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RESEARCH ARTICLE

Comparative assessment of nutritional composition, mineral profiling and therapeutic potential of leaf extracts from different mango cultivars

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Abstract

The mango (*Mangifera indica* L.), an economically significant tropical fruit, is widely valued for its nutritional, flavor and health benefits. While mango fruit is consumed extensively, other parts of the mango tree, such as leaves, are rich in bioactive compounds and hold untapped therapeutic potential. This study conducts a comparative analysis of the bioactive properties in the leaf extracts of ten mango cultivars (Surangudi, Fatkiri, Kalepad, Banganappalli, Imampasand, Malgoa, Peter, Neelam, PKM - 1, Kottur sinnarasam) from Tamil Nadu, India, to evaluate their antioxidant and antidiabetic activities. Fresh leaves were collected and processed using cold maceration for crude extraction, with their morphological traits, nutrient profiles and bioactive compound concentrations examined. Key compounds, including polyphenols and flavonoids, were quantified using standard methods to assess their total phenolic content (TPC) and total flavonoid content (TFC), with Malgoa and Imampasand showing higher concentrations. The antioxidant activity of the leaf extracts was determined via DPPH and superoxide radical scavenging assays, where Malgoa exhibited superior radical scavenging properties. Additionally, the antidiabetic potential was assessed by measuring α-glucosidase enzyme inhibition, with Malgoa and Imampasand demonstrating potent inhibition, suggesting their utility in managing diabetes. These findings emphasize the potential of mango leaves as a source of functional ingredients with health-promoting properties, supporting sustainable use of agricultural byproducts and the valorization of underutilized mango cultivars for therapeutic applications. This study highlights the significant bioactive diversity among cultivars, with implications for breeding programs aimed at enhancing mango's health benefits.

Keywords

antioxidant potential; macro and micro nutrients; *Mangifera indica*; phytochemicals

Introduction

The mango (*Mangifera indica* L.), a tropical fruit belonging to the Anacardiaceae family, is thought to have evolved 5000 years ago in the Indo-Burma region, which stretches from eastern India, Myanmar, Bangladesh and Southeast Asia. The global mango production is 60.5 million metric tons (2023). India is the world's largest mango producer, with an annual production of 26.3 million tonnes from an area of 2.62 million hectares (2022-23). The fruit is mainly relished for its delicious flavor, juiciness, nutritional value and substantial economic significance (1). This delectable fruit holds a prominent position in international agricultural trade, as it is enjoyed both in its fresh form and processed into an array of products, including juices, dried slices, jams and chutneys. Mangoes are widely acknowledged for their high content of essential nutrients and vitamins, Mangoes are widely acknowledged for their high content of essential nutrients and vitamins, notably beta-carotene (a precursor of vitamin A), ascorbic acid (vitamin C), thiamine (vitamin B1), riboflavin (vitamin B2), niacin (vitamin B3) (2, 3). Additionally, mangoes are abundant in phytochemicals, bio -active compounds known for their antioxidant, anti-inflammatory, immunomodulatory effects and health-enhancing properties which have drawn the attention of researchers (4).

In addition to the delicious pulp, the mango tree yields valuable bioactive compounds in its peel, seed and leaves. These often-discarded byproducts are teeming with polyphenols, flavonoids and dietary fibers, offering antioxidant, antimicrobial and anti-inflammatory properties (4). Recent studies have refined on harnessing these components for their functional qualities, presenting potential for diverse applications in the realms of food, pharmaceuticals and cosmetics. By recognizing the untapped potential of these overlooked mango parts, this approach not only enhances resource efficiency but also plays a significant part in minimizing food waste and promoting sustainable, circular economy practices (5).

Mango leaves are regarded to be crop waste with enriched resources than have been highly esteemed in diverse cultures for their medicinal and therapeutic attributes. Recent scientific exploration has unveiled a plethora of bioactive compounds present in mango leaves, leading to a surge in scholarly attention. Abundant in polyphenols, flavonoids, terpenoids and alkaloids, mango leaves showcase a wide array of health-enhancing effects, encompassing antioxidant, anti-inflammatory, antimicrobial and antidiabetic properties (6). Traditionally, mango leaves are used to treat various ailments like respiratory disorders, urinary tract infection, skin diseases, diarrhoea, syphilis and diabetes. Bioactive constituents like mangiferin, quercetin, tocopherols, carotenoids, phenolic acid, benzophenones are some prominent contributors to various pharmacological potentialities of mango leaves (5).

