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Phytochemical profiling and antioxidant potential of *Morinda citrifolia* L. fruit extract from Panikondanviduthi, Tamil Nadu, India

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Abstract

This study investigated the phytochemical composition and antioxidant activity of *Morinda citrifolia* fruit extract. Qualitative analysis revealed the presence of various phytochemical compounds, with strong presence of amino acids, flavonoids, phenols, reducing sugar, steroids, and terpenoids. Quantitative analysis estimated the amounts of these compounds, ranging from 0.93±0.11 to 2.95±0.62 µg/10g recorded in the fruit sample. The respective plant extract exhibited antioxidant activity in both hydrogen peroxide and DPPH assays, with maximum activity observed at 300 µg/ml (58.47±0.10%) and 500 µg/ml (80.90±0.11%) respectively. These findings suggested that *M. citrifolia* fruit extract is a rich source of phytochemicals with potential antioxidant properties, making it a valuable resource for pharmaceutical and food industries.

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Introduction

The resurgence of interest in traditional medicine has sparked a surge in scientific research focused on unraveling the mysteries of plant-based bioactive compounds. The vast array of phytochemicals present in plants has been a subject of immense interest particularly in the context of their potential pharmaceutical applications. Phytochemical screening serves as a crucial initial step in understanding the complex chemical composition of plants providing valuable insights into their possible range of bioactivities. This preliminary analysis can pave the way for further research into the separation, purification, and application of these compounds (Isah *et al.,* 2021).

A diverse range of phytochemicals including phytoestrogens, terpenoids, carotenoids, and anthocyanins have been identified as possessing potential health benefits. With over 25,000 phytochemicals discovered from various plant parts, it is evident that these compounds are abundantly present in colorful fruits, vegetables, nuts, legumes and whole grains (Ajibola *et al.,* 2012).

Morinda citrifolia commonly known as Noni, is a plant species that has been traditionally used for its medicinal properties. Despite its widespread use, there is a notable scarcity of scientific literature on the phytochemical components and biological activities of Noni. This knowledge gap highlights the need for comprehensive research into the phytochemical profile and antioxidant activity of Noni juice (Chede, 2013).

This study aims to bridge this gap by investigating the phytochemicals present in Noni juice and examining its antioxidant activity. By exploring the complex chemical composition of Noni juice, this research seeks to contribute to the understanding of its potential therapeutic applications and provide insights into its possible uses in the prevention and treatment of various diseases.

Morinda citrifolia, a member of the Rubiaceae family, is a versatile plant species that thrives in diverse environmental conditions. Its adaptability allows it to grow in a range of habitats from shady forests to open rocky or sandy shores. This plant can reach heights of up to 9 meters and matures relatively quickly, typically within 18 months (Nelson *et al.,* 2003). Notably, *Morinda citrifolia* demonstrates remarkable resilience to harsh conditions, including saline soils, drought, and poor secondary soils. Its ability to tolerate a wide range of environmental stresses contributes to its widespread distribution and potential for utilization in different context (Veermuthu *et al.,* 2006).

The use of plant extracts in traditional medicine has been a longstanding practice, with a notable correlation between the therapeutic properties of pure substances and their respective crude extracts (Usman *et al.,* 2021). According to the World Health Organization (WHO), a significant proportion of the global population relies on plant-based remedies for their medicinal needs.

However, despite the widespread use of plants like *Morinda citrifolia* (Noni) for therapeutic purposes, there is a surprising lack of comprehensive scientific data on their physicochemical composition and pharmacological applications (World Health Organization, 2021).

Noni fruit, in particular, has been touted for its potential health benefits but a thorough categorization of its phytochemical constituents and exploration of its pharmacological properties is warranted (Singh, 2012). The growing interest in natural antioxidants has also highlighted the importance of investigating the antioxidant activity of Noni, given the role of oxidative stress in various human diseases, such as cancer, hyperglycemia, and heart disease.

Natural antioxidants are considered a safer alternative to synthetic ones, making the study of Noni's antioxidant properties a promising area of research (Jamuna *et al.,* 2014).

