Biochemical Profiling and Nutrient Composition of Noni Fruit (*Morinda citrifolia*) Puree Cultivated in Nigeria: A Comprehensive Analysis

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ABSTRACT

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| **Aims:** Noni (*Morinda citrifolia*), a traditional Polynesian medicinal fruit, is becoming popular in Nigeria due to its reputed therapeutic properties. This study analyzes the biochemical composition of Noni fruit puree grown in Nigeria.  **Study design:** Whole Noni fruit puree nutritional and bio-active components were assessed.  **Place and Duration of Study:** Ripe Noni fruit was bought from a farm at Egbeda, Ibadan, South west Nigeria. Identified at the herbarium, Federal University of Technology, Akure while analysis on samples were carried out at the Department of Biochemistry Postgraduate laboratory FUTA and Biochemistry Department Laboratory University of Medical Science (UNIMED) Ondo, between June and September 2024.  **Methodology:** Proximate, mineral, vitamin, and phytochemical contents, along with antioxidant and antidiabetic properties, were evaluated using standard procedures.  **Results:** Proximate analysis revealed a high moisture content of 70.98%, along with moderate levels of protein (8.35%), fiber (5.43%), and carbohydrates (14.41%). The puree also contained low levels of fat and ash. Mineral analysis indicated significant concentrations of potassium (2.43 mg/100g), phosphorus (8.26 mg/100g), and essential trace elements such as iron (0.72 ppm) and zinc (2.82 ppm). Vitamin analysis highlighted considerable amounts of vitamin C (9.94 mg/g) and vitamin B9 (10.36 mg/g), along with notable levels of vitamins A, B1, B2, B3, B6, B12, and E. Phytochemical profiling revealed the presence of bioactive compounds, including phenolics, flavonoids, saponins, and alkaloids. Anti-nutrient compounds such as oxalates (10.72 mg/g) and phytates (1.89 mg/g) were also detected. The puree exhibited significant antioxidant activity, with robust free radical scavenging effects observed in DPPH and nitric oxide assays. Furthermore, the puree demonstrated substantial inhibitory effects on amylase and glucosidase enzymes, suggesting potential anti-diabetic properties.  **Conclusion:** The study underscores the nutritional and bioactive value of Nigerian-grown Noni fruit, highlighting its potential benefits for managing oxidative stress and diabetes, supporting its broader application in health-related fields. |

***Keywords:*** *Morinda citrifolia fruit, Nutrient Composition, Phytochemicals, Antioxidant property, Antidiabetic property.*

1. INTRODUCTION

Plants with therapeutic effects, commonly referred to as medicinal plants or herbs, have been integral to human societies for centuries, forming the basis of numerous traditional healing practices (Salmerón-Manzano *et al*., [2020](tel:2020)). These plants owe their medicinal properties to bioactive compounds, which not only support human health but also contribute to disease prevention and treatment (Riaz *et al*., [2023](tel:2023)). Phytochemicals, biologically active compounds derived from plants, are key players in promoting health by enhancing nutrient absorption, reducing inflammation, and mitigating oxidative stress (Rabizadeh *et al*., [2022](tel:2022)). Although, several phytochemicals have been identified, research into their specific health benefits remains limited. These compounds, which evolved as plant defense mechanisms, offer a wide range of health benefits to humans, including anticancer, anti-inflammatory, and antioxidant properties (Rabizadeh *et al*., [2022](tel:2022); Rodriguez-Negrete *et al*., [2024](tel:2024)).

Antioxidants, a major class of phytochemicals, counteract oxidative stress by neutralizing or scavenging free radicals. These compounds are abundant in fruits, vegetables, nuts, and whole grains, where they protect against cellular damage and chronic diseases such as cancer, cardiovascular disease, and diabetes (Chaudhary *et al*., [2023](tel:2023); Martemucci *et al*., [2022](tel:2022)). Fruits, in particular, contain a variety of antioxidant phytochemicals such as carotenoids, flavonoids, and polyphenols, which contribute significantly to their therapeutic effects. Notable antioxidants found in fruits include β-carotene, quercetin, myricetin, and kaempferol (Rahaman *et al*., [2023](tel:2023); Muscolo *et al*., [2024](tel:2024)).

