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Bioactive and Antioxidant Properties of Kiwano (*Cucumis metuliferus*) Cultivated in Antalya

Civan ÇELİK[1], Berna ÇELİK[2], Ayşen Melda ÇOLAK[3]

[1]Isparta University of Applied Sciences, Faculty of Agriculture, Department of Agricultural Biotechnology, Isparta, Türkiye
[2]Isparta University of Applied Sciences, Faculty of Agriculture, Department of Horticulturae, Isparta, Türkiye
[3]Uşak University, Faculty of Agriculture, Department of Horticulturae, Uşak, Türkiye

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Corresponding Author
Civan Çelik
civancelik@isparta.edu.tr

Author ORCID
[1]https://orcid.org/0000-0002-1696-5902
[2]https://orcid.org/0000-0001-8620-6031
[3]https://orcid.org/0000-0003-0113-2104

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Abstract

Cucumis metuliferus (commonly known as kiwano or horned melon) is a member of the *Cucurbitaceae* family, which has attracted increasing scientific interest due to its nutritional value and bioactive compounds. In recent years, growing attention has been directed toward identifying natural sources of antioxidants and phytochemicals that contribute to human health and disease prevention. Although kiwano has been traditionally consumed in certain regions, scientific data on its biochemical composition and functional properties remain limited. This study was conducted to determine certain biochemical properties of Kiwano (*Cucumis metuliferus*) fruit. Analyses were performed on samples grown under the ecological conditions of Kumluca district, Antalya province. The results revealed that the fruit is particularly rich in phenolic compounds, flavonoids, and chlorophyll. The obtained data indicated high levels of total phenolic content, total flavonoid content and phenolic compounds, which were considered to contribute directly to the antioxidant capacity of the fruit. The antioxidant activity was further supported by in vitro assays such as 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging, lipid peroxidation inhibition, and reducing power tests. Additionally, the measured amounts of chlorophyll a and b demonstrated that photosynthetic pigments were preserved at certain levels in the fruit, depending on its maturity stage Overall, the findings suggest that Kiwano fruit possesses a rich content of biologically active compounds and has the potential to be considered as a functional food.

Keywords: Horned melon, *Cucumis metuliferus*, Biochemical composition, Nutritional value, Alternative fruits

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INTRODUCTION

The *Cucurbitaceae* family has gained increasing scientific and societal significance in recent years, in parallel with the rising global interest in plant-based diets and functional foods. The growing tendency of individuals to adopt plant-based dietary patterns, along with the increasing demand for natural, nutrient-dense foods, has contributed to the prominence of cucurbits within contemporary nutritional models. Furthermore, the expanding popularity of functional foods, which not only meet basic nutritional requirements but also provide additional health benefits, has further underscored the potential of cucurbits in disease prevention and health maintenance (Rolnik and Olas, 2020; Borecka and Karaś, 2025). Kiwano fruit (*Cucumis metuliferus*) is a tropical fruit belonging to the *Cucurbitaceae* family that is notable for its striking appearance, high adaptability to arid climates, natural resistance to diseases and long shelf life (National Research Council [NRC], 2008; Šeregelj et al., 2022). It is regarded as a promising alternative agricultural product in the fight against climate change, particularly due to its low water requirement and its capacity to thrive in harsh environmental conditions. While this species, native to the southern half of Africa, naturally occurs in the wild, it is now cultivated on a commercial scale in countries including New Zealand, Israel, the United States and the Mediterranean basin, particularly in the Antalya (Kumluca, Alanya) and Manisa provinces of Türkiye (Lim, 2012; Šeregelj et al., 2022). However, up-to-date and comprehensive production data for this species are scarce; therefore, the absence of reliable statistics should be explicitly acknowledged when such data are unavailable. In the context of Türkiye, kiwano is still a novel and scarcely cultivated species. The ecological conditions of the Mediterranean region, particularly Antalya and its surroundings, are considered suitable for its cultivation, suggesting that the crop may contribute to agricultural diversification and offer alternative economic opportunities.

