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Nutritional composition and antimicrobial potential of *Morinda citrifolia* (L.) fruits against clinical pathogens

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Abstract

This study evaluated the proximate composition and antimicrobial potential of *Morinda citrifolia* fruit extract. The proximate analysis revealed a high moisture content (85.2±1.12%), carbohydrate content (73.2±2.56%), and moderate amounts of ash, protein and fiber. The energy value was found to be 64.5±2.12 kcal/100g. The antibacterial activity of *M. citrifolia* fruit extract was assessed against five clinical bacteria, including *Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Salmonella typhi* and *Streptococcus pyogenes*. The extract exhibited significant antibacterial activity, with zone of inhibitions ranging from 9.1±0.35 to 25.3±0.84 mm. The antifungal activity was evaluated against five clinical fungi, including *Aspergillus flavus, A. niger, A. oryzae, Neurospora crassa* and *Trichophyton rubrum*. The extract showed notable antifungal activity, with zone of inhibitions ranging from 7.15±0.13 to 19.2±0.54 mm. These findings suggest that *M. citrifolia* fruit extract has potential applications in food preservation and pharmaceutical industries due to its rich nutritional composition and significant antimicrobial activity.

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Introduction

Morinda citrifolia L., a tropical evergreen tree, has been widely cultivated and utilized for its medicinal and nutritional properties. Native to tropical regions, this plant is known by various names globally, including noni, and has been a staple in traditional medicine for centuries. The noni tree's fruits, leaves, roots, and stems are rich in bioactive compounds, making them valuable for consumption and therapeutic applications (Dussossoy *et al.,* 2011; Jahurul *et al.,* 2021).

The noni fruit, in particular, has garnered attention for its potential health benefits, including antioxidant, anti-inflammatory, and antimicrobial properties. Research has highlighted the fruit's potential in managing various health conditions, such as hypertension, diabetes, and cancer. The presence of bioactive compounds in noni fruits and leaves has led to their increased consumption as a healthy food option (Brett *et al.,* 2018).

Studies have extensively documented the medicinal properties of noni, showcasing its versatility and potential as a natural remedy. The plant's ability to stimulate the immune system, promote wound healing, and exhibit anticancer effects has sparked interest in its therapeutic applications. As research continues to uncover the benefits of *Morinda citrifolia*, its potential as a valuable resource for the food and pharmaceutical industries becomes increasingly evident (Chufru *et al.,* 2024).

The global demand for noni fruit products has experienced significant growth, driven by the recognition of noni fruit juice as a novel food by the European Union. This recognition has led to an expansion of the noni fruit juice industry, with numerous producers worldwide. Noni fruit products, including juice and puree, are now widely used in various food applications, such as dairy products, baked goods, and nutritional supplements (Shixin *et al.,* 2010).

The versatility of noni fruit products has made them a popular choice for food manufacturers. Noni puree, in particular, has been used to create innovative products, such as cheese, with promising results. Research has demonstrated the potential of noni fruit as a source of milk-clotting enzymes, highlighting its potential applications in the dairy industry (Farias *et al.,* 2024).

The growing demand for noni fruit products has also led to increased production and trade. French Polynesia, for example, has emerged as a significant producer of noni fruit puree, exporting large quantities to countries like the United States. As the demand for noni products continues to grow, it is essential to explore the potential uses and benefits of noni fruit and its by-products (Hou *et al.,* 2025).

Morinda citrifolia, commonly known as noni, is a medicinal plant renowned for its diverse phytochemical composition (Mulat *et al.,* 2019). The plant's various parts have been traditionally used in several cultures to treat a range of health conditions, including inflammation, infections, and chronic diseases (Anand *et al.,* 2019). Research has identified numerous bioactive compounds in noni, including terpenoids, flavonoids, and alkaloids, which exhibit potent antibacterial properties (Manucuso *et al.,* 2021).

The phytochemical profile of noni fruit has been extensively studied, revealing a complex mixture of secondary metabolites with therapeutic potential (O'Neill, 2016). These compounds have been shown to exhibit antimicrobial activity against a range of bacterial species, including pathogens responsible for various diseases (Fesseha *et al.,* 2019). The discovery of specific compounds, such as pentacetyl-β-D-glucopyranose and iridoid acubin, has highlighted the potential of noni fruit as a source of novel antimicrobial agents (Gajdacs, 2019).