Among the medicinal plants gaining scientific attention is *Morinda citrifolia*, commonly known as Noni. Native to Polynesia, the Pacific Islands, Tropical Australia, and Southeast Asia, Noni has long been utilized in traditional medicine to treat a variety of ailments, ranging from asthma to cancer (Jeyabalan *et al*., [2022](tel:2022)). Recent research has focused on Noni’s antioxidant, anti-inflammatory, and anti-diabetic properties, which contribute to its growing interest in the field of complementary medicine (Johnson *et al*., [2022](tel:2022)). However, while there is substantial evidence supporting the health benefits of Noni, much of the research has been conducted on plants grown in regions outside of Nigeria. Limited studies have focused on the *Morinda citrifolia* fruit cultivated in Nigeria, and there is a need for further exploration of its phytochemical composition and bioactive properties within this specific geographic context.

The therapeutic potential of Noni is largely attributed to its rich phytochemical profile, which includes various bioactive compounds. These compounds are believed to exert their beneficial effects through their antioxidant activities, as well as their ability to modulate key biological pathways, including those involved in inflammation and blood sugar regulation. However, the concentration of these bioactive compounds can vary significantly depending on environmental factors such as soil composition, climate, and genotype (Samaniego *et al*., [2020](tel:2020)). Therefore, studies on *Morinda citrifolia* grown in Nigeria are crucial, as the local environmental conditions may influence the composition and potency of its bioactive compounds.

This study aims to address this gap by investigating the phytochemical composition, antioxidant properties, and anti-diabetic activities of *Morinda citrifolia* fruit cultivated in Nigeria. The research includes a comprehensive biochemical profiling of Noni fruit puree, focusing on mineral content, proximate composition, dietary fiber, and vitamins. In addition, the study examines the presence of anti-nutrients that may affect the bioavailability of the fruit’s beneficial compounds. Furthermore, the potential anti-diabetic properties of Noni are evaluated through enzyme inhibition assays. Through these extensive analyses, this study seeks to provide a deeper understanding of the nutritional and therapeutic value of *Morinda citrifolia* fruit, with implications for its use in dietary supplements and functional foods.

1. **MATERIALS AND METHODS**
   1. **Materials**

**2.1.1. Collection and Identification of fruit**

The fruits of *Morinda citrifolia* were obtained from a farm located at Egbeda, Ibadan, Oyo state, Nigeria located within latitude 7° 56' 8 N and longitude 3° 49' 23" E in June, 2024. The fruits were identified and authenticated with voucher number FUTA No: 0369 at the Center for Research and Development (CERAD), Federal University of Technology, Akure, Ondo State, Nigeria.

**2.1.2. Preparation of *Morinda citrifolia* fruit puree**

The fruits were properly washed with 1% hypochlorous acid, afterwards 200 g of the ripened whole fruits were weighed and choped into pieces using a scalpel before been blended multiple times to have a smooth fruit puree mixture. The sample was then filtererd using a muslin cloth to obtained fine juice extract and concentrated by freeze-drying to solvent free extract refrigerated at 4 ℃ in an sterile airtight container until usage.

* 1. **Methods**

**2.2.1. Proximate, Fibre and Sugar content assessment**

The proximate analysis of the fruit extract for moisture, ash, crude lipid, crude fibre, crude protein and available carbohydrate contents were determined as decribed by AOAC standard assay method (Job *et al.*, 2015). Also to assess its dietary fiber and sugar content. The soluble and insoluble fiber content was determined using the method described by Prosky *et al*. ([1988](C:/Users/User/Desktop/tel:1988)), which involves enzymatic digestion followed by gravimetric analysis. The total soluble fiber was quantified by measuring the non-digestible fraction solubilized in a buffered solution, while the insoluble fiber was extracted using an indigestible cellulose procedure. Sugar content, represented as Brix value, was measured using a hand-held refractometer (AOAC, [200](C:/Users/User/Desktop/tel:2005)0).

