36 g) and Allision (27.73 g), while the outer fruit weights remained similar across all samples, suggesting comparable skin thickness. In conclusion, the Hayward Old variety stands out for its higher weight and larger edible yield, while Allision, despite its elongated shape, had a relatively lower edible mass. These results highlight the distinct characteristics of each variety, with Hayward Old offering a more favorable yield and growth performance.

Table1: Comparative analysis of physical and organoleptic characteristics of *Actinidia deliciosa* (fruits) strains.

Sample name	**Avg. wt. (g)**	**Avg Length (mm)**	**Avg Width**	**Colour**	**Taste**	**Wt. of Inner part (%)**	**Wt. of Outer part (%)**
Hayward	50.0± 5.522	53.46 ± 5.785	46.30 ± 4.585	Dark brown	sour	82.92 ± 3.001	17.08 ± 3.001
Hayward	38.9± 4.270	51.16 ± 4.772	45.28 ± 3.060	Greenish Yellow	sour	78.05 ± 2.818	21.95 ± 2.818

Allision	36.29 ± 5.257	63.23 ± 6.922	34.82 ± 6.805	Brownish Green	sour	76.40 ± 3.175	23.60 ± 3.175

Qualitative screening of phyto-chemicals: Phytochemicals such as Alkaloids, Carbohydrates, Glycosides, Sterols and Triterpenes, Saponins, Protein and amino acids, Tannins, Phenols, Flavonoids were qualitative determined in all the samples of kiwi fruits cited in Table 2.

Phytochemical screening shows that various biologically active compounds such as carbohydrates, sterols and triterpenes, saponins, proteins, tannins, phenols, and flavonoids, and alkaloids are present in *A. deliciosa* strains (Allison, New Hayward, and Old Hayward) while glycosides were uniformly absent, consistent with earlier reports on *A. deliciosa* varieties. These compounds, particularly flavonoids and phenols, highlight the antioxidant, antimicrobial, and anti-inflammatory potential of the species, demonstrating their therapeutic relevance. The relatively uniform presence of these phytochemicals across strains reflects the consistent biochemical profile of the species. Corroborating these findings, Al-Kawaz and AL-Mashhady (2016) concluded that hydroalcoholic extract contained good amounts of primary and secondary amines, alkaloids, terpenoids, and flavonoids further emphasizing the role of extraction methods in enhancing the phytochemical yield.[22] Together, these results underscore the functional and therapeutic value of *A. deliciosa* and the importance of extraction techniques in optimizing the concentration of its bioactive compounds.

Table 2: Qualitative screening of phyto-chemicals

Phytochemicals	Allison	Hayward	New Hayward Old
Alkaloids	+	+	+
Carbohydrates	+	+	+
Glycosides	-	-	-
Sterols and Triterpenes	+	+	+
Saponins	+	+	+
Protein	+	+	+
Tannins	+	+	+
Phenols	+	+	+
Flavonoids	+	+	+

Screening of Physicochemical Properties: The physicochemical properties like total ash, acid insoluble ash, water soluble ash, loss on drying (LOD), total soluble solids and pH and were determined as per AOAC guidelines in all three samples of Kiwi fruits presented in Table 3. Maximum physicochemical like LOD, acid insoluble ash, water soluble ash and total soluble solids were recorded in Allison, whereas as maximum total ash and pH were recorded in old Hayward strain of kiwi fruits.

The analysis of various compositional attributes across two kiwifruit strains (Allison and Hayward) and different ages of the kiwi orchard (New & Old Hayward) revealed notable differences in moisture content, mineral composition, acidity, and sweetness. Allison exhibited the highest moisture content (76.05±1.739%), making it more suitable for fresh consumption but potentially limiting its shelf life. Similarly, Krokida reported moisture contents of 70-85% in fresh kiwifruit samples [23]. Old Hayward had the highest total ash content (7.74±0.578%), reflecting greater mineral composition, while New Hayward had the lowest (5.72±0.751%) on a dry weight basis. Similarly, Fourie & Hansmann and FSSAI reported a total Ash value of 7.88% in freeze-dried kiwi samples. [24,25] Water-soluble ash levels were similar across the strains (1.16±0.121%–1.19±0.13%), indicating consistent mineral solubility. Acid-insoluble ash ranged from 4.10±0.223% to 4.22±0.24%, with Allison showing slightly higher values. pH levels, indicating acidity, ranged from 2.9±0.1 in Allison to 3.3±0.2 in Old Hayward, aligning with expected flavor profiles, where Allison appeared tangier. The Total Soluble Solids (TSS) content was highest in Allison (0.43±0.02%), suggesting greater sweetness. These findings confirm varietal differences and are consistent with past research, offering insights into their suitability for fresh consumption, storage, and processing.