The growing concern of multi-drug resistance has sparked interest in exploring alternative sources of bioactive compounds (Vyas *et al.,* 2012). Noni plant cell cultures have been proposed as a viable method for the commercial production of valuable

compounds, such as flavonoids and anthraquinones (Ekor, 2013). This approach could provide a sustainable and efficient means of harnessing the therapeutic potential of noni (Paramanya *et al.,* 2020; Frederick *et al.,* 2024).

Morinda citrifolia, commonly known as Noni, is a medicinal plant of immense significance in Southeast Asia. Its diverse array of phytochemical constituents, including terpenoids, flavonoids, and alkaloids, has garnered attention for their remarkable antibacterial properties. In traditional medicine, various parts of the Noni plant have been employed to alleviate symptoms of various ailments, such as headaches, burns, arthritis, and chronic conditions like diabetes, hypertension, and tuberculosis.

The Noni plant's broad spectrum of bioactive compounds has sparked interest in its potential applications. Research has identified over 200 phytochemicals in different parts of the plant, which exhibit antimicrobial properties (Farhadi *et al.,* 2019). Specifically, secondary metabolites like flavonoids, terpenoids, alkaloids, and steroids have been detected in the fruit's extracts.

These compounds have been shown to exert antibacterial effects against a range of bacterial species, including *Salmonella typhi, Escherichia coli, Staphylococcus aureus* and *Shigella dysenteriae* (Almeida *et al.,* 2019). Given the growing concern of multi-drug resistance, exploring alternative sources of bioactive compounds is crucial (Singh, 2012). *M. citrifolia* casual root cultures have emerged as a promising approach for the commercial production of biotechnology-based compounds, such as flavonoids, rubiadin, anthraquinones, and phenolics.

This method could provide a sustainable solution to address the pressing issue of antibiotic resistance (Saah aand Adu-Poku, 2021).

The significance of *M. citrifolia* as a medicinal plant is underscored by its rich history of traditional use and the growing body of scientific evidence supporting its bioactive properties. As research continues to unravel the complexities of the plant's phytochemical constituents, its potential applications in modern medicine become increasingly apparent. This study will build upon existing knowledge and explore, with the ultimate goal of harnessing the therapeutic potential of *M. citrifolia* (AlSheikh *et al.,* 2020).

The lack of scientific documentation on the antibacterial properties of noni plant extracts highlights a significant knowledge gap. Investigating the antibacterial potential of local noni plant varieties could provide valuable insights into their utility in controlling endemic bacterial infections. Most of the study aims to bridge this gap by examining the antibacterial properties of *Morinda citrifolia* root, leaf, and fruit extracts (fresh, dried, and fermented) against a range of gram-positive and gram-negative bacteria. The selected bacterial strains, including *Listeria monocytogenes, Bacillus cereus, Enterococcus faecium, Klebsiella* sp., *Campylobacter* sp., *Vibrio cholerae, Yersinia enterocolitica* and *Shigella* sp., are significant pathogens that pose considerable public health concerns (Frederick *et al.,* 2024).

Notably, noni extracts have been found to inhibit the growth of various fungi, including *Candida albicans, Aspergillus* species, and other plant pathogens. The essential oils extracted from noni fruit have also been shown to exhibit antifungal activity against specific pathogens, such as *Exserohilum turcicum* and *Bipolaris maydis*, which cause Northern Corn Leaf Blight and Southern Corn Leaf Blight, respectively. These findings suggest that noni plant extracts possess a wide range of bioactive compounds with potential applications in medicine and agriculture.

The discovery of natural antifungal agents from plants like *M. citrifolia* could provide a valuable alternative to synthetic fungicides, which can have adverse environmental and health impacts. As the demand for sustainable and eco-friendly solutions grows, the potential applications of noni plant extracts in agriculture and medicine become increasingly significant (Oktira and Larasati, 2020).