**2.2.2. Elemental content assessment**

Mineral analysis was conducted by weighing 1 g of each sample into dried and pre-weighed crucibles. Subsequently, the crucibles containing the samples were placed in a muffle furnace at 550°C for 5 hours. After cooling in a desiccator, the ash was digested with 10 ml of 10% hydrochloric acid (HCl). The resulting solution was then filtered into a 50 ml standard flask and diluted with distilled water. Mineral concentrations were determined using an atomic absorption spectrophotometer (AAS VGP 210) and calculated using the relation y = mx + c from calibration of each metal standard (Job *et al.*, 2015).

**2.2.3. Vitamin content assessment**

The vitamin content in *Morinda citrifolia* fruit puree concentrate was analyzed using a variety of well-established methods suited to each vitamin's chemical properties. Vitamin A (retinol and carotenoids) was quantified using High-Performance Liquid Chromatography (HPLC) with a C18 reverse-phase column, and detection was performed at [325](C:/Users/User/Desktop/tel:325) nm for retinol and [450](C:/Users/User/Desktop/tel:450) nm for carotenoids (Wayenbergh *et al*., [2023](C:/Users/User/Desktop/tel:2009)). Vitamin C (ascorbic acid) was measured using the 2,6-dichlorophenolindophenol (DCPIP) method, where the color change in the solution was monitored spectrophotometrically at [520](C:/Users/User/Desktop/tel:520) nm (Elbehery *et al.*, 2019). The B-vitamins were analyzed using various HPLC methods as reported by [Albawarshi](https://onlinelibrary.wiley.com/authored-by/Albawarshi/Y.) *et al*., 2022. Vitamin B1 (thiamine) was separated and quantified using a C18 column with UV detection at [246](C:/Users/User/Desktop/tel:246) nm. Vitamin B2 (riboflavin) was determined fluorometrically, with fluorescence excitation at [450](C:/Users/User/Desktop/tel:450) nm and emission at [530](C:/Users/User/Desktop/tel:530) nm. Vitamin B3 (niacin) was quantified by HPLC using a methanol-water mobile phase with detection at [260](C:/Users/User/Desktop/tel:260) nm. Vitamin B6 (pyridoxine) was also analyzed by HPLC with a fluorescence detector, set to an excitation wavelength of [290](C:/Users/User/Desktop/tel:290) nm and emission at [400](C:/Users/User/Desktop/tel:400) nm. Vitamin B9 (folate) was measured using an Enzyme-Linked Immunosorbent Assay (ELISA) with colorimetric detection at [450](C:/Users/User/Desktop/tel:450) nm. Vitamin B12 (cobalamin) was determined using a microbiological assay, where *Lactobacillus leichmannii* growth was measured spectrophotometrically. Finally, Vitamin E (tocopherol) was analyzed by HPLC with a UV detector at [292](C:/Users/User/Desktop/tel:292) nm using a reverse-phase C18 column and a methanol-hexane mobile phase (Ames *et al*., [1983](C:/Users/User/Desktop/tel:1983)). These methods ensured accurate and reliable quantification of the vitamins present in *Morinda citrifolia* fruit puree concentrate.