Physico-chemical Properties	**Allison**	**Hayward New**	**Hayward Old**
Loss on drying (Moisture %)	76.05±1.739	74.8±1.435	74.2±1.561
Total Ash (%)	6.78±0.553	5.72±0.751	7.74±0.578

Water Soluble Ash (%)	1.19±0.13	1.19±0.08	1.16±0.121
Acid insoluble Ash (%)	4.22±0.24	4.18±0.219	4.18±0.219
pH	2.9±0.1	3.1±0.2	3.3±0.2
TSS (%)	0.43±0.02	0.20±0.03	0.38±0.03

Quantitative Screening of phytochemicals: A comprehensive quantitative analysis of phytochemicals in Kiwi fruit strains was carried out. The results of phytochemicals analysis are showed in table 4.

Table 4: Quantitative screening of phytochemicals

Sample	Carbohydrates (g/100 g)	Proteins (g/100g)	Phenolic (mg/100g)	Tannins (mg/100g)	Flavonoids (mg/100g)	Ascorbic Acid (mg/100g)	Crude Fiber (%)	Fat (%)	
ALL	23.345±0.254^{b}	0.348±0.004^{a}	751.304±83.478^{b}	638.16±24.824^{a}	74.121±3.113^{c}	442.907±21.090^{c}	7.201±0.032^{b}	4.500±0.024	13.361±0.021^{b}
NH	28.755±0.590^{c}	0.499±0.006	158.596±18.246^{a}	193.091±18.495^{a}	24.029±0.718^{a}	257.734±11.557^{b}	6.503±0.021^{a}	4.303±0.032	12.422±0.059^{a}
OH	20.138±0.546^{a}	0.455±0.0103^{b}	724.638±5.797^{b}	547.224±9.011^{b}	45.685±2.424^{b}	147.962±10.739^{a}	8.504±0.052^{c}	4.700±0.024^{a}	13.881±0.181^{c}

The values not sharing the same letter are significantly different (Duncan's test) at $P < 0.05$ probability level.

A comparative analysis of the biochemical constituents across various strains of *Actinidia deliciosa* (Allison, New Hayward, and Old Hayward) revealed notable differences. Carbohydrate and protein levels were highest in the New Hayward (NH) strain compared to Old Hayward (OH) and Allison (All). Conversely, phenolics, tannins, flavonoids, and ascorbic acid were more abundant in the Allison strain than in NH and OH. The Old Hayward strain exhibited the highest levels of fat, crude fiber, and reducing sugars **Table 4**.

The analysis of various biochemical components across the different samples revealed distinct nutritional characteristics. Carbohydrate levels ranged from 20.138± 0.546 g/100g in OH to 28.755± 0.590 g/100g in NH, with NH showing the highest carbohydrate content. Reducing sugars ranged from 12.42±0.059 g/100g in NH to 13.88±0.181 g/100g in OH, reflecting similar sweetness profiles. Protein content was generally low, varying from 0.3483±0.004g/100g in OH to 0.4998±0.006 g/100g in NH.

Phenolics, or polyphenols, are indeed secondary plant metabolites that are universally present in plants and their derived products [26]. Studies show that polyphenols when consumed in a dose of 1 gm/ day show antiproliferative effects in humans.[27] Phenols are having free radical scavenging activity because of hydroxyl group [28]. Tannis show antioxidants properties and prevents tissue damaging by neutralizing the free radicals [29,30]. Tannins have been known since long time as the astringent, having the capacity to combine with tissue proteins and precipitate them [31]. In current study, phenolic compounds and tannins displayed a wide range of values, with the highest concentrations found in the All sample (751.3±83.478mg/100g for phenolics and

638.16±24.824mg/100g for tannins), while NH had the lowest.