Materials and methods

Sample collection

The *Morinda citrifolia* (Noni) fruits were collected from Panikondanviduthi, Thanjavur, Tamil Nadu, India. The fruits were selected based on their

maturity and freshness and care was taken to ensure that they were free from any visible damage or disease. The collected fruits were washed thoroughly with distilled water to remove any dirt or impurities and then air-dried to prevent spoilage. The samples were stored in a cool, dry place until further processing and extraction. The collection was carried out in accordance with standard protocols to ensure the quality and authenticity of the plant material.

Preparation of M. citrifolia fruit extract

Ten grams (10g) of dried *M. citrifolia* fruit was weighed and ground into a fine powder. The powder was then mixed with 100ml of distilled water in a clean container. The mixture was subjected to continuous stirring for a specified period followed by filtration through a Whatman filter paper or a similar filtration method. The resulting filtrate was collected and centrifuged if necessary to remove any remaining impurities. The aqueous extract obtained was then stored in a refrigerator at a temperature range of 2-8°C for further analysis and experimentation. This procedure ensured the preparation of a consistent and reliable aqueous extract of *M. citrifolia* fruit for subsequent phytochemical and antioxidant studies.

Qualitative phytochemical analysis (Harborne, 1998)

Alkaloids

The determination of alkaloids in the *M. citrifolia* fruit extract was carried out using a standard protocol. Five grams (5g) of the dried fruit powder was mixed with 50ml of 2% hydrochloric acid (HCl) in a conical flask. The mixture was then stirred and left to stand for a specified period.

After filtration, the extract was treated with Mayer's reagent or Dragendorff's reagent. The formation of a precipitate or color change indicated the presence of alkaloids. The intensity of the reaction was observed and recorded. This qualitative test provided an indication of the presence of alkaloids in the *M. citrifolia* fruit extract.

Amino acids

The determination of amino acids in the *M. citrifolia* fruit extract was carried out using a standard protocol. A known quantity of the extract was hydrolyzed with 6N hydrochloric acid (HCl) in a sealed tube at a specified temperature for a certain period. After hydrolysis, the mixture was filtered and the resulting solution was analyzed using techniques such as paper chromatography, thin-layer chromatography (TLC), or high-performance liquid chromatography (HPLC) to detect and quantify the amino acids present. Ninhydrin reagent was used to detect the presence of amino acids, which produced a purple-colored complex with the amino acids. The intensity of the color was directly proportional to the concentration of amino acids. The amount of amino acids present in the extract was calculated and expressed as a percentage or in micrograms per gram (µg/g) of the extract. The results were then documented and used for further analysis.

Coumarins

The determination of coumarins in the *M. citrifolia* fruit extract was carried out using a standard protocol. A known quantity of the extract was dissolved in a suitable solvent, such as ethanol or methanol. The solution was then treated with 10% sodium hydroxide (NaOH) solution. The mixture was observed for a color change or fluorescence under ultraviolet (UV) light, which indicated the presence of coumarins. Additionally, the extract was subjected to thin-layer chromatography (TLC) or high-performance liquid chromatography (HPLC) analysis to detect and quantify the coumarins present. The results were then documented, and the presence or absence of coumarins was recorded.

Flavonoids

The determination of flavonoids in the *M. citrifolia* fruit extract was carried out using a standard protocol. A known quantity of the extract was mixed with a few drops of 1% aluminum chloride ($AlCl_3$) solution in a test tube. The mixture was then observed for a color change, typically a yellow or orange color, which indicated the presence of

flavonoids. Additionally, the extract was subjected to thin-layer chromatography (TLC) or high-performance liquid chromatography (HPLC) analysis to detect and quantify the flavonoids present. The flavonoid content was estimated using a calibration curve or by comparing the retention factor (Rf) values with standard flavonoid compounds. The amount of flavonoids present in the extract was calculated and expressed as a percentage or in micrograms per gram (µg/g) of the extract. The results were then documented and used for further analysis.