There are about one thousand cultivars of mangos recorded worldwide. Unfortunately, poor propagation practices, negligence and management led to extinction of viable indigenous cultivars with efficient breeding potential. Therefore, it is crucial to focus on conserving the existing genetic resources of elite cultivars. Although there are several studies on biological efficiencies, morpho-biochemical studies related to mango extracts, but the studies on comparison of nutritional, biochemical profiling and therapeutic efficacies of different cultivars in India are scare (1).

The findings from the comprehensive review by Zarasvand et al. (7) indicate that out of 1001 animal and human studies, twenty-eight (31%) met the criteria for inclusion in research related to the antidiabetic effects of various mango components, including leaves (31%), flesh (38%), seed-kernel (7%), peel (14%), stem-bark (7%) and by-products (3%). The results support the glucose-lowering effects of mango in both animal and human studies and mechanisms for its antidiabetic actions involve the inhibition of α-amylase and α-glucosidase, enhanced antioxidant capacity, improved insulin sensitivity, increased glucose uptake and modulation of genes related to glucose transporter type 4, phosphoinositide 3-kinase and insulin receptor substrate (7). Both animal studies and randomized controlled trials suggest that mango could be a beneficial antidiabetic agent.

In consideration of the aforementioned points, this study endeavors to conduct a comprehensive comparative analysis of 10 distinct mango cultivars such as Surangudi, Fatkiri, Kalepad, Banganappalli, Imampasand, Malgoa, Peter, Neelam, PKM - 1 and Kottur Sinnarasam. The primary objective is to evaluate the bioactive potential of their leaf extracts in managing diabetes and serving as an antioxidant. Through systematic experimentation and analysis, we aim to characterize the phytochemical and nutritional composition of each cultivar's leaf extract and evaluate its efficacy in controlling diabetes and oxidative stress. Ultimately, this research provides valuable insights into harnessing the therapeutic potential of different cultivars of mango leaves in combating chronic diseases and promoting human health and well-being, as well as identifying superior cultivars to enhance breeding management.

Materials and Methods

Collection and extraction of leaf extracts

Fresh and disease-free leaves of 10 mango cultivars such as Surangudi, Fatkiri, Kalepad, Banganappalli, Imampasand, Malgoa, Peter, Neelam, PKM - 1, Kottur Sinnarasam were collected from the experimental plots of Anbil Dharmalingam Agricultural College and Research Institute (Tamil Nadu Agricultural University), Tiruchirappalli, India. Cold maceration method was followed for crude extraction.

The age of the mango trees in the orchard was 20 years. The soil analysis of the mango orchard recorded the pH (8.5%), EC (0.18 dsm^{-1}) and ESP (15%) and the nutrient status Organic Carbon (0.4%) Nitrogen (376 kg/ha), Phosphorus (20.2 kg/ha), Potassium (431 kg/ha). And the mango trees were fertilized regularly with 1:1:1.5 kg/tree/year of NPK twice in two splits during March and October. The 6 to 7 months-old leaves of 10 samples taken from each cultivar from the middle of non-fruiting shoots, from all directions and heights (8).

Morphometric analysis

A sum of 5 morphological traits of the leaves of Surangudi, Fatkiri, Kalepad, Banganappalli, Imampasand, Malgoa, Peter, Neelam, PKM - 1 and Kottur Sinnarasam (Fig.1) were recorded by following the test guidelines for mango descriptor published by Biodiversity International (9). The qualitative traits scrutinized for leaf included leaf length, leaf width, petiole length, leaf weight, mean leaf area and the ratio of length and width of a leaf was measured. The length of the leaf from leaf tip to the petiolar end was measured using a measuring scale and expressed in centimeters. For leaf breadth, the maximum distance between the two edges of the leaf lamina was measured with a measuring scale and expressed in centimeters. Leaf Area (m_2) is calculated by,

A measuring scale in centimeters was used to determine the length (cm) and width (cm). Millimeter chart sheets were used for leaf area measurements. Ten mature leaves of each cultivar were selected randomly and the mean ± SD was calculated.

Nutritional profiling

The fresh leaves were washed with water and dried in a drying cabinet. The dried leaves were then reduced to a particle size of 1.0 mm using an electric grinder and stored in an air-tight container for further use. The nutritional factors of different mango cultivars' leaf extracts were examined by the previously described standard procedures of AOAC (10).

Fig. 1. Leaf traits of 10 mango cultivars.