Flavonoids are also important compounds in plants and their products. It has been reported that the flavonoid possesses antioxidant properties and was found to be useful in the treatment of liver damage, human health and fitness. The antioxidant properties of flavonoids depend on their unique structural capability of scavenging the free radicals [32,33]. The flavonoids were most abundant in All (74.12±3.113 mg/100g) and lowest in NH (24.02±0.718 mg/100g), suggesting that All may be a stronger source of antioxidants.

Ascorbic acid, also known as Vit C, is indeed a naturally occurring antioxidant compound that's widely distributed in various plant-based foods like fruits, grains, nuts and vegetables. It performs several biochemical and physiological actions as it acts as a reducing agent due to its electron donating nature. It is a powerful antioxidant with water soluble nature [32]. We found the highest content of ascorbic acid in All (442.91± 21.090 mg/100g) and was lowest in OH (147.96± 10.739 mg/100g). In view of the above study, both strains, Allision and Haywards are potentially rich in antioxidant compounds, emphasizing their antioxidant, antimicrobial, and anti-inflammatory potential, with Allison exhibiting the highest levels of phenolics, tannins, flavonoids, and ascorbic acid, reflecting its potent antioxidant activity as compared to Haywards strains. This study is supported by [33].

Crude fiber is of two types: soluble and insoluble. They have good swelling properties, which depend on their porosity, shape, size, water retention ability, and viscosity. They are liable for fermentation. They are broken down into short-chain fatty acids, which provide health benefits [34]. In a study, fiber content ranged from 6.5±0.02% in NH to 8.5±0.05% in OH, with OH having the highest fiber content. Similarly, Deman has reported 5.99% crude fibre in freeze-dried kiwi samples.[35] Fat levels were minimal, with NH at 4.3±0.03% and OH at 4.7±0.02%, consistent with previous reports on low-fat content.

Overall, these results align with earlier studies and highlight variability in biochemical content across different samples, with specific samples, such as All, demonstrating higher antioxidant potential. Similar studies revealed that kiwi fruit extracts exhibit a notable antioxidant profile, characterized by total phenolic content (6.27±0.43 mg GAE), total flavonoids (1.89±0.22 mg CE), flavanols (130±6.17 μg CE), and vitamin C (4.07±0.25 mg AA) [36]. The total phenolic content in four kiwi varieties ranging from 160.34±2.30 to 220.20±1.13 mg GAE/100 g FW and flavonoid content ranging from 40.57±0.16 to 49.08±0.14 mg GAE/100 g FW [37]. In another study it was highlighted that nutritional benefits of kiwi, noting total phenolic content of 258.55mg/100g, indicating strong antioxidant properties for combating oxidative stress and inflammation. Additionally, a crude fiber content of 11.22% supports digestive health and may aid in weight management and cholesterol reduction, while 3.7mg/100g of dietary fiber enhances gastrointestinal function. The flavonoid level of 1.68 mg/100g and ascorbic acid content of 15.52 mg/100g further reinforce kiwi's role as a nutrient-dense fruit, offering anti-inflammatory, cardiovascular, and immune support benefits. Together, these findings emphasize the health-promoting potential of kiwi fruit.

Antioxidant Activity: The DPPH and ABTS methods are among the most commonly used techniques for assessing the in-vitro FRSA of plants and their components. In these methods, DPPH and ABTS act as free radicals and are neutralized by antioxidant compounds such as total phenolics, total tannins, and ascorbic acid. The study evaluated the antioxidant potential of Kiwi samples based on free radical scavenging activity, using IC50 as the parameter. IC50 represents the concentration (quantity per microliter) of antioxidant components required to achieve 50% neutralizing of DPPH and ABTS free radicals Table 5a.

Table 5a: Antioxidant activity as FRSA

Sample Name	**% Inhibition**		**IC 50 (mg/mL)**	
	DPPH	**ABTS**	**DPPH**	**ABTS**
Allison	79.90	75.12	2.993	3.613
New Hayward	44.03	42.08	4.561	5.294
Old Hayward	57.21	53.71	3.743	4.154

The maximum antioxidant activity as percentage inhibition (79.9% and 75.12%) was found in the Allison sample of Kiwi as determined by DPPH and ABTS methods, respectively. Similarly, the minimum IC50 value was reported in Allison samples as compared with Hayward samples of Kiwi fruits.