Moreover, considering its richness in bioactive compounds and its potential as a functional food, the introduction and evaluation of kiwano cultivation in Türkiye hold both scientific and economic significance (Owino et al., 2020).

The kiwano is also referred to by a number of alternative names, including "prickly melon", "African horned melon", "gel melon" and "English tomato". It is regarded as one of the species with the highest agricultural potential within its family (NRC, 2008). The fruit is rich in vitamin C (ascorbic acid), vitamin A and B group vitamins, which are important in human nutrition (Šeregelj et al., 2022; Borecka and Karaś, 2025; Sebati et al., 2025). The edible pulp contains high levels of vitamins, as well as essential minerals such as calcium, potassium and magnesium, while the rind contains vitamins E, D and K, and various micronutrients such as folic acid, thiamine and riboflavin. The majority of these compounds have been demonstrated to possess antioxidant properties and function as coenzymes within metabolic processes (Šeregelj et al., 2022).

Kiwano is rich in nutrients and contains enough components to meet approximately 18% of the daily vitamin C requirement, 6% of vitamin A, 7% of vitamin B6, 21% of magnesium, 13% of iron, 8% of phosphorus and 3% of calcium (Mwanza et al., 2023). It has been determined that it has higher values, especially in terms of protein, compared to many fresh fruits (Mwanza et al., 2023). The fruit has also been reported to have antimicrobial, antiviral, antihypertensive, antidiabetic, antifungal and antioxidant effects, which are attributed to the presence of phenolic compounds and vitamins (Matsusaka and Kawabata, 2010; Usman et al., 2015; Vieira et al., 2020). In the contemporary era, there is a discernible upsurge in the interest surrounding alternative plant production resources within the overarching paradigm of sustainable agricultural practices. In this regard, it is imperative to investigate unique species that exhibit high climatic adaptability, are rich in nutritional value and possess significant commercial potential (Kassam and Kassam, 2021).

The objective of this study is to ascertain the biochemical properties (total phenolic matter, total flavonoid content, total antioxidant activity, chlorophyll and phenolic compounds) of kiwano fruit cultivated in the ecological conditions of the Kumluca district of Antalya province. The study also aims to reveal the agricultural potential of this species on a scientific basis. The extant literature on kiwano fruit has predominantly concentrated on the peel and seed, with a paucity of biochemical content studies, particularly in the context of fruit juice.

MATERIALS AND METHODS

Materials

The *C. metuliferus* (kiwano) fruits used in this study were obtained from a greenhouse located in the Kumluca district of Antalya province in the Mediterranean region of Türkiye (Figure 1). Harvesting was conducted when the fruits reached optimal commercial ripeness, defined as the stage at which the exterior skin turns yellow-orange and the fruit structure becomes suitable for consumption. In order to ensure homogeneity in the procurement of plant material, a total of 20 fruits were selected using a random sampling method from plants grown at different points of the greenhouse.