Glycosides

The determination of glycosides in the *M. citrifolia* fruit extract was carried out using a standard protocol. A known quantity of the extract was treated with hydrochloric acid (HCl) and heated to hydrolyze the glycosides. The resulting solution was then analyzed for the presence of glycosides. The extract was treated with glacial acetic acid and $FeCl_3$, followed by the addition of concentrated sulfuric acid (H_2SO_4). A blue or green color indicated the presence of glycosides.

Phenols

The qualitative determination of phenols in the *M. citrifolia* fruit extract was carried out using a standard protocol. A few drops of ferric chloride ($FeCl_3$) solution were added to the extract. The appearance of a green, blue, or purple color indicated the presence of phenols. This test provided a preliminary indication of the presence of phenolic compounds in the *M. citrifolia* fruit extract.

Proteins

A few drops of ninhydrin solution were added to the extract and heated. A purple color indicated the presence of proteins or amino acids.

Reducing sugar

The extract was treated with Benedict's reagent and heated. A color change from blue to green, yellow, orange, or red-brick indicated the presence of reducing sugars.

Saponins

The qualitative determination of saponins in the *M. citrifolia* fruit extract was carried out using a standard protocol. The foam test was performed: A known quantity of the extract was mixed with distilled water in a test tube. The mixture was shaken vigorously for a few minutes. The formation of a stable foam layer indicated the presence of saponins. The persistence of the foam layer for a specified period confirmed the presence of saponins in the extract.

Steroids

The qualitative determination of steroids in the *M. citrifolia* fruit extract was carried out using standard protocols. The extract was treated with chloroform and concentrated sulfuric acid (H_2SO_4). A reddish-brown color at the interface indicated the presence of steroids.

Tannins

The qualitative determination of tannins in the *M. citrifolia* fruit extract was carried out using standard protocols. The extract was treated with ferric chloride ($FeCl_3$) solution. A blue or green color indicated the presence of tannins.

Tepenoids

The qualitative determination of terpenoids in the *M. citrifolia* fruit extract was carried out using a standard protocol. The Salkowski test was performed: The extract was mixed with chloroform and then treated with concentrated sulfuric acid (H_2SO_4). A reddish-brown color at the interface indicated the presence of terpenoids.

Quantitative phytochemical analysis (Harborne, 1998)

Alkaloids

The quantitative estimation of alkaloids in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The extract was dissolved in a suitable solvent and then treated with bromocresol green reagent. The absorbance of the resulting solution was measured using a UV-Vis

spectrophotometer at 470 nm. A calibration curve was prepared using a standard alkaloid compound, such as atropine, and the amount of alkaloids present in the extract was calculated. The total alkaloid content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Amino acids

The quantitative estimation of amino acids in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The extract was treated with ninhydrin reagent, and the resulting purple-colored complex was measured. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer at 570 nm. A calibration curve was prepared using a standard amino acid compound, such as glycine, and the amount of amino acids present in the extract was calculated. The total amino acid content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Flavonoids

The quantitative estimation of flavonoids in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The extract was treated with aluminum chloride ($AlCl_3$) reagent, and the resulting yellow-colored complex was measured. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer at 415 nm. A calibration curve was prepared using a standard flavonoid compound, such as quercetin, and the amount of flavonoids present in the extract was calculated. The total flavonoid content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Glycosides

The quantitative estimation of glycosides in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method, specifically targeting anthraquinone glycosides or other specific glycoside types. The extract was hydrolyzed and treated with suitable reagents. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer. The wavelength used depended on the specific glycoside type, but common ranges include 200-400 nm or specific wavelengths like 280 nm for certain glycoside-reagent complexes. A calibration curve was prepared using a standard glycoside compound, and the amount of glycosides present in the extract was calculated. The total glycoside content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Phenols

The quantitative estimation of phenols in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The extract was treated with Folin-Ciocalteu reagent, and the resulting blue-colored complex was measured. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer at 765 nm. A calibration curve was prepared using a standard phenolic compound, such as gallic acid, and the amount of phenols present in the extract was calculated. The total phenol content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Proteins