All extracts showed the highest antioxidant activity, with 79.90% inhibition in the DPPH assay (IC_{50} = 2.993 mg/mL) and 75.12% inhibition in the ABTS assay (IC_{50}= 3,613 mg/mL). This was followed by the OH extract, which demonstrated moderate activity with 57.21% (DPPH, IC_{50}= 3.743 mg/mL) and 53.71% (ABTS, IC_{50}= 4.154 mg/mL). The NH extract exhibited the lowest activity with 44.03% inhibition in the DPPH assay (IC_{50}= 4.561 mg/mL) and 42.08% inhibition in the ABTS assay (IC_{50}= 5.294 mg/mL). Antioxidant profiling using DPPH and ABTS methods for different varieties of Kiwi varieties was given in Table 5b and 5c below.

Table 5b Antioxidant activity as % inhibition by DPPH Method

Vol (ul)	**Allison (1g/40 ml)**	**New Hayward (1g/40 ml)**	**Old Hayward (1g/40 ml)**
	% Inhibition	% Inhibition	% Inhibition
0	0.0	0.0	0.00
50	26.59	19.20	22.63
100	35.34	24.94	26.77
150	44.32	33.74	43.38
200	63.59	38.77	47.63
250	79.90	44.03	57.21

Table 5c Antioxidant activity as % inhibition by ABTS Method

Vol (ul)	**Allison (1g/40 ml)**	**New Hayward (1g/40 ml)**	**Old Hayward (1g/40 ml)**
	% Inhibition	**% Inhibition**	**% Inhibition**
50	15.02	11.45	15.94
100	23.31	19.86	25.10
150	45.59	32.00	38.86
200	64.24	37.13	46.40
250	75.12	42.08	53.71

The strong antioxidant properties of *Actinidia deliciosa* L. (kiwifruit), highlighted by IC50 values 48.55 µg/mL for DPPH• and 77.00 µg/mL for ABTS•+ radicals, demonstrating its ability to effectively neutralize free radicals. Similarly, reported the antioxidant capacity of the Hayward kiwi species, with ABTS and DPPH assay values of 20.42 ± 1.17 µM TE and 12.45 ± 1.12 µM TE, respectively, the methanolic extracts of *A. deliciosa* fruits exhibited significant free radical scavenging activity due to bioactive compounds like alkaloids, glycosides, terpenoids, vitamins, and other constituents. Additionally, A study shows that Kiwi fruit has a rich antioxidant profile similar findings were also observed by [38,39,40 41,42].

Conclusion: The comparative analysis of morphological, phytochemical, and nutritional attributes of two kiwifruit varieties (Allison and Hayward) and the age of the orchard (New & Old Hayward highlighted distinct varietal differences in growth, composition, and bioactive properties. Old Hayward exhibited superior fruit size, weight, and edible inner fruit proportion, whereas Allison stood out for its elongated shape, highest moisture content, and tangier flavor profile. New Hayward displayed the highest carbohydrate and protein content, making it nutritionally dense. Phytochemical screening revealed consistent bioactive compounds across all strains, emphasizing their antioxidant, antimicrobial, and anti-inflammatory potential, with Allison exhibiting the highest levels of phenolics, tannins, flavonoids, and ascorbic acid, reflecting its potent antioxidant activity. Fiber and fat contents were low across the board, aligning with typical kiwifruit profiles. Collectively, these findings underscore the unique attributes of each strain, suggesting diverse applications: Old Hayward for its robustness and storage potential, Allison for fresh consumption and therapeutic value, and New Hayward for higher nutritional content, paving the way for targeted utilization in both fresh and processed forms.

Conflicts of Interest: No conflicts of interest

Funding Support: This research was supported by a grant from the Defence Institute of Bio-Energy Research (DIBER), DRDO.

Acknowledgement: Authors are thankful to OIC IVRI, Mukteshwar, for providing samples of Kiwi fruits for the study.

Registration number of clinical trials: NA

REFERENCES

1. Arya RKK, Kumar P, Singh A, Rana M, Rana AJ, Kumar A. Coenzyme Q: an endogenous antioxidant. In: Nabavi SM, Silva AS, editors. *Antioxidants Effects in Health*. Elsevier; 2022. p. 91-104. doi:10.1016/B978-0-12-819096-8.00023-9.
2. Rotariu D, Babes EE, Tit DM, Moisi M, Bustea C, Stoicescu M, et al. Oxidative

stress–complex pathological issues concerning the hallmark of cardiovascular and metabolic disorders. *Biomed Pharmacother*. 2022;152:113238. doi:10.1016/j.biopha.2022.113238.