Lowry's method was used to determine the total protein content in mango leaf extracts. Anthrone method was employed to estimate the total carbohydrate content. Total and reducing sugar were measured by DNSA method (dinitro salicyclic acid) and crude fibre content were measured by AOAC method. The composition of macro-nutrients and micro-nutrients in the extracts was figured out through Inductively Coupled Plasma Mass Spectrometer (ICP-MS, Thermo Scientific™ iCAP™ RQ) by generation of ions. The digestion of the leaf samples was weighed accurately around 0.2 g in a pre-cleaned, dry 50 mL volume microwave digestion vessel. To this, 6.0 mL HNO_3 (Nitric acid, 67-70%, for trace metal analysis) and 1.0 mL of HCl (trace metal analysis) were added. Vessels were allowed to stand in a fume hood to facilitate pre-digestion at atmospheric conditions for 15 min. The microwave digestion vessels were closed and the microwave digestion process was initiated. The digested sample solutions were quantitatively transferred into 50 mL volumetric flasks.

Determination of total phenolic content (TPC) and total flavonoid content (TFC)

For the quantification of TPC, gallic acid was used as the standard to prepare the reference curve and the results were expressed in gallic acid equivalents (mg GAE/g) (11). The TFC was measured by the Aluminium chloride ($AlCl_3$) colorimetric method by following the protocols of Amalraj et al. (11) using quercetin to establish a standard curve and the resultant values were expressed as quercetin equivalents (mg QE/g).

Antioxidant activity of mango leaf extracts

Free radicals scavenging efficiency of the mango leaf extract of twelve cultivars was determined against the radicals DPPH and ABTS by following the standard procedures of Raj et al. (12). Ascorbic acid was used as standard inhibitor. The percentage of inhibition exhibited by the mango leaf extracts and the standard was calculated by following the equation (I),

$$\% \text{ inhibition} = [(\text{Control}^{Abs} - \text{Sample}^{Abs)} / \text{Control}^{Abs}] \times 100 \quad (I)$$

Antidiabetic activity of mango leaf extracts

The enzyme inhibitory potential of ten cultivars of mango leaf extracts was determined over the enzymes, alpha amylase and alpha glucosidase by following the protocols of Raj et al. (12). Acarbose was used as reference indicator. The inhibitory potential of the mango leaf extracts was calculated by the following equation (II),

$$\% \text{ inhibition} = [(\text{Control}^{Abs} - \text{Sample}^{Abs)} / \text{Control}^{Abs}] \times 100 \quad (II)$$

Statistical significance

The statistical analyses were executed with GraphPad Prism (Ver. 9.0.2) and also to derive graphical illustrations of the obtained results. All the experimentations were carried out in triplicate. The data were expressed as the mean ± standard deviation. The obtained data were analyzed with ANOVA and the comparisons analysis was done by the Tukey multiple comparisons test. Statistical significance was defined at $P < 0.05$. The final results were denoted as IC_{50} values (the concentration of samples required to inhibit half (50%) of the enzyme or free radical scavenging activity) for both enzyme inhibition and antioxidant activity.

Results and Discussion

Morphological traits of leaves of different mango cultivars

From various cultivars of mango leaves, common characteristics were observed, including spiral phyllotaxy on branches, a lanceolate to elliptical shape, pointed ends and leaves borne on petioles of the shoots. The average results of the morphological characteristics of the leaves are presented in Table 1. The leaf lengths of different mango cultivars were ranged from 14.46 to 21.6 cm, while the width of the leaves was ranged from 3.76 to 4.93 cm. The weight of the leaves was varied from 0.67 to 1.99 g (Table 1). The longest petiole lengths were recorded for the Malgoa (4.16 cm) and Imampasand (4.1cm) cultivars, while the shortest was found in Banganappalli (1.56 ± 0.4 cm). The heaviest dry leaf weight was noted in Mulgoa (1.99 g) and the lightest was Banganappalli (0.67 g).

Regarding leaf surface area among the different cultivars, the largest mean leaf area (62.66 cm^2) was observed in both the Banganappalli and Imampasasand cultivars, followed by PKM 1 (61 cm^2). The smallest surface area was found in Surangudi 43.33 cm^2). Similarly, Zhang et al. (13) studies morphological trait of the mango leaves obtained from three regions and reported the highest blade length, width, petiole length with 21.00, 5.60, 4.10 cms respectively and the result were in accordance with our study. Similar reports made by Shah et al. (14) and Igbari et al. (15), also supported the present research. Leaves play an important role in the development of plants as well as its fruits. They act as site for manufacturing of food material from raw material drawn through the roots and the environment by the process of photosynthesis. The more leaf weight, leaf area per unit in Mulgoa, Banganappalli and Imampasand resulted in more quantity of metabolites essential for fruit development and ultimately increased yield.