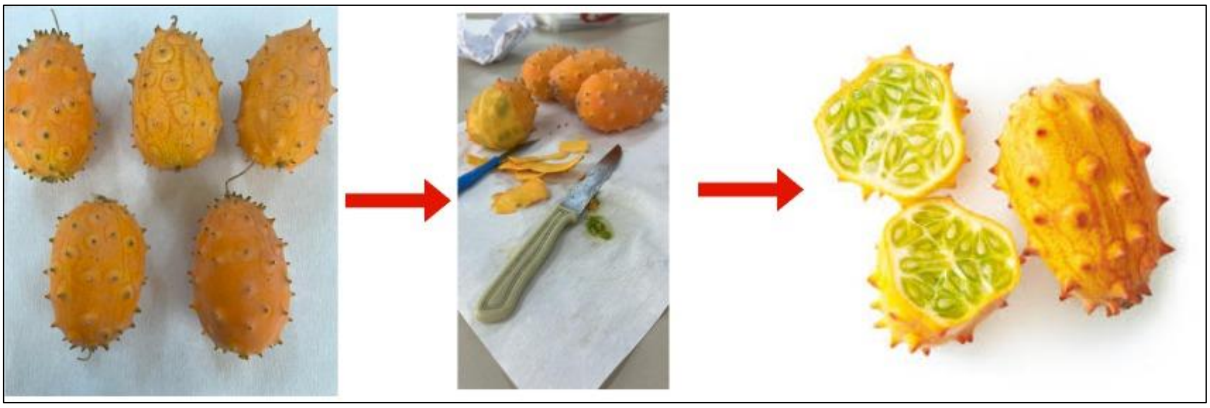

Figure 1. Morphology of kiwano fruit.

Methods

Total phenolic content (mg GAE/100 g) was determined according to the method described by Velioglu et al. (1998). Samples extracted with 60% ethanol were analysed using the Folin-Ciocalteu spectrophotometric method at a wavelength of 765 nm. The results were expressed as mg GAE/100 g.

Total flavonoid content was determined according to the method described by Dewanto et al. (2002). The samples extracted with 60% ethanol were analysed at a wavelength of 510 nm using the procedure specified by the researchers. The results were expressed as mg catechin/100 g.

Total antioxidant activity (mmol TE/g) was determined according to the method described by Kumaran and Karunakaran (2007). Samples extracted with 60% ethanol were analysed at a wavelength of 517 nm using the procedure specified by the researchers. The results were expressed as mmol TE/g.

Chlorophyll a, chlorophyll b and total chlorophyll (mg/100 g) analyses were carried out according to the method described by Sibley et al. (1996). In-fruit samples extracted with dimethylformamide (DMF) were read at wavelengths of 664 and 647 nm and the results were calculated using the formula provided by the researchers. The results were expressed as mg/100 g.

The phenolic compounds present in fresh kiwano fruits harvested at commercial ripeness were analysed using a High Performance Liquid Chromatography (HPLC) (Shimadzu, Japan) (Artik et al., 1998). An extraction solution consisting of 80% methanol, 20% water and 1% hydrochloric acid (HCl) was prepared. The fruit was pitted and homogenised, and 10 g of the sample was mixed with 20 ml of the extraction solution and 0.1 g of butylated hydroxytoluene (BHT). The mixture was then filtered and evaporated at 40 °C. The resulting residue was then injected into the HPLC system to analyse the levels of catechin, p-hydroxybenzoic acid, chlorogenic acid and caffeic acid. The results were expressed as micrograms per gram of fresh weight (µg/g FW).

Statistical analysis

The data obtained were analysed using the Minitab.17 software package (Newton, 2014). Basic descriptive statistics were calculated using the 'Basic Statistics' command.

RESULTS AND DISCUSSION

This study determined the total phenolic and total flavonoid contents of kiwano (*C. metuliferus*) fruit harvested at commercial maturity to be 76.47 mg GAE/100g and 151.39 mg CE/100g, respectively. The total antioxidant capacity, determined in terms of Trolox equivalents, was found to average 265.29 mmol TE/g. These values suggest that the fruit has a high antioxidant capacity. The fruit's chlorophyll a and chlorophyll b content was found to be 0.84 mg/100g and 6.43 mg/100g, respectively, with a total chlorophyll content of 7.27 mg/100g (see Table 1). The presence of these pigments lends credence to the nutritional and functional properties of kiwano fruit.