3. Reddy VP. Oxidative stress in health and disease. *Biomedicines*. 2023;11:2925. doi:10.3390/biomedicines11112925.
4. Rice-Evans CA, Miller NJ, Paganga G. Structure antioxidant activity relationships of flavonoids and phenolic acids. *Free Radic Biol Med*. 1996;20:933-956.
5. Prior RL, Cao G. Variability in dietary antioxidant-related natural product supplements: the need for methods of standardization. *J Am Nutraceutical Assoc*. 1999;2:46-56.
6. Shafras M, Sabaragamuwa R, Suwair M. Role of dietary antioxidants in diabetes: an overview. *Food Chem Adv*. 2024;4:100666. doi:10.1016/j.focha.2024.100666.
7. Ward C, Courtney D. Kiwifruit: taking its place in the global fruit bowl. *Adv Food Nutr Res*. 2013;68:1-14.
8. Marcellán O, Briguglio M, Irastorza J, Godoy C, Murcia M. Actinidia interspecific hybrids: valuable resources for the selection and breeding of kiwifruit rootstocks. *J Appl Hortic*. 2022;24(1):3-8.
9. Sharma L, Neizohunuo. Physico-chemical characterization of kiwifruit grown in different parts of India. *J Appl Hortic*. 2025;27(1):89-93.
10. Wei FW, Heng TC, Lu LL, Xue MX, Feng LH, Yuan ZD. Chemical constituents from the root of *Actinidia deliciosa*. *Chin J Nat Med*. 2010;8(4):247-249.
11. Tyagi S, Nanher AH, Sahay S, Kumar V, Bhamini K, Nishad SK, et al. Kiwifruit: health benefits and medicinal importance. *Rashtriya Krishi*. 2015;10(2):98-100.
12. Witham FH, Blaydes DF, Devlin RM. *Experiments in Plant Physiology*. New York: Van Nostrand; 1971.
13. World Health Organization. *Quality Control Methods for Medicinal Plant Material*. Geneva: WHO; 1998. p.115.
14. Sofowora A. *Medicinal Plants and Traditional Medicine in Africa*. New York: John Wiley and Sons; 1982. p.256.
15. Abdullahi II, Abdullahi N, Abdu AM, Ibrahim AS. Proximate, mineral and vitamin analysis of fresh and canned tomato. *Biosci Biotechnol Res Asia*. 2016;13(2):1163-1169. doi:10.13005/bbra/2147.
16. Guglani A, Pandey HK, Arya RKK, Bala M. In vitro antioxidant activity, total phenolic, flavonoid and tannin contents in *Ajuga bracteosa* Wall. ex Benth grown at middle hill climatic condition of Western Himalayas. *Def Life Sci J*. 2020;5(3):198-203.
17. Meena H, Bhallabh B, Arya S, Bala M. Evaluation of phytochemicals, antioxidant property and effects of *Cichorium intybus* cultivated at foothill area of Uttarakhand on hyperglycemic rats. *IP Int J Compr Adv Pharmacol*. 2022;7(1):54-64. doi:10.18231/j.ijcaap.2022.010.
18. Maynard AJ. *Methods in Food Analysis*. New York: Academic Press; 1970. p.176.
19. Hatano T, Edamatsu R, Mori A, Fujita Y, Yasuhara E. Effect of tannins and related polyphenols on superoxide anion radical and on DPPH radical. *Chem Pharm Bull*. 1988;37:2016-2037.
20. Meena H, Pandey HK, Pandey P, Arya MC, Ahmed Z. Evaluation of antioxidant activity of two important memory enhancing medicinal plants *Bacopa monnieri* and *Centella asiatica*. *Indian J Pharmacol*. 2012;44(1):114-121.
21. Al-Kawaz HS, Al-Mashhady LA. Evaluation of the phytochemical constituents and oxidant-antioxidant status for *Actinidia deliciosa* extracts. *Int J Pharm Ther*. 2016;7(1):35-36.
22. Krokida M, Karathanos VT, Maroulis ZB. Effect of freeze-drying conditions on shrinkage and porosity of dehydrated agricultural products. *J Food Eng*. 1998;35(4):369-380.
23. Fourie CP, Hansmann FC. Nutritional benefits of kiwifruit. *N Z J Crop Hortic Sci*. 1992;20:449-452.
24. Food Safety and Standards Authority of India. *Training Manual for Food Safety Regulators. Vol 1: Introduction to Food and Food Processing*. New Delhi: FSSAI; 2006.