Therefore, this study aimed to investigate the proximate composition and antimicrobial properties of *M. citrifolia* fruit extracts. Our research evaluated the moisture, ash, crude protein, crude fat, crude fiber, carbohydrates and energy value of the fruits. Additionally, we assessed the antibacterial and antifungal activities of the fruit extracts against common clinical pathogens, including bacteria like *Bacillus cereus, Escherichia coli*, *Klebsiella pneumoniae Salmonella typhi* and *Streptococcus pyogenes* and fungi like *Aspergillus flavus, A. niger*, *A. oryzae, Neurospora crassa* and *Trichophyton rubrum*. The findings of this study provide insights into the nutritional and antimicrobial properties of *M. citrifolia* fruits, highlighting their potential applications in medicine and food industries.

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.

Proximate analysis of M. citrifolia fruits (AOAC, 1980)

The proximate composition of *Morinda citrifolia* (L.) fruits including moisture, ash, crude protein, crude fat, crude fiber, carbohydrates and energy value was determined.

Moisture content

The moisture content of *Morinda citrifolia* fruits was estimated using the following procedure. A clean and dry Petri dish was weighed (W1). Fresh *Morinda citrifolia* fruit sample was placed in the Petri dish and weighed (W2). The sample was dried in a hot air oven at 105°C for 24 hours. After drying, the Petri dish with the sample was weighed again (W3).

The moisture content was calculated using the formula:

Moisture content (%) = [(W2 - W3) / (W2 - W1)] × 100

Where:

W1 = Weight of empty Petri dish

W2 = Weight of Petri dish with fresh sample

W3 = Weight of Petri dish with dried sample

Ash content

A clean and dry crucible was weighed (W1). A known weight of dried *Morinda citrifolia* fruit sample was placed in the crucible (W2). The sample was incinerated in a muffle furnace at 550-600°C for 4-6 hours. After incineration, the crucible with ash was cooled and weighed (W3).

Ash content (%) = [(W3 - W1) / (W2 - W1)] × 100

Where:

W1 = Weight of empty crucible

W2 = Weight of crucible with sample

W3 = Weight of crucible with ash

Crude protein

The crude protein content of *Morinda citrifolia* fruits was estimated using the Kjeldahl method. A known

weight of dried sample was digested with concentrated sulfuric acid and a catalyst mixture in a Kjeldahl flask. The digested mixture was then distilled with sodium hydroxide, and the liberated ammonia was collected in a boric acid solution. The ammonia was titrated with a standard sulfuric acid solution, and the crude protein content was calculated using a conversion factor (6.25). The crude protein content was expressed as a percentage.

Crude protein (%) = [(V × N × 14.007 × 6.25) / W] × 100
Where:
V = Volume of standard sulfuric acid used for titration (ml)
N = Normality of standard sulfuric acid
14.007 = Atomic weight of nitrogen
6.25 = Conversion factor (nitrogen to protein)
W = Weight of sample (g)

Crude fat

The crude fat content of *Morinda citrifolia* fruits was estimated using the Soxhlet extraction method. A known weight of dried sample was placed in a thimble and extracted with petroleum ether in a Soxhlet apparatus for a specified period. The extract was then collected, and the solvent was evaporated. The residue was weighed and the crude fat content was calculated as a percentage of the sample weight.

Crude fat (%) = [(Weight of fat extracted / Weight of sample)] × 100
Where:
Weight of fat extracted = Weight of residue after evaporation of solvent
Weight of sample = Initial weight of dried sample

Crude fiber

The crude fiber content of *Morinda citrifolia* fruits was estimated by treating a known weight of dried sample with acid and alkali solutions to remove proteins, fats and other soluble materials. The sample was first digested with sulfuric acid, followed by sodium hydroxide solution. The residue was filtered, washed, dried and weighed. The crude fiber content was calculated as the loss in weight on ignition of the dried residue.

Crude fiber (%) = [(Weight of dried residue - Weight of ash) / Weight of sample] × 100
Where:
Weight of dried residue = Weight of residue after acid and alkali treatment and drying
Weight of ash = Weight of residue after ignition
Weight of sample = Initial weight of dried sample

Carbohydrates

The carbohydrate content of *Morinda citrifolia* fruits was estimated by subtracting the sum of moisture, ash, crude protein, crude fat, and crude fiber percentages from 100. This calculation provided the percentage of carbohydrates in the sample. The carbohydrate content was calculated using the following formula:

Carbohydrates (%) = 100 - (Moisture (%) + Ash (%) + Crude protein (%) + Crude fat (%) + Crude fiber (%))

Energy value (kcal/100g)

The energy value of *Morinda citrifolia* fruits was estimated using the Atwater system. The energy value was calculated by multiplying the percentages of crude protein, crude fat, and carbohydrates by their respective energy factors (4 kcal/g for protein, 9 kcal/g for fat, and 4 kcal/g for carbohydrates) and summing the results.