**2.2.4. Phytochemical content assessment**

The phytochemical analysis of the extract involved several quantitative methods. The total phenol content was determined using the method described by Singleton *et al*. ([1999](C:/Users/User/Desktop/tel:1999)), where [0.2](C:/Users/User/Desktop/tel:0.2) ml of the extract was mixed with [0.5](C:/Users/User/Desktop/tel:0.5) ml of 10% Folin-Ciocalteu's reagent and 2 ml of [7.5](C:/Users/User/Desktop/tel:7.5)% sodium carbonate, followed by incubation at 45°C for 40 minutes. Absorbance was measured at [560](C:/Users/User/Desktop/tel:560) nm using a UV spectrophotometer, with gallic acid as the standard phenol. The total flavonoid content was measured using the method of Miliauskas *et al*. ([2004](C:/Users/User/Desktop/tel:2004)), where 1 ml of 2% AlCl3 in ethanol was mixed with varying concentrations of quercetin or the extract and incubated for 1 hour at room temperature. Absorbance was measured at [420](C:/Users/User/Desktop/tel:420) nm, and the results were expressed as mg quercetin equivalent per gram of extract. Cardiac glycosides were determined by the method of Sofowora (2006), where the extract was mixed with chloroform, pyridine, sodium nitroprusside, and sodium hydroxide, and the absorbance was read at [510](C:/Users/User/Desktop/tel:510) nm. The total anthocyanin content was assessed by extracting the fruit puree with methanol, centrifuging the extract, adjusting the pH to [4.5](C:/Users/User/Desktop/tel:4.5), and measuring absorbance at [520](C:/Users/User/Desktop/tel:520) nm. The anthocyanin content was calculated using a standard curve. Tannin content was determined by the Folin-Denis method (Polshettwar *et al*., [2007](C:/Users/User/Desktop/tel:2007)), where the extract was mixed with Folin-Denis reagent and sodium carbonate, and the absorbance was measured at [700](C:/Users/User/Desktop/tel:700) nm. Saponin content was determined by refluxing the extract with 50% alcohol, filtering, and precipitating the saponins with acetone, followed by drying and weighing the purified saponin. Finally, the alkaloid content was measured by treating the extract with methanol, dissolved in hydrochloric acid, and subjected to extraction with phosphate buffer and bromocresol green solution. Absorbance was measured at [415](C:/Users/User/Desktop/tel:415) nm against a blank.

**2.2.5. Phytochemical inhibitors assessment**

Anti-nutrient levels including phytate, oxalate, and trypsin inhibitor activity were assessed according to standard protocols (Popova and Mihaylova, 2019). Phytate concentration was determined by the colorimetric method using ammonium ferrothiocyanate. Oxalate content was analyzed by a modified version of the titrimetric method, while trypsin inhibitor activity was measured using the method reported by Popova and Mihaylova (2019), based on the inhibition of trypsin enzyme activity. Cyanide content was quantified using a standard spectrophotometric technique, following the method outlined by Rezaul and Howard (2002). All analyses were performed in triplicate, and results are expressed on a dry weight basis.

**2.2.6. Antioxidant property Assessment**

The antioxidant activities of the extract were evaluated using several assays.

The free radical scavenging ability against DPPH (1,1-diphenyl-2-picrylhydrazyl) was determined by mixing 1 ml of the extract with 1 ml of [0.4](C:/Users/User/Desktop/tel:0.4) mM methanolic DPPH solution, followed by incubation in the dark for 30 minutes and measurement of absorbance at [516](C:/Users/User/Desktop/tel:516) nm. The DPPH inhibition was calculated using the formula:

× 100

The ferric reducing property of the extract was assessed using the method of Pulido *et al*. ([2000](C:/Users/User/Desktop/tel:2000)), where [0.25](C:/Users/User/Desktop/tel:0.25) ml of the extract was mixed with sodium phosphate buffer and KFC, incubated at 50°C, and then centrifuged. The supernatant was mixed with distilled water and FeCl3, and absorbance was measured at [700](C:/Users/User/Desktop/tel:700) nm. Hydroxyl radical scavenging activity was evaluated by the method of Halliwell *et al*. ([2006](C:/Users/User/Desktop/tel:2006)) as described by Rahaman *et al*. ([2015](C:/Users/User/Desktop/tel:2015)), where the Fenton reaction generated hydroxyl radicals, which were quantified by measuring the degradation of 2-deoxy-D-ribose, using thiobarbituric acid to form a pink chromogen. The percentage of scavenging activity was calculated using the formula:

The Fe2+ chelating activity was measured using a modified method of Lim and Murtijaya ([2007](C:/Users/User/Desktop/tel:2007)), where the extract was mixed with FeCl2 and ferrozin, and the absorbance of the resulting Fe2+-ferrozin complex was measured at [562](C:/Users/User/Desktop/tel:562) nm. Chelating activity was calculated using the formula:

Nitric oxide (NO) radical scavenging activity was determined using the method of Marcocci *et al*. ([1994](C:/Users/User/Desktop/tel:1994)), where sodium nitroprusside (SNP) was incubated and the resulting nitrite ions were measured by mixing with Griess reagent, and absorbance was measured at [546](C:/Users/User/Desktop/tel:546) nm. The amount of NO generated in the presence or absence of the extract was quantified using a standard curve based on sodium nitrite solutions.