The quantitative estimation of proteins in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The extract was treated with Folin-Ciocalteu reagent, and the absorbance was measured at 660 nm or 750 nm. A calibration curve was prepared using a standard protein compound, such as bovine serum albumin (BSA), and the amount of proteins present in the extract was calculated. The total protein content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Reducing sugar

The quantitative estimation of reducing sugars in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method, specifically the 3,5-dinitrosalicylic acid (DNS) assay. The extract was treated with DNS reagent, and the resulting solution was heated. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer at 540 nm. A calibration curve was prepared using a standard reducing sugar compound, such as glucose, and the amount of reducing sugars present in the

extract was calculated. The total reducing sugar content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Steroids

The quantitative estimation of steroids in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method, specifically the Libermann-Burchard assay. The extract was treated with acetic anhydride and sulfuric acid, and the resulting solution was measured. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer at 420 nm or 640 nm, depending on the specific protocol. A calibration curve was prepared using a standard steroid compound, and the amount of steroids present in the extract was calculated. The total steroid content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Tannins

The quantitative estimation of tannins in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The vanillin assay, the extract was treated with vanillin reagent and sulfuric acid, and the absorbance was measured at 500 nm. A calibration curve was prepared using a standard tannin compound, such as tannic acid or catechin, and the amount of tannins present in the extract was calculated. The total tannin content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Tepenoids

The quantitative estimation of terpenoids in 10g of *M. citrifolia* fruit extract was carried out using a spectrophotometric method. The extract was treated with chloroform and sulfuric acid, resulting in a reddish-brown coloration. The absorbance of the resulting solution was measured using a UV-Vis spectrophotometer at 538 nm. A calibration curve was prepared using a standard terpenoid compound, such as linalool or β-carotene might not be suitable, and the amount of terpenoids present in the extract was calculated. The total terpenoid content was expressed as micrograms per 10 grams (µg/10g) of the extract.

Antioxidant activity

Hydrogen peroxide assay (Al-Amiery et al., 2015)

The hydrogen peroxide (H_2O_2) scavenging assay was performed to evaluate the antioxidant potential of *M. citrifolia* extract. Different concentrations (100, 200, 300, 400, and 500 µg/ml) of the extract were prepared, and ascorbic acid was used as a standard. A solution of H_2O_2 (40 mM) was prepared in phosphate buffer (pH 7.4). The extract solutions and ascorbic acid standard were added to the H_2O_2 solution, and the absorbance was measured at 230 nm using a UV-Vis spectrophotometer.

The percentage scavenging activity was calculated using the formula:

% scavenging = $[(A_0 - A_1) / A_0] \times 100$,

Where A_0 is the absorbance of the control (H_2O_2 solution alone) and A1 is the absorbance of the test solution (H_2O_2 + extract or standard).

The results showed that *M. citrifolia* extract exhibited concentration-dependent H_2O_2 scavenging activity, with increasing scavenging percentages at higher concentrations. The scavenging activity of the extract was compared to that of ascorbic acid, and the results were documented for further analysis.

DPPH assay (Baliyan et al., 2022)

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay was performed to evaluate the antioxidant potential of *M. citrifolia* extract. Different concentrations (100, 200, 300, 400, and 500 µg/ml) of the extract were prepared, and ascorbic acid was used as a standard. A solution of DPPH (0.1 mM) was prepared in methanol. The extract solutions and ascorbic acid standard were added to the DPPH solution, and the mixture was incubated in the dark for 30 minutes. The absorbance was measured at 517 nm using a UV-Vis spectrophotometer.

The percentage scavenging activity was calculated using the formula:

% scavenging = $[(A_0 - A_1) / A_0] \times 100$,

Where A_0 is the absorbance of the control (DPPH solution alone) and A_1 is the absorbance of the test solution (DPPH + extract or standard).

The results showed that *M. citrifolia* extract exhibited concentration-dependent DPPH radical scavenging activity with increasing scavenging percentages at higher concentrations. The scavenging activity of the extract was compared to that of ascorbic acid and the results were documented for further analysis.