Phenolic compound analysis revealed that catechin was the dominant compound in the fruit, with an average content of 6,180.15 µg/g fresh weight (FW). This was followed by epicatechin (1,864.61 µg/g FW) and gallic acid (448.03 µg/g FW). Among the hydroxycinnamic acid derivatives, p-coumaric acid, caffeic acid, chlorogenic acid and trans-ferulic acid were present at concentrations of 126.21, 57.11, 77.53 and 43.06 µg/g FW, respectively. The significant levels of these compounds in the fruit support its potential as a functional food. Among the flavonoid compounds, rutin, quercetin and kaempferol were detected at average levels of 37.35, 5.04 and 5.79 µg/g FW, respectively. Additionally, the triterpene compounds oleanolic acid and ursolic acid were found at levels of 571.82 and 536.27 µg/g fresh weight (FW), respectively (Table 1).

Table 1. Phytochemical composition of kiwano pulp

Variable	Mean±StDev	SE Mean±StDev*	Mean	Maximum	Coef Var
Gallic acid (µg/g)	427.2±1.80	10.40±1.80	448	459.20	4.03
Catechin (µg/g)	5879.36±2.78	160.00±2.78	6180	6427.54	4.49
Epicatechin (µg/g)	1738.47±1.94	112.00±1.94	1865	2088.41	10.42
Chlorogenic acid (µg/g)	75.42±1.86	1.07±1.86	77.53	78.92	2.4
Caffeic acid (µg/g)	52.64±4.31	2.49±4.31	57.11	61.23	7.54
p-Coumaric acid (µg/g)	124.45±1.54	0.89±1.54	126.21	127.32	1.22
trans-ferulic acid (µg/g)	36.76±5.92	3.42±5.92	43.06	48.51	13.75
Rutin (µg/g)	35.46±1.96	1.13±1.96	37.35	39.38	5.26
Quercetin (µg/g)	3.54±1.34	0.77±1.34	5.043	6.13	26.66
Kaempferol (µg/g)	5.13±0.59	0.34±0.59	5.793	6.29	10.32
Oleanolic acid (µg/g)	545.8±28.50	16.50±28.50	571.8	602.30	4.99
Ursolic acid (µg/g)	529.45±6.22	3.59±6.22	536.27	541.64	1.16
Total phenolic content(mg GAE/100g)	72.73±5.30	3.06±5.30	76.47	82.53	6.93
Total flavonoid content (mg CE/100g)	148.08±3.91	2.26±3.91	151.39	155.70	2.58
Total antioxidant (mmol TE/g)	259.81±4.74	2.74±4.74	265.29	268.02	1.79
Chlorophyll a (mg/100g)	0.65±0.17	0.09±0.17	0.8433	0.98	20.3
Chlorophyll b (mg/100g)	5.97±0.65	0.37±0.64	6.426	7.16	10.04
Chlorophyll a+b (mg/100g)	6.86±0.49	0.28±0.49	7.265	7.81	6.76