Macro and micro nutrient analysis in different Mango cultivars

The macro and micronutrient composition of mango leaves from different cultivars is detailed in Table 2. Among the macronutrients, magnesium content (241.25 mg/100g) was the highest, followed by phosphorus (179.95 mg/100g), calcium (61.04 mg/100g), nitrogen (61.04 mg/100g) and potassium (8.67 mg/100g). The cultivar Malgoa recorded the highest levels of magnesium (241.25 mg/100g), phosphorus (179.95 mg/100g) and potassium (8.67 mg/100g). Calcium content varied across all ten cultivars, ranging from 29.91 mg/100g to 61.04 mg/100g. The cultivar Peter exhibited the highest calcium content at 61.04 mg/100g, followed by Surangudi at 46.65 mg/100g, while Banganappalli had the lowest at 29.92 mg/100g. Banganappalli also had the highest nitrogen content at 61.04 mg/100g, closely followed by Imampasand at 13.21 mg/100g. The nitrogen levels ranged from 3.80 mg/100g to 13.31 mg/100g, with the lowest recorded in the cultivar Neelam (3.80 mg/100g).

The mango leaves were also analyzed for their micronutrient content, which includes iron (Fe), manganese (Mn), boron (B), molybdenum (Mo), copper (Cu), zinc (Zn), nickel (Ni), cobalt (Co) and sodium (Na). Among the ten varieties, the highest iron content was found in the cultivar PKM - 1 (27.55 mg/100g). The mango cultivar Peter had the highest manganese (21.09 mg/100g) and boron (8.59 mg/100g) contents. Molybdenum was highest in the cultivar Kottur Sinnarasam (0.028 mg/100g). Additionally, Surangudi recorded the highest levels of copper (0.97 mg/100g) and nickel (0.16 mg/100g).

The cultivar Malgoa exhibited the highest zinc (5.936 mg/100g) and cobalt content (0.008 mg/100g). Lastly, sodium content was found to be highest in the cultivar Fatiri (0.582 mg/100g). Similarly, Ali et al. (16) estimated the mineral composition of mango leaves (dry matter) and their concentrations are phosphorus (480.00 mg/100g), potassium (589.00 mg/100g), calcium (368.00 mg/100g), iron (343.00 mg/100 g), magnesium (98.00 mg/100 g), zinc (14.00 mg/100 g), sodium (28.00 mg/100g), manganese (3.00 mg/100 g) and nitrogen (2.00 mg/100 g) of dry weight. The minerals present in mango leaves reported in various studied by many authors and these minerals are important for human nutrition, as they play a major role in various activities such as maintenance of healthy bones and teeth, nerve functioning, muscles contraction and relaxation, immune system health, blood pressure regulation, blood clotting, energy metabolism and part of many enzymes (17, 18).

Table 1. Morphological characteristics of leaves of selected Mango cultivars

Mango cultivars	Leaf length (cm)	Leaf breadth (cm)	Petiole length (cm)	Weight (g)	Length: Breadth (mean)	Mean leaf area (cm^2)
Surangudi	15.40 ± 1.20	4.40 ± 0.70	3.60 ± 2.60	1.82 ± 0.60	3.50 ± 0.20	43.33 ± 1.50
Fatiri	14.46 ± 1.90	4.20 ± 1.90	2.40 ± 0.30	1.17 ± 0.10	3.44 ± 0.52	46.33 ± 1.30
Kalepad	21.60 ± 1.90	4.50 ± 0.20	3.76 ± 1.30	0.67 ± 0.61	4.80 ± 0.23	55.67 ± 2.80
Banganappalli	17.16 ± 1.30	3.80 ± 0.10	1.56 ± 0.40	1.91 ± 0.14	4.51 ± 0.10	62.66 ± 1.95
Imampasand	17.96 ± 0.80	4.66 ± 1.20	4.10 ± 0.40	1.92 ± 0.67	4.51± 0.25	62.66 ± 2.50
Mulgoa	17.43 ± 2.60	4.53 ± 0.50	4.16 ± 0.70	1.99 ± 0.50	3.85 ± 0.51	64.00 ± 2.10
Peter	15.63 ± 1.60	4.16 ± 0.50	2.43 ± 1.20	1.28 ± 0.12	3.75 ± 0.11	47.00 ± 1.00
Neelam	20.10 ± 1.60	4.93 ± 0.80	3.96 ± 1.30	1.58 ± 0.45	4.07 ± 0.15	58.60 ± 1.25
PKM -1	15.86 ± 4.70	3.76 ± 0.60	3.30 ± 1.00	1.65 ± 0.30	4.21 ± 0.26	61.00 ± 1.15
Kottur Sinnarasam	18.66 ± 0.50	4.70 ± 1.50	2.66 ± 1.50	1.68 ± 0.65	3.97 ± 0.32	54.00 ± 0.80
Mean	17.43	4.36	3.19	1.56	3.85	55.59
SEd	0.12	0.11	0.15	0.07	0.03	0.04
CD (p:0.05)	0.25	0.23	0.31	0.15	0.06	0.09
CV%	3.51	5.99	9.72	6.19	1.78	0.74