Results

The phytochemical analysis of *Morinda citrifolia* (Noni) fruit extract were carried out with following phytochemical compounds such as alkaloids, amino acids, coumarins, flavonoids, glycosides, phenols, proteins, reducing sugar, saponins, steroids, tannins and tepenoids respectively. In the qualitative phytochemical analysis revealed that the presence of alkaloids, amino acids, flavonoids, glycosides, phenols, proteins, reducing sugar, steroids, tannins and tepenoids respectively. In this investigation found with strongly presence of amino acids, flavonoids, phenols, reducing sugar, steroids and terpenoides (Table 1).

Table 1. Qualitative phytochemical analysis of *Morinda citrifolia* (Noni) fruit extract

Name of the phytochemical compounds	Inference
Alkaloids	+
Amino acids	++
Coumarins	-
Flavonoids	++
Glycosides	+
Phenols	++
Proteins	+
Reducing sugar	++
Saponins	-
Steroids	++
Tannins	+
Terpenoids	++

(+) - Present; (++) - Strongly Present; (-) – Absent

In qualitatively determined phytochemical compounds were performed for the estimation of phytochemical compounds. The 0.93±0.11, 2.95±0.62, 1.56±0.58, 1.32±0.47, 2.01±0.29, 1.05±0.84, 2.32±0.36, 1.99±0.21, 1.17±0.52 and 1.23±0.39µg/10g quantities of alkaloids, amino acids, flavonoids, glycosides, phenols, proteins, reducing sugar, steroids, tannins and tepenoids were estimated respectively (Table 2).

Table 2. Quantitative phytochemical analysis of *Morinda citrifolia* (Noni) fruit extract

Name of the phytochemical compounds	Quantity (µg/10g)
Alkaloids	0.93±0.11
Amino acids	2.95±0.62
Flavonoids	1.56±0.58
Glycosides	1.32±0.47
Phenols	2.01±0.29
Proteins	1.05±0.84
Reducing sugar	2.32±0.36
Steroids	1.99±0.21
Tannins	1.17±0.52
Terpenoids	1.23±0.39

In-vitro hydrogen peroxide antioxidant assay were analyzed with different concentrations (100, 200, 300, 400 and 500µg/ml) of *M. citrifolia*. These activities were compared to different concentrations of standard ascorbic acid. The standard concentrations (100, 200, 300, 400 and 500µg/ml) exhibited anti-oxidant activity percentages of 57.04±0.01, 59.21±0.05, 62.08±0.00, 55.11±0.09 and 50.42±0.07 found to be recorded respectively. In *M. citrifolia*, the 100, 200, 300, 400 and 500µg/ml were treated for anti-oxidant activity and showed the following percentage of activity such as 49.35±0.14, 53.30±0.05, 58.47±0.10, 40.47±0.13 and47.86±0.04% was represented in aqueous extract (Fig. 1).

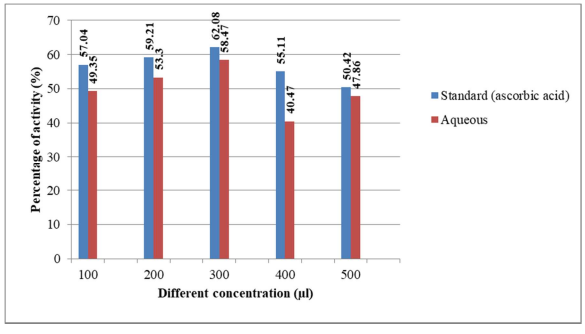

Fig. 1. Antioxidant activity of H_2O_2 assay of two different solvents from *M. citrifolia* fruit extract

In vitro DPPH anti-oxidant activities were analyzed with different concentrations (100, 200, 300, 400

and 500µg/ml) of *M. citrifolia*. These activities were compared to different concentrations of standard Vitamin C. The standard concentrations (100, 200, 300, 400 and 500µg/ml) exhibited anti-oxidant activity percentages of 60.12±0.06, 67.51±0.12, 72.08±0.02, 80.16±0.00 and 98.14±0.06%, respectively. In *M. citrifolia*, the 100, 200, 300, 400 and 500µg/ml were treated for anti-oxidant activity and showed the following percentage of activity such as 54.47±0.67, 59.93±0.94, 60.78±0.35, 72.33±0.22 and 80.90±0.11% results in aqueous extract (Fig. 2).