***SE**: Standard Error, **StDev**: Standard Deviation

Phenolic compounds constitute the most important antioxidant groups of kiwano fruit. Šeregelj et al. (2022) reported that the total phenolic content in fruit pulp was in the range of 47.2-200 mg GAE/100g dry matter, and these values could be as high as 500 mg GAE/100g in peel and 400 mg mg GAE/100g in seed. In the same study, it was reported that 49% of the total phenolic content in the peel and 79% in the pulp consisted of flavonoid compounds. Micu and Popoviciu (2024) reported 51,751 mg/kg total phenolic content in pulp and 37,624 mg/kg total phenolic content in peel of Tempus cultivar. These data reveal that phenolic content levels in peel and pulp may vary according to the sample investigated. Ani et al. (2022) reported phenol content in kiwano peel as 261.73 ± 13.54 mg GAE/100g dry matter and flavonoid content as 130.86 ± 9.66 mg GAE/100g dry matter. The data obtained in this study clearly demonstrated that phenolic compounds have high antioxidant potential. Rodica S et al. 2024 also found total phenol content in kiwano fruits ranging from 29.62 to 48.78 mg GAE/100g. The total phenol content of fresh *C. metuliferus* juice was 14.424 mg/L (Mester et al., 2019), 18.97 mg GAE/mL; (Busuioc et al., 2020).According to the reports of Ferrara (2018), the horned melon pulp contains lower levels of flavonol aglycones (myricetin and quercetin) and high amounts of flavonol glycosides (rutin). Busuioc et al. (2020) investigated the chemical composition of horned melon fresh juice cultivated in Romania. According to these authors, the horned melon juice contains a large number of triterpenes and significant amounts of both polyphenols and flavonoids. The main metabolites were catechin (928.74 mg/kg), followed by oleanolic (347.67 mg/kg) and ursolic acids (193.92 mg mg/kg). Catechin is a flavonoid that presents a high antioxidant activity in living systems, while ursolic acid is known for its activity against HIV-1 protease, which is a homodimeric enzyme (Busuioc et al., 2020). Other phytochemicals occurring at noteworthy levels in horned melon juice were rutin (33.78 mg/kg), kaempferol-3-glucoside (19.61 mg/kg), epicatechin (17.66 mg/kg), p-coumaric acid (6.99 mg/kg), quercetin (5.96 mg/kg), gallic acid (5.76 mg/kg), caffeic acid (5.56 mg/kg), neochlorogenic acid (4.68 mg/kg), kaempferol (4.32 mg/kg), and quercetin-3-d-galactoside (2.35 mg/kg) (Šeregelj et al., 2022). Carotenoids are less abundant than other bioactive compounds in horned melon pulp (88 µg β-carotene/100g dw) (USDA, 2021).

The antioxidant activity by DPPH ranged from 93.8 µM TE/100g (fruit harvested at the ripe stage) to 140.9 µM TE/100g (fruit harvested at the immature stage) and from 71.78 µM AsA/100g (fruit harvested at the immature stage) to 103.0 µM AsA/100g (fruit harvested at the ripe stage) (Rodica et al. 2024). As posited by Olja et al. (2022), the DPPH activity was found to range between 60.13 and 85.81 µmol TE/100g. Concurrently, the total chlorophyll content in kiwano pulp was determined to be within the range of 4.23-5.06 mg/100g. The value was then divided into chlorophyll a (~1.41 mg/100g) and chlorophyll b (~2.78 mg/100g). It was thus determined that the level of chlorophyll b was higher than that of chlorophyll a.

Although the obtained data were largely consistent with the values reported in the existing literature, discrepancies were observed in the levels of certain phenolic compounds depending on the source of the sample and the analysis method used. For instance, while certain studies have reported higher levels of phenolic content in the peel and pulp, our study demonstrated a significant antioxidant effect, although the analysis of the fruit flesh was more limited. Furthermore, the levels of chlorophyll and triterpene compounds were found to be consistent with the data reported in the existing literature.

CONCLUSION

In this study, *C. metuliferus* (kiwano) fruit harvested at commercial maturity was found to have a phytochemical composition rich in phenolic compounds, flavonoids, pigments and antioxidant capacity. The high antioxidant potential of the fruit is particularly supported by the presence of phenolic compounds, including catechin, epicatechin, gallic acid, and flavonoids, such as rutin, quercetin, and camferol. Furthermore, the presence of significant levels of pigments such as chlorophyll a and b in the fruit serves to increase its importance as both a nutritious and functional food. A comparative analysis of the literature revealed that the quantities of bioactive compounds present in the fruit may be subject to variation depending on the growing conditions, maturity level, and the analysis methods employed. In this context, kiwano fruit is of particular interest as a functional food and natural antioxidant source, owing to its nutritional properties and positive effects on health.

Compliance with Ethical Standards
Peer Review
This article has been reviewed by independent experts in the field using a rigorous double-blind peer review process.
Conflict of Interest
The authors declare no conflicts of interest.
Author Contributions
All authors contributed equally to the study design, data collection, analysis, and manuscript preparation.
Ethics Committee Approval
Ethical approval was not required for this study.
Consent to Participate / Publish
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Data Availability
Not applicable.

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