Table 2. Mineral composition (macro and micro-nutrients) in different mango cultivar leaves

Mango cultivar	Nitrogen (mg/100g)	Phosphorus (mg/100g)	Calcium (mg/ 100g)	Potassium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)	Manganese (mg/100g)	Boron (mg/100g)	Molybdenum (mg/100g)	Copper (mg/ 100g)	Zinc (mg/ 100g)	Nickel (mg/ 100g)	Cobalt (mg/ 100g)	Sodium (mg/ 100g)
Surangudi	6.240	42.964	46.650	4.423	155.766	18.863	7.762	3.602	0.025	0.970	4.489	0.167	0.005	0.532
Fatiri	12.832	114.024	41.895	3.763	210.833	12.758	3.289	3.392	0.022	0.700	2.761	0.063	0.002	0.582
Kalepad	12.832	68.961	44.965	2.645	22.215	19.144	8.068	6.027	0.022	0.281	1.114	0.092	0.006	0.439
Banganappalli	13.312	106.302	29.917	4.416	225.720	12.007	6.674	3.822	0.021	0.588	3.793	0.067	0.003	0.577
Imampasand	13.216	116.554	36.152	7.423	114.217	18.124	4.498	5.756	0.025	0.756	3.325	0.126	0.006	0.573
Mulgoa	10.816	179.951	43.669	8.675	241.250	25.334	7.207	4.527	0.018	0.771	5.936	0.152	0.008	0.562
Peter	5.408	155.807	61.043	6.723	188.054	24.924	21.097	8.593	0.021	0.709	4.622	0.143	0.006	0.491
Neelam	3.805	91.357	37.781	3.335	211.707	18.208	6.611	2.901	0.015	0.464	2.976	0.092	0.005	0.501
PKM -1	5.840	119.350	41.290	5.360	181.981	27.551	8.004	3.252	0.025	0.632	4.842	0.135	0.007	0.574
Kottur Sinnarasam	6.864	112.759	33.575	5.853	151.600	17.140	3.584	3.322	0.028	0.732	4.197	0.101	0.004	0.563
Mean	0.17	1.87	0.48	0.06	3.08	0.31	0.10	0.07	0.01	0.02	0.06	0.01	0.01	0.02
SEd	0.24	2.65	0.68	0.09	4.36	0.44	0.14	0.09	0.02	0.03	0.09	0.02	0.02	0.02
CD (p:0.05)	0.51	5.56	1.42	0.19	9.17	0.92	0.29	0.20	0.04	0.06	0.18	0.04	0.04	0.05
CV%	3.29	2.92	1.97	1.93	3.13	2.71	2.14	2.35	4.72	3.21	2.58	4.46	3.03	3.36