Energy value (kcal/100g) = [(% crude protein × 4) + (% crude fat × 9) + (% carbohydrates × 4)]
This calculation provided the energy value in kcal per 100g of sample.

Antimicrobial activity (Daoud et al., 2015)

Antibacterial activity

The antibacterial activity of *Morinda citrifolia* fruits aqueous extract was assessed. Different concentrations (25, 50, 75 and 100 µl) of the extract were tested against various bacterial strains (*Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Salmonella typhi* and *Streptococcus pyogenes*) using

the agar well diffusion method. The zones of inhibition were measured and recorded as mean ± standard deviation.

Antifungal activity

The antifungal activity of *Morinda citrifolia* fruits aqueous extract was evaluated. Different concentrations (25, 50, 75 and 100 µl) of the extract were tested against various fungal strains (*Aspergillus flavus, Aspergillus niger, Aspergillus oryzae, Neurospora crassa* and *Trichophyton rubrum*) using the agar well diffusion method. The zones of inhibition were measured and recorded as mean ± standard deviation.

Results

In the proximate compositions such as moisture, ash, crude protein, crude fat, crude fiber, carbohydrates contents and energy value of *Morinda citrifolia* (L.) fruits were performed. In the present study revealed that the 85.2±1.12, 4.56±0.23, 3.12±0.15, 2.45±0.11, 5.67±0.34 and 73.2±2.56% of moisture, ash, crude protein, crude fat, crude fiber and carbohydrates contents presence in *M. citrifolia* fruits. Additionally, this study founded the 64.5±2.12kcal/100g of energy value from *M. citrifolia* fruits respectively (Table 1).

Table 1. Proximate analysis of *Morinda citrifolia* fruits

Name of the proximate contents	Quantity
Moisture content (%)	85.2±1.12
Ash content (%)	4.56±0.23
Crude protein (%)	3.12±0.15
Crude fat (%)	2.45±0.11
Crude fiber (%)	5.67±0.34
Carbohydrates (%)	73.2±2.56
Energy value (kcal/100g)	64.5±2.12

The values are expressed with Mean ± Standard deviation

The antibacterial activity of *Morinda citrifolia* fruit extract was carried out with common clinical bacteria such as *Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Salmonella typhi* and *Streptococcus pygenes* respectively. The *B. cereus* growth was inhibited with 12.2±0.39, 14.5±0.57, 16.1±0.98 and 21.4±0.63mm by 25, 50, 75 and 100µl of *M. citrifolia* fruit extracts.

Table 2. Antibacterial activity of *Morinda citrifolia* fruits aqueous extract

Name of the bacteria	Zone of inhibitions (mm)			
	25µl	50µl	75µl	100µl
Bacillus cereus	12.2±0.39	14.5±0.57	16.1±0.98	21.4±0.63
Escherichia coli	15.1±0.25	17.3±0.82	18.6±0.14	24.1±0.58
Klebsiella pneumoniae	10.3±0.69	15.8±0.12	19.1±0.67	25.3±0.84
Salmonella typhi	-	09.1±0.35	11.7±0.36	13.4±0.55
Streptococcus pyogenes	09.5±0.23	13.9±0.27	16.7±0.64	24.1±0.38

The values are expressed with Mean ± Standard deviation

Table 3. Antifungal activity of *Morinda citrifolia* fruits aqueous extract

Name of the fungi	Zone of inhibitions (mm)			
	25µl	50µl	75µl	100µl
Aspergillus flavus	16.7±0.33	17.1±0.52	18.8±0.26	19.2±0.54
Aspergillus niger	14.6±0.87	15.3±0.41	16.8±0.32	17.3±0.69
Aspergillus oryzae	-	10.8±0.17	11.4±0.38	13.2±0.99
Neurospora crassa	-	-	7.15±0.13	7.82±0.26
Trichophyton rubrum	-	12.9±0.38	14.1±0.64	15.8±0.71