25. Padayatty SJ, Katz A, Wang Y, Eck P, Kwon O, Lee JH, et al. Vitamin C as an antioxidant: evaluation of its role in disease prevention. *J Am Coll Nutr*. 2003;22:18-35.
26. Tanaka M, Kuei CW, Nagashima Y, Taguchi T. Application of antioxidative Maillard reaction products from histidine and glucose to sardine products. *Nippon Suisan Gakkaishi*. 1998;54:1409-1414.
27. Minussi RC, Rossi M, Bologna L, Cordi L, Rotilio D, Pastore GM, et al. Phenolic compounds and total antioxidant potential of commercial wines. *Food Chem*. 2003;82:409-416.
28. Shon MY, Kim TH, Sung NJ. Antioxidants and free radical scavenging activity of *Phellinus baumii* extracts. *Food Chem*. 2003;82:593-597.
29. Ansell J, Parkar S, Paturi G, Rosendale D, Blatchford PA. Modification of the colonic microbiota. In: Boland M, Moughan PJ, editors. *Nutritional Benefits of Kiwifruit*. *Adv Food Nutr Res*. 2013;68:205-217.
30. Raja RR, Sreenivasulu M. Drugs containing tannins—an overview. *Indo Am J Pharm Res*. 2016;6:5610-5621.
31. Ullah A, Munir S, Badshah SL, Khan N, Ghani L, Poulson BG, et al. Important flavonoids and their role as a therapeutic agent. *Molecules*. 2020;25(22):5243.
32. Li M, Qian M, Jiang Q, Tan B, Yin Y, Han X. Evidence of flavonoids on disease prevention. *Antioxidants*. 2023;12(2):527.
33. Pal RS, Kumar AV, Arora S, Sharma AK, Kumar V, Agrawal S. Physicochemical and antioxidant properties of kiwifruit as a function of cultivar and fruit harvested month. *Braz Arch Biol Technol*. 2015;58(2):262-271.
34. Deman MJ. *Principles of Food Chemistry*. 3rd ed. New York: Springer; 2004.
35. Kim YM, Park YS, Park YK, Ham KS, Kang SG, Barasch D, et al. Phytochemical analysis of two main varieties of persimmon and kiwifruit and their antioxidative and quenching capacities. *Eur Food Res Technol*. 2020;246:1259-1268.
36. Saeed KM, You LJ, Chen C, Zhao ZG, Fu X, Liu RH. Comparative assessment of phytochemical profiles and antioxidant and antiproliferative activities of kiwifruit (*Actinidia deliciosa*) cultivars. *J Food Biochem*. 2019;43(11):e13025.
37. Shehata MSM, Soltan SS. Effects of bioactive component of kiwi fruit and avocado (fruit and seed) on hypercholesterolemic rats. *World J Dairy Food Sci*. 2013;8(1):82-93.
38. Ozden EM, Bingol Z, Mutlu M, Karagecili H, Köksal E, Goren AC, et al. Antioxidant, antiglaucoma, anticholinergic, and antidiabetic effects of kiwifruit (*Actinidia deliciosa*) oil: metabolite profile analysis using LC-HR/MS, GC/MS and GC-FID. *Life*. 2023;13(9):1939.
39. Qadir A, Khan N, Ullah SNMN, Ali A, Gupta DK, Khan SA. GC-MS analysis of phytoconstituents present in methanolic extract of *Actinidia deliciosa* fruits and its antioxidant activity. *J Indian Chem Soc*. 202.
40. Park YS, Jung ST, Kang SG, Drzewiecki J, Namiesnik J, Haruenkit R, et al. In vitro studies of polyphenols, antioxidants and other dietary indices in kiwifruit (*Actinidia deliciosa*). Int J Food Sci Nutr. 2006;57(1-2):107-122.
41. Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radic Biol Med. 1999;26(9-10):1231-1237.
42. Zhang J, Tian J, Gao N, Gong ES, Xin G, Liu C, et al. Assessment of the phytochemical profile and antioxidant activities of eight kiwi berry (*Actinidia arguta* (Siebold & Zucc.) Miquel) varieties in China. Food Sci Nutr. 2021;9(10):5616-5625.