Nutrient profiling of leaf extracts of different mango cultivars

The highest levels of reducing sugars and crude fiber were found in the Malgoa cultivar, which contained 552.06 mg /100g of reducing sugars and 26.3 % of crude fiber. This was followed by the PKM-1 cultivar with 399.92 mg/100g of reducing sugars and Imampasand with 26.10 mg of crude fiber. The lowest levels were recorded in the Fatiri cultivar, with 113.00 mg/100g of reducing sugars and Kalepad which had 20.90 mg/g of crude fiber. Regarding protein content, the Banganappalli cultivar had the highest value at 83.20 mg/g, followed closely by Imampasand with 82.60 mg/g and Fatiri with 80.20 mg/g. The cultivar Neelam exhibited the lowest protein content, with only 23.78 mg/g. Carbohydrate content varied among the ten cultivars, ranging from 19.50 to 28.50 mg/g. The Surangudi cultivar had the highest carbohydrate content at 28.50 mg/g, followed by Imampasand with 28.2 mg/g. Kottur Sinnarasam had the lowest carbohydrate content at 19.50 mg/g. Laulloo et al. (17) evaluated the crude protein content in three cultivars of mango and reported that the highest percentage of crude protein was recorded with the cultivar Nigerian variety (20.38%) followed by dauphiné Mauritian variety (13.6%) and Laos variety (6.90%). The mango leaves are enriched with supplementary proteins, vitamins and minerals and an efficient alternative for livestock feed in developing countries to meet the shortage of fodder (5). One of the major biomacromolecules studied in mango leaves is protein. Protein acts as a building block of the cell and also plays a major role in growth, maintenance, enzyme regulation, cell signaling and also acts as a biocatalyst. Studies on nutritional content in mango leaves are limited, considering their role in improving the biomass and their suitability as a fodder crop have been investigated in animal models. Mango leaves meal found crude protein content (171.40 g kg^{-1} DM) to determine performance, nutrient utilization and carcass evaluation of growing rabbits (*19*). Mango leaf protein was assessed for its efficacy as a fodder crop in the meals fed to animals such as rabbit and black Bengal goats (19, 20). Mango leaves are a good source of supplementary protein, vitamins and minerals. These can be utilized as an alternative source of livestock feeding in developing countries for alleviating food shortage for livestock.

Total phenolic and flavonoid content in leaf extracts of different mango cultivars

The total phenolic content (TPC) and total flavonoid content (TFC) of the mango leaf extract from different cultivars are presented in Fig. 2. It can be seen that there were significant differences in TPC and TFC among the mango leaf cultivars. The range of TPC value was from 141.20 to 251.94 mg GAE/g. It was observed that Malgoa (251.94 mg GAE/g) exhibited the highest TPC, followed by Imampasand (237.68 mg GAE/g), Banganappalli (215.64 mg GAE/g) and Kalepad (214.90 mg GAE/g). On the contrary, the TPC values of Kottur Sinnarasam (166.01±0.32 mg GAE/g) and Fatkiri (141.20±0.64 mg GAE/g) were relatively low. The range of TFC value was from 91.148 to 147.50 mg QE/g. It was seen that Malgoa presented the highest TFC and Fatkiri (91.148 mg QE/g) had the lowest TFC, which was consistent with the result of TPC. Similarly, Laulloo et al. (17) estimated the TPC and TFC of mango leaf crude, ethyl acetate and methanol extract and the crude extract exhibited higher proportion of TPC (230.00 mg/g) and TFC (131.00 mg/g).

The mango leaves are abundant in phenolic and flavonoid compounds, which are known for their potent protective effects against a wide range of diseases. These natural bioactive substances play a crucial role in enhancing and sustaining human health. Their remarkable properties in combating oxidative stress and anti-inflammatory agents that help reduce inflammation in the body. This unique combination of health benefits makes mango leaves an invaluable natural resource for preventing illness and promoting overall wellness. Incorporating mango leaves into one's health regimen can support a holistic approach to disease prevention and well-being (5, 18).

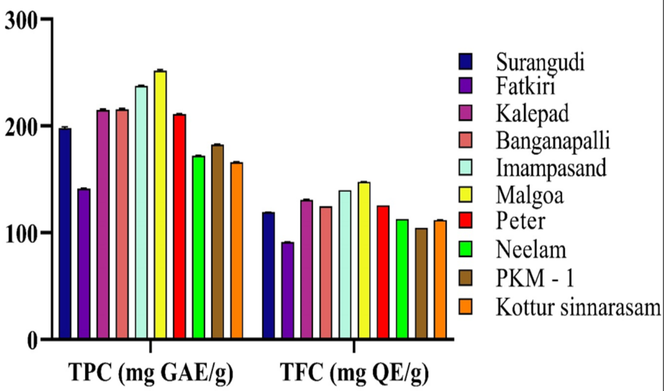

Fig. 2. Quantitative estimation of total phenolic content (TPC) and total flavonoid content in the leaf extracts from different cultivars of mango.

Antioxidant activity of leaf extracts of different mango cultivars

The phenolic compounds present in plants are integral to their capacity to counteract oxidative stress, mainly due to their remarkable redox properties. These properties enable phenolic compounds to function as effective reducing agents, allowing them to donate electrons and neutralize free radicals. In addition, they act as hydrogen donors, providing essential hydrogen atoms for various biochemical processes. Moreover, phenolic compounds can quench singlet oxygen, a highly reactive form of oxygen that can lead to cellular damage. Together, these functions make phenolics vital components of a plant's defense mechanisms, protecting cells from harmful oxidative damage and enhancing overall resilience (21).