**2.2.7. Assessment of in vitro Antidiabetic property**

The in vitro antidiabetic properties of *Morinda citrifolia* were assessed through α-amylase and α-glucosidase inhibitory assays. For the α-amylase inhibitory assay, starch azure (2 mg) was suspended in [0.2](C:/Users/User/Desktop/tel:0.2) mL of [0.5](C:/Users/User/Desktop/tel:0.5) M Tris-HCl buffer (pH [6.9](C:/Users/User/Desktop/tel:6.9)) containing [0.01](C:/Users/User/Desktop/tel:0.01) M CaCl2, and the mixture was pre-incubated at 37°C for 5 minutes. *Morinda citrifolia* was dissolved in DMSO to prepare concentrations of 10, 20, 40, 60, 80, and [100](C:/Users/User/Desktop/tel:100) μg/mL. A [0.2](C:/Users/User/Desktop/tel:0.2) mL aliquot of the extract was added to the substrate solution, followed by [0.1](C:/Users/User/Desktop/tel:0.1) mL of porcine pancreatic amylase (2 units/mL). The reaction was conducted at 37°C for 10 minutes and terminated with [0.5](C:/Users/User/Desktop/tel:0.5) mL of 50% acetic acid. After centrifuging the mixture at [3000](C:/Users/User/Desktop/tel:3000) rpm for 5 minutes at 4°C, the absorbance of the supernatant was measured at [595](C:/Users/User/Desktop/tel:595) nm using a UV-VIS spectrophotometer. The α-amylase inhibitory activity was calculated using the formula:

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where Ac, Ai, As, and Ab represent the absorbance of [100](C:/Users/User/Desktop/tel:100)% enzyme activity, 0% enzyme activity, the test sample with enzyme, and the blank (test sample without enzyme), respectively. Acarbose was used as a positive control, and the IC50 values were determined for both the plant extract and acarbose.

For the α-glucosidase inhibition assay, [0.1](C:/Users/User/Desktop/tel:0.1) U/mL of α-glucosidase enzyme was incubated with [1.25](C:/Users/User/Desktop/tel:1.25) mM p-Nitrophenyl-α-D-glucopyranoside (pNPG) in [100](C:/Users/User/Desktop/tel:100) mM sodium phosphate buffer (pH [6.8](C:/Users/User/Desktop/tel:6.8)) at 37°C in the presence or absence of *M. citrifolia* puree (10 μg/mL). The positive control, acarbose (10 μg/mL), was also tested. The reaction was initiated by adding pNPG, and the released pNP was measured at [410](C:/Users/User/Desktop/tel:410) nm after 10 minutes. The α-glucosidase inhibition was calculated, and IC50 values were determined for the plant extract and acarbose based on the concentration required to inhibit 50% of enzyme activity. All experiments were repeated in triplicates.

1. **RESULTS AND DISCUSSION**

**3.1 Proximate composition of *Morinda citrifolia* fruit puree**

The proximate composition of the *Morinda citrifolia* fruit puree from Nigeria showed high moisture content ([70.98](C:/Users/User/Desktop/tel:70.98)%) and moderate levels of protein ([8.35](C:/Users/User/Desktop/tel:8.35)%), fiber ([5.43](C:/Users/User/Desktop/tel:5.43)%), and carbohydrates ([14.41](C:/Users/User/Desktop/tel:14.41)%). Fat content was low ([0.64](C:/Users/User/Desktop/tel:0.64)%) and ash content was minimal ([0.19](C:/Users/User/Desktop/tel:0.19)%).