The values are expressed with Mean ± Standard deviation

The 15.1±0.25, 17.3±0.82, 18.6±0.14 and 24.1±0.58mm zone of inhibitions were observed from *E. coli* at 25, 50, 75 and 100µl of *M. citrifolia* fruit extracts. In 25, 50, 75 and 100µl of *M. citrifolia* fruit extracts expressed 10.3±0.69, 15.8±0.12, 19.1±0.67 and 25.3±0.84mm zone of inhibitions against the *Klebsiella pneumoniae*. The *S. typhi* was observed with 09.1±0.35, 11.7±0.36 and 13.4±0.55mm zone of inhibitions at 50, 75 and 100µl of *M. citrifolia* fruit extracts. The 09.5±0.23, 13.9±0.27, 16.7±0.64 and 24.1±0.38mm zone of inhibitions

observed from *S. pyogenes by* the *M. citrifolia* fruit extracts at 25, 50, 75 and 100µl of concentrations respectively (Table 2; Fig. 1).

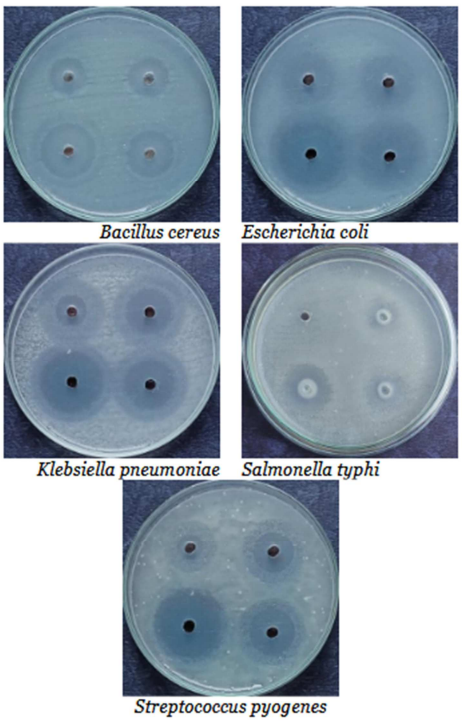

Fig. 1. Antibacterial activity of *Morinda citrifolia* fruits aqueous extract

The antifungal activity of *Morinda citrifolia* fruit extract was carried out with common clinical fungi such as *Aspergillus flavus, A. niger, A. oryzae, Neurospora crassa* and *Trichophyton rubrum* respectively. The *A. flavus* growth was inhibited with 16.7±0.33, 17.1±0.52, 18.8±0.26 and 19.2±0.54mm by 25, 50, 75 and 100µl of *M. citrifolia* fruit extracts. The 14.6±0.87, 15.3±0.41, 16.8±0.32 and 17.3±0.69mm zone of inhibitions were observed from *A. niger* at 25, 50, 75 and 100µl of *M. citrifolia* fruit extracts. In 50, 75 and 100µl of *M. citrifolia* fruit extracts expressed 10.8±0.17, 11.4±0.38 and 13.2±0.99mm zone of inhibitions against the *A. oryzae*. The *N. crassa* was observed with 7.15±0.13 and 7.82±0.26mm zone of inhibitions at 75 and 100µl of *M. citrifolia* fruit extracts. The 12.9±0.38, 14.1±0.64 and 15.8±0.71mm zone of inhibitions observed from *T. rubrum* by the *M. citrifolia* fruit extracts at 50, 75 and 100µl of concentrations respectively (Table 3; Fig. 2).