The free radical scavenging potential of different mango cultivars leaf extracts was evaluated using two different methods including 2,2-diphenyl-1-picrylhydrazyl (DPPH) and super oxide (SO) free radicals scavenging activity (Fig. 3). The antioxidant potential (IC_{50} values) of the mango leaf extracts against DPPH radical ranged from 83.28±1.16 to 192.01 µg/ml. Cultivars like Malgoa, Imampasand and Banganappalli expressed better radical scavenging potential with the IC_{50} 83.28, 95.39 and 102 µg/ml. The mango leaf extract of cultivar Fatkiri expressed very low results (192.01 µg/mL) when compared to other cultivars. The inhibitory potential of the mango cultivar against the free radical super oxide was estimated and the highest scavenging was recorded with the cultivar Malgoa (77.42 µg/mL) and it was almost closer to the commercially purchased standard antioxidant ascorbic acid with the IC_{50} value 63.87 µg/ml. Similarly, Wu et al. (22) tested the antioxidant activity of mango leaf extracts of ten varieties. It was found that the cultivar Cui Yu exhibited notable scavenging activity against DPPH free radical with the value 784.37 µmol TE/g DW. The higher antioxidant potential attributed by the range of phenolic and flavonoid content present in the leaf (23).

Antidiabetic activity of leaf extracts of different mango cultivars

Effective management of hyperglycemia in diabetes treatment requires inhibiting key enzymes involved in starch digestion and glucose absorption following carbohydrate intake. α-Glucosidase inhibitors, widely recognized as frontline drugs for diabetes mellitus (DM), are essential for controlling blood glucose levels. Additionally, polyphenols derived from plant sources offer promising potential as natural enzyme inhibitors, providing an alternative or complementary approach to conventional therapies (24, 25). The enzyme inhibitory potential of mango leaf extracts of different cultivars was determined against the α-glucosidase (Fig. 4). The extracts derived from Malgoa leaves followed by Imampasand leaves expressed significant inhibitory effect with the lowest IC_{50} of 70.19 µg/mL and 78.06 µg/mL, respectively, indicating potent inhibitory activity against the α -glucosidase enzyme. Likewise, Selim et al. (25) evaluated the antidiabetic potential of various species of mango leaves extract and reported with the IC_{50} values 0.73 mg/mL and 0.91 mg/mL of Sukari and Sedika cultivars respectively, that showed very poor inhibition when compared to our results.

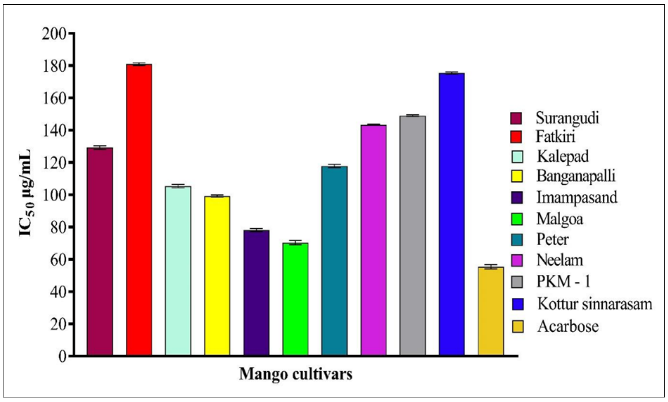

Fig. 4. IC_{50} values of the enzyme inhibitory potential expressed by the mango cultivars against the enzymes α-glucosidase. All the values are specified as mean (n = 3) ± standard deviation.