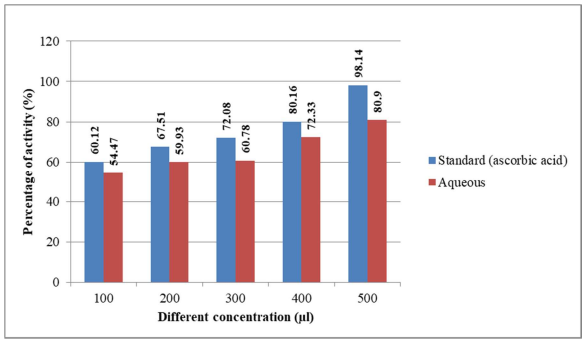

Fig. 2. Antioxidant activity of DPPH assay of two different solvents from *M. citrifolia* fruit extract

Discussion

Phytochemical analysis of *Morinda citrifolia* fruit extracts revealed a diverse range of secondary metabolites across different solvents, including ethanol, methanol, and aqueous extracts. The presence of alkaloids, saponins, and reducing sugars was consistently observed in all three extracts suggesting their widespread distribution in the fruit. Other compounds such as steroids, phenols, tannins, and terpenoids, were also detected, although their presence varied slightly between extracts. The variation in phytochemical composition between extracts highlights the importance of solvent selection in phytochemical analysis. Notably, protein was detected in aqueous and ethanol extracts but not in methanol extract, indicating that solvent polarity may influence the extraction of specific compounds. The absence of certain compounds, such as resin, anthraquinone, and phlobatannin, in all extracts suggests that *Morinda citrifolia* fruit may not be a rich source of these particular phytochemicals. Overall, this study provides valuable insights into the phytochemical profile of *Morinda citrifolia* fruit and lays the groundwork for further research into its potential therapeutic applications (Sridevi *et al.,* 2012).

A study's findings highlight the rich phytochemical composition of *Morinda citrifolia*, with aqueous extracts revealing a diverse range of secondary metabolites, including steroids, cardiac glycosides, tannins, terpenoids, carbohydrates, flavonoids, and proteins. The absence of resins, anthraquinones, and phlobatannins in the extract suggests that these compounds may not be significant contributors to the plant's bioactivity. The antioxidant potential of *M. citrifolia* was evaluated using multiple assays, including DPPH, ABTS, FRAP, nitric oxide scavenging, reducing power and phosphomolybdenum methods. These assays collectively demonstrated the extract's ability to scavenge free radicals and exhibit antioxidant activity which can be attributed to the presence of various phytochemicals. The results of this study provide a scientific basis for the potential therapeutic applications of *M. citrifolia*, particularly in relation to its antioxidant properties. Further research is needed to isolate and characterize the specific compounds responsible for the observed antioxidant activity and to explore their potential benefits in preventing or treating various diseases (Sajani Jose and Maya, 2020).

This study's findings are consistent with previous research that has reported the presence of various bioactive compounds in Noni, including alkaloids, flavonoids, glycosides, and terpenoids. These phytochemicals are known for their antioxidant properties and potential therapeutic benefits. The presence of these compounds in Noni juice could contributed to its reported antioxidant and wound-healing activities. The identification of these bioactive compounds provides a scientific basis for the traditional use of Noni in various medicinal applications (Maryam *et al.,* 2023).

Findings are consistent with previous research that has reported the presence of various bioactive compounds in *Morinda citrifolia*. Studies have shown

that *M. citrifolia* contains a range of phytochemicals, including flavonoids, terpenoids, and phenolic compounds, which may contribute to its potential therapeutic benefits. The detection of steroids, cardiac glycosides, phenol, tannins, terpenoids, alkaloids, carbohydrates, flavonoids, and reducing sugars in our study supports the idea that *M. citrifolia* is a rich source of secondary metabolites. These compounds may play a role in the plant's antioxidant, anti-inflammatory and other bioactive properties. The variation in phytochemical composition reported in different studies may be due to factors such as geographical location, extraction methods, and solvent used. Nonetheless, the presence of these bioactive compounds in *M. citrifolia* highlights its potential as a valuable source of natural products for therapeutic applications (Bhakti and Thankamani, 2015).