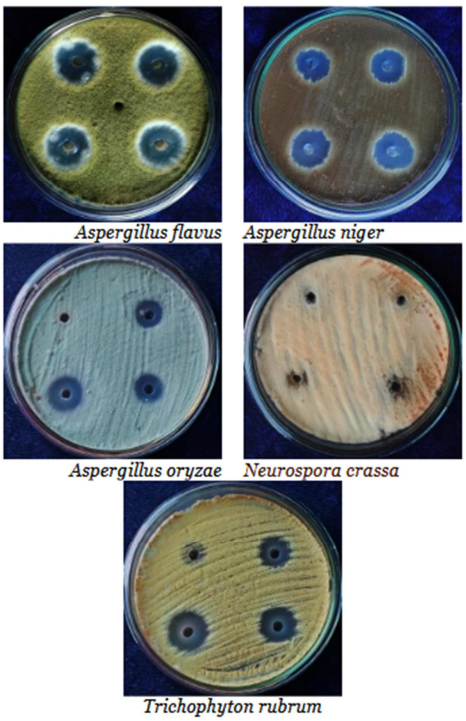

Fig. 2. Antifungal activity of *Morinda citrifolia* fruits aqueous extract

Discussion

Moisture content plays a crucial role in determining the nutritional value and shelf life of animal feeds and crude drugs (Thiex and Richardson, 2003). Low moisture levels can prevent chemical deterioration and microbiological contamination, while excessive moisture can lead to degradation of essential compounds and promote microbial growth. Ash values serve as important indicators of a sample's authenticity and purity (Aghedo and Ogbeide, 2022). In the context of *M. citrifolia*, the protein content is significant for its potential use as a nutritional supplement. Both noni seed and stem bark exhibit notable protein content, suggesting their potential as valuable protein sources. Lipids present in crude fat include various compounds such as triglycerides and phospholipids. Crude fiber, comprising indigestible components like cellulose and lignin, is essential for maintaining healthy digestion and reducing the risk of chronic diseases. Adequate dietary fiber intake offers numerous health benefits, underscoring the importance of fiber-rich foods and supplements (Chandaka *et al.*, 2022; Ogbeide *et al.,* 2024).

The present study investigated the proximate composition of *Morinda citrifolia* (L.) fruits, providing valuable insights into their nutritional content. Our findings revealed that the fruits contain 85.2% moisture, indicating a high water content that may contribute to their perishable nature. The ash content (4.56%) suggests the presence of essential minerals, while the crude protein (3.12%) and crude fat (2.45%) contents indicate a moderate level of macronutrients. The crude fiber content (5.67%) is notable, suggesting potential benefits for digestive health. The carbohydrate content (73.2%) is substantial, indicating that *M. citrifolia* fruits may serve as a valuable energy source. The energy value of 64.5 kcal/100g supports this notion. These findings have implications for the potential uses of *M. citrifolia* fruits in food, nutrition, and medicine. The nutritional profile suggests that the fruits could be utilized as a dietary supplement or ingredient in food products, providing essential nutrients and energy. Further research is warranted to explore the bioavailability and potential health benefits of these nutrients in *M. citrifolia* fruits.

A recent investigation evaluated the in vitro antibacterial activity of various *Morinda citrifolia* plant extracts, including fermented fruit, dried fruit, fresh fruit, root, and leaf, using ethanol and water as solvents. The study demonstrated that all five plant extracts exhibited antibacterial effects against a range of pathogenic bacteria, including both Gram-positive (*Listeria monocytogenes, Bacillus cereus* and *Enterococcus faecium*) and Gram-negative (*Klebsiella* sp., *Campylobacter* sp., *Vibrio cholerae*, *Yersinia enterocolitica*, *Shigella* sp. and *E. coli* ATCC 25922) strains. Notably, the antibacterial activity varied depending on the bacterial strain and the type of solvent used, highlighting the importance of extract preparation and bacterial susceptibility in determining the efficacy of *M. citrifolia* extracts as antibacterial agents (Frederick *et al.,* 2024).

Our results align with previous studies that have demonstrated the antibacterial properties of *M. citrifolia* fruit extracts (Sina *et al.,* 2021). These extracts have been shown to inhibit the growth of various bacteria, including *Staphylococcus aureus, Staphylococcus epidermidis, Micrococcus luteus, Streptococcus oralis, Enterococcus faecalis, Pseudomonas aeruginosa, Proteus mirabilis, Proteus vulgaris, Escherichia coli* and *Salmonella typhi*. The antibacterial effects are thought to be due to the presence of secondary metabolites such as polyphenols, alkaloids, and glycosides, which have been shown to exert inhibitory effects on bacterial growth. These findings support the potential use of *M. citrifolia* extracts as antibacterial agents (Srinivasahan and Durairaj, 2014).

The antibacterial activity of *Morinda citrifolia* leaf extracts has shown varying results. While some studies have reported no inhibition against certain bacteria, such as *Listeria monocytogenes, Enterococcus faecium, Campylobacter, Shigella* and *Klebsiella*, others have demonstrated significant antibacterial effects against a range of pathogens (Candida *et al.,* 2014).