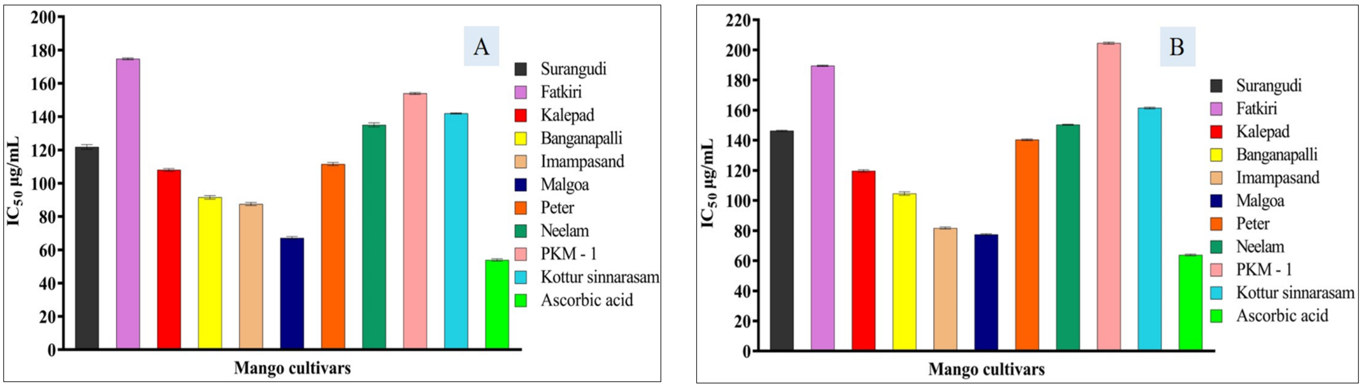

Fig. 3. IC_{50} values of the free radical scavenging potential expressed by the mango cultivars against the radicals DPPH (A) and SO (B). All the values are specified as mean (n = 3) ± standard deviation.

Table 3. Nutritional compositions in the leaves of selected mango cultivars

Mango cultivar	Protein (mg/g)	Carbohydrate (%)	Reducing Sugar (mg/100g)	Crude Fibre (%)
Surangudi	39.00±1.20	28.50±0.55	234.70±2.20	23.60±0.20
Fatiri	80.20±1.82	22.81±0.40	113.00±1.25	25.50±0.42
Kalepad	81.50±1.50	23.60±0.50	156.50±1.75	20.90±0.25
Banganappalli	83.20±1.10	24.62±0.75	321.67±2.50	23.80±0.30
Imampasand	82.60±1.00	27.67±0.65	126.00±1.85	26.10±0.52
Mulgoa	67.60±0.90	27.30±0.40	552.06±3.90	26.30±0.32
Peter	33.80±0.85	20.57±1.20	152.14±1.05	24.70±0.18
Neelam	23.78±0.25	28.20±0.50	170.00±1.02	22.00±0.10
PKM -1	36.50±0.45	26.38±0.95	399.92±1.45	22.60±0.29
Kottur Sinnarasam	42.90±1.05	19.50±1.02	360.80±2.10	24.00±0.18
Mean	0.33	0.18	0.50	0.08
SEd	0.46	0.25	0.71	0.11
CD (p:0.05)	0.97	0.53	1.5	0.24
CV%	1.06	1.22	0.34	0.57

Conclusion

This research presents an in-depth examination of the morphological, nutritional and biochemical characteristics of mango leaves from ten cultivars, uncovering notable differences in their antioxidant and antidiabetic properties. The morphological analysis of the leaves indicates the greatest variation in length, width, weight and the highest leaf area corresponds to an increased number of metabolites. The results demonstrating that, among the ten varieties, Mulgoa, Imampasand and Banganappalli were identified as superior possess exceptional bioactive properties, attributed to their high levels of phenolics and flavonoids, which contribute to robust antioxidant activity. These cultivars also indicated promising inhibition of α-glucosidase enzyme, suggesting their potential as natural agents against diabetes. The highest protein content was noted in Banganappalli and Imampasand, while Mulgoa, Imampasand, PKM-1 and Surangudi showed the highest carbohydrate content. Mulgoa variety recorded the most reducing sugars, crude fibre in Mulgoa, Imampasand and Fatiri and the highest concentrations of minerals such as phosphorus, magnesium, zinc, nickel and cobalt were found in Mulgoa, while Banganappalli had the highest amount of nitrogen, calcium and manganese. Whereas, copper was abundant in Surangudi and sodium was higher in Fatiri. This varied array of macro and micro nutrients in mango leaves demonstrates their potential as both a health-promoting and economically advantageous resource.

This study emphasizes the therapeutic efficacy of mango leaves from the Mulgoa, Imampasand and Banganappalli varieties that could be beneficial in addressing oxidative stress and diabetes, providing valuable perspectives on their application in functional foods and nutraceuticals. Innovating new extraction techniques and formulations could improve the efficacy and stability of the bioactive compounds found in mango leaves, aiding their use in pharmaceuticals and functional food products. Additionally, investigating the genetic variation in mango leaves may help identify specific cultivars that exhibit enhanced bioactive qualities, which would support breeding strategies aimed at maximizing crop yield and health benefits.

Authors' contributions

All authors contributed equally to this research.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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