A study on the DPPH scavenging activity of *M. citrifolia* fruit extract is consistent with previous research that has reported concentration-dependent antioxidant activity. The varying degrees of scavenging capacities observed at different concentrations suggest that the extract's antioxidant potential is influenced by the concentration of bioactive compounds. The correlation between DPPH scavenging activity and the presence of flavonoids in *M. citrifolia* extract is supported by previous studies, which have identified flavonoids as potent antioxidants. The ability of *M. citrifolia* extract to scavenge DPPH radicals indicates its potential to neutralize free radicals and protect against oxidative stress. These findings are in line with other research that has reported enhanced antioxidant activity in fermented *M. citrifolia* extracts, suggesting that fermentation may increase the bioavailability of antioxidant compounds. Overall, our study provides further evidence for the antioxidant potential of *M. citrifolia* fruit extract and highlights its potential therapeutic applications (Ruhomall *et al.,* 2016; Thirukkumar *et al.,* 2017).

The traditional use of *Morinda citrifolia* for treating infectious diseases, with the aqueous extract exhibiting significant antibacterial activity against *Escherichia coli* and *Pseudomonas aeruginosa*. The maximum antibacterial activity was observed at a concentration of 100µl, with inhibition rates of 52.24% and 61.46% against *E. coli* and *P. aeruginosa*, respectively. The phytochemical analysis revealed the presence of various primary and secondary metabolites, including alkaloids, flavonoids, terpenoids, steroids, saponins, phenol, tannins, and cardiac glycosides. These compounds may contribute to the observed antibacterial and antioxidant activities. The antioxidant activity of the aqueous extract, evaluated using the DPPH assay, showed a concentration-dependent increase in radical scavenging activity, with maximum inhibition (68.94%) observed at 100µl concentration. This suggests that *M. citrifolia* extract has potential antioxidant properties, which may help protect against oxidative stress. Overall, our study provides scientific evidence for the therapeutic potential of *M. citrifolia*, supporting its traditional use in medicine. Further research is needed to isolate and characterize the specific compounds responsible for the observed bioactivities and to explore their potential applications (Febitha and Aruna, 2021).

Research findings are consistent with previous research that has identified *Morinda citrifolia* as a rich source of antioxidant phytochemicals. The presence of flavonoids, iridoids, and coumarins in *M. citrifolia* may contribute to its potent free radical scavenging capacity and antioxidant potential. Studies have shown that *M. citrifolia*-derived compounds can upregulate endogenous antioxidant enzymes and modulate key pathways involved in antioxidant defense. The Nrf2/Keap1 pathway, in particular, plays a crucial role in regulating antioxidant responses, and *M. citrifolia's* ability to modulate this pathway may contribute to its antioxidant effects. The dual antioxidant and anti-inflammatory effects of polysaccharides and iridoids in *M. citrifolia* are notable, and their ability to regulate gut microbiota may be an important mechanism underlying their bioactivity. Overall, our study provides further evidence for the antioxidant potential of *M. citrifolia* and highlights its potential therapeutic applications (Hou *et al.,* 2025).

A study highlights the potential health benefits of Noni fruit which can be attributed to its rich phytochemical composition. The use of solid-liquid extraction or leaching as a separation technique allows for the generation of bioactive extracts that retain the beneficial properties of the fruit. The presence of polyphenols and flavonoids in Noni fruit is particularly noteworthy as these compounds have been shown to possess a range of health-promoting properties. These bioactive molecules may contribute to the fruit's antioxidant, anti-inflammatory and other beneficial effects, making Noni a valuable resource for the development of natural health products (Ratih *et al.,* 2024).