For example, *M. citrifolia* leaf extracts have been shown to inhibit the growth of *Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa* and *Salmonella* (Usha *et al.,* 2010). The presence of phenolic compounds is thought to contribute to the antibacterial properties of *M. citrifolia*. Differences in extraction methods and processing may affect the potency of the leaf extracts, potentially influencing their antibacterial activity (Das *et al.,* 2021).

Studies have also highlighted the importance of solvents, such as ethanol and water, in extracting bioactive compounds from *M. citrifolia* leaves (Ademiluyi *et al.,* 2018).

The antibacterial activity of *Morinda citrifolia* fruit extract was evaluated against five common clinical bacterial strains. Our findings demonstrated that the extract exhibited significant antibacterial effects against all tested bacteria, including *Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Salmonella*

typhi and *Streptococcus pyogenes*. The zone of inhibition increased in a dose-dependent manner, with the highest concentration (100µl) of the extract showing the most pronounced antibacterial activity. Notably, the extract showed broad-spectrum antibacterial activity, inhibiting the growth of both Gram-positive (*B. cereus* and *S. pyogenes*) and Gram-negative (*E. coli, K. pneumoniae*, and *S. typhi*) bacteria. The most susceptible bacteria to the extract were *K. pneumoniae* and *E. coli,* with zone of inhibitions of 25.3mm and 24.1mm, respectively, at 100µl concentration. These findings suggest that *M. citrifolia* fruit extract possesses potent antibacterial compounds that could be explored as potential therapeutic agents against bacterial infections. The broad-spectrum activity of the extract highlights its potential as a valuable resource for the development of new antimicrobial agents. Further studies are warranted to identify the bioactive compounds responsible for the antibacterial activity and to evaluate their efficacy *in-vivo*.

Morinda citrifolia fruit extract has demonstrated antimicrobial activity against various microorganisms, including bacteria, fungi, and viruses. Studies have shown that the extract can inhibit the growth of *Candida albicans, Candida krusei, Staphylococcus aureus, Pseudomonas aeruginosa,* and *Bacillus subtilis* (Afiff and Amilah, 2017). The extract's antifungal activity against *C. albicans* has been reported to be dose-dependent, with higher concentrations exhibiting greater inhibitory effects. Research has also highlighted the potential of *M. citrifolia* extract as an alternative to traditional antifungal agents, particularly in the context of azole resistance in *Candida* species, including *C. albicans, C. parapsilosis, C. tropicalis, C. krusei* and *C. glabrata* (Susilawati *et al.,* 2023). The development of azole resistance in these fungal species poses a significant challenge in clinical settings, underscoring the need for novel antifungal agents (Barani *et al*., 2014; Whaley *et al.,* 2017).

The antifungal activity of *Morinda citrifolia* fruit extract was investigated against five common clinical fungal strains. Our results demonstrated that the extract exhibited significant antifungal effects against all tested fungi, including *Aspergillus flavus, A. niger, A. oryzae, Neurospora crassa* and *Trichophyton rubrum*. The zone of inhibition increased in a dose-dependent manner, with the highest concentration (100µl) of the extract showing the most pronounced antifungal activity. The extract showed broad-spectrum antifungal activity, inhibiting the growth of various *Aspergillus* species, as well as *N. crassa* and *T. rubrum*. *A. flavus* was found to be the most susceptible fungus to the extract, with a zone of inhibition of 19.2mm at 100µl concentration. These findings suggest that *M. citrifolia* fruit extract possesses potent antifungal compounds that could be explored as potential therapeutic agents against fungal infections. The broad-spectrum activity of the extract highlights its potential as a valuable resource for the development of new antifungal agents. Further studies are warranted to identify the bioactive compounds responsible for the antifungal activity and to evaluate their efficacy *in-vivo*. The results of this study contribute to the growing body of evidence supporting the medicinal properties of *M. citrifolia* and its potential applications in the treatment of fungal infections.

Conclusion

The study demonstrated that *Morinda citrifolia* fruits possess significant nutritional value and antimicrobial properties. The proximate composition analysis revealed high moisture and carbohydrate content, along with notable amounts of crude fiber and moderate energy value. The fruit extract exhibited potent antibacterial and antifungal activities against various clinical pathogens, suggesting its potential as a natural antimicrobial agent. These findings highlight the potential of *Morinda citrifolia* fruits as a valuable resource for nutrition and medicine.

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