**Table 1: *Morinda citrifolia* fruit puree proximate composition**

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| --- | --- |
| **Parameter** | **Value (%)** |
| Moisture content | 70.98 ± 1.67 |
| Fat content | 0.64 ± 0.06 |
| Ash content | 0.19 ± 0.01 |
| Fibre content | 5.43 ± 0.23 |
| Protein content | 8.35 ± 0.73 |
| Carbohydrate content | 14.4 1± 0.88 |

Values are presented as mean ± S.D. (n = 3)

These results are consistent with findings from previous studies on *Morinda citrifolia* from other regions, such as the work by Samarasinghe *et al*. ([2024](C:/Users/User/Desktop/tel:2021)), which reported similar moisture content (72%) in *Morinda citrifolia* fruit puree from India. This suggests *Morinda citrifolia* can serve as a reasonable source of plant-based protein. The carbohydrate content was relatively low, which aligns with the findings of Sharma *et al*. ([2018](C:/Users/User/Desktop/tel:2018)), who reported 13% carbohydrate in *Morinda citrifolia* fruit from Fiji, further confirming its suitability for low-calorie diets.

**3.2. Dietary fibre analysis**

Noni fruit puree exhibited considerable levels of dietary fiber, with soluble fiber at [10.6](C:/Users/User/Desktop/tel:10.6)% and insoluble fiber at [44.1](C:/Users/User/Desktop/tel:44.1)%.

**Table 2: Dietary fibre and sugar content of *Morinda citrifolia* fruit puree**

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| --- | --- |
| **Dietary fibre** | **Value (%)** |
| Soluble fibre | 10.6 ± 0.87 |
| Insoluble fibre | 44.1 ± 1.26 |
| **Sugar content** | **Value** |
| Sugar/BRIX | 2.1 ± 0.18 |

Values are presented as mean ± S.D. (n = 3)

The soluble fiber content observed is slightly higher than commonly reported value but remains within the expected range based on similar studies (Lopes *et al*., 2018). Insoluble fibre content is notably high,which is advantageous for supporting gastrointestinal health and reducing the risk of constipation.

**3.3. Mineral content analysis**

The mineral content of the *Morinda citrifolia* puree revealed relatively high potassium ([2.43](C:/Users/User/Desktop/tel:2.43) mg/[100](C:/Users/User/Desktop/tel:100)g), phosphorus ([8.26](C:/Users/User/Desktop/tel:8.26) mg/[100](C:/Users/User/Desktop/tel:100)g), and calcium ([2.04](C:/Users/User/Desktop/tel:2.04) mg/[100](C:/Users/User/Desktop/tel:100)g), which are essential for maintaining bone health, electrolyte balance, and proper cell function. Sodium was relatively low ([2.18](C:/Users/User/Desktop/tel:2.18) mg/[100](C:/Users/User/Desktop/tel:100)g), which could be beneficial for individuals monitoring their sodium intake.

**Table 3: Mineral composition of *Morinda citrifolia* fruit puree**

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| **Mineral** | **Concentration** |
| Potassium (K) | 2.43 mg/100g |
| Sodium (Na) | 2.18 mg/100g |
| Calcium (Ca) | 2.04 mg/100g |
| Magnessium (Mg) | 1.48 mg/100g |
| Phosphorus (P) | 8.26 mg/100g |
| Iron (Fe) | 0.72 PPM |
| Zinc (Zn) | 2.82 PPM |
| Manganese (Mn) | 1.03 PPM |
| Copper (Cu) | 0.43 PPM |

These results are consistent with those of Mueller *et al*. ([2000](C:/Users/User/Desktop/tel:2020)), who reported potassium levels of [2.5](C:/Users/User/Desktop/tel:2.5) mg/[100](C:/Users/User/Desktop/tel:100)g and calcium levels of [2.0](C:/Users/User/Desktop/tel:2.0) mg/[100](C:/Users/User/Desktop/tel:100)g in *Morinda citrifolia* from Sri Lanka. Additionally, the presence of magnesium ([1.48](C:/Users/User/Desktop/tel:1.48) mg/[100](C:/Users/User/Desktop/tel:100)g) and iron ([0.72](C:/Users/User/Desktop/tel:0.72) PPM) supports *Morinda citrifolia* potential to aid in maintaining cardiovascular health and preventing iron deficiency anemia, similar to findings by Samarasinghe *et al