Findings are consistent with the traditional use of *Morinda* plants for various therapeutic purposes, which can be attributed to their rich composition of bioactive compounds. The presence of secondary metabolites such as terpenoids, glycosides, anthraquinones, polyphenols, steroids, saponins, and reducing sugars may contribute to the plant's pharmacological activities.

The pronounced antidiabetic, antioxidant, antiplasmodial, antidepressant, wound healing, anticancer, and anti-inflammatory effects exhibited by *Morinda* plant extracts, fractions, and isolates suggest a strong potential for therapeutic applications. These bioactivities can be linked to the presence of specific secondary metabolites, highlighting the importance of phytochemical analysis in understanding the plant's medicinal properties. The diverse applications of *Morinda* plants in industries such as textiles, metallurgy, agrochemicals, and food also underscore their economic and practical significance. Overall, our study provides further evidence for the potential health benefits and industrial applications of *Morinda* plants, supporting their continued use in traditional medicine and beyond (Oladeji *et al.,* 2022).

The present study aimed to investigate the phytochemical composition and antioxidant potential of *Morinda citrifolia* (Noni) fruit extract. Our results revealed the presence of various phytochemical compounds, including alkaloids, amino acids, flavonoids, glycosides, phenols, proteins, reducing sugars, steroids, tannins, and terpenoids. The qualitative phytochemical analysis showed a strong presence of amino acids, flavonoids, phenols, reducing sugars, steroids, and terpenoids in the extract. These findings are consistent with previous studies that have reported the presence of similar phytochemical compounds in Noni fruit. The quantitative estimation of phytochemical compounds revealed significant amounts of these compounds in the extract. Notably, amino acids, phenols, and reducing sugars were found in higher quantities, which may contribute to the antioxidant potential of the extract.

The antioxidant activity of *M. citrifolia* extract was evaluated using hydrogen peroxide (H_2O_2) and DPPH radical scavenging assays. Our results showed that the extract exhibited concentration-dependent antioxidant activity in both assays, although the activity was slightly lower compared to the standard ascorbic acid. The H_2O_2 scavenging assay revealed that the extract showed maximum activity at 300 µg/ml concentration, with a percentage inhibition of 58.47±0.10%. Similarly, the DPPH assay showed maximum activity at 500 µg/ml concentration, with a percentage inhibition of 80.90±0.11%.

The antioxidant potential of *M. citrifolia* extract can be attributed to the presence of various phytochemical compounds, particularly phenols, flavonoids and terpenoids, which are known for their antioxidant properties. These compounds may work synergistically to scavenge free radicals and protect against oxidative stress. Overall, our study highlights the potential of *M. citrifolia* fruit extract as a natural antioxidant agent, which could be useful in preventing or treating various diseases associated with oxidative stress. Further studies are needed to isolate and characterize the specific phytochemical compounds responsible for the antioxidant activity and to explore their potential therapeutic applications.

Conclusion

In conclusion, the present study demonstrated the presence of various phytochemical compounds in *Morinda citrifolia* (Noni) fruit extract, with a strong presence of amino acids, flavonoids, phenols, reducing sugars, steroids, and terpenoids. The quantitative estimation of these compounds revealed significant amounts of alkaloids, amino acids, flavonoids, glycosides, phenols, proteins, reducing sugars, steroids, tannins, and terpenoids. The antioxidant potential of *M. citrifolia* extract was evaluated using hydrogen peroxide and DPPH radical scavenging assays, which showed concentration-dependent antioxidant activity. Although the biological activity was slightly lower compared to the standard ascorbic acid and Vitamin C, the extract exhibited notable antioxidant potential. The findings of this study suggest that *M. citrifolia* fruit extract could be a valuable source of natural antioxidants, which could be useful in preventing or treating various diseases associated with oxidative stress. Further studies are needed to isolate and characterize the specific phytochemical compounds responsible for the antioxidant activity and to explore their potential therapeutic applications. Overall, this study provides scientific evidence for the potential health benefits of *M. citrifolia* fruit extract and supports its traditional use in various medicinal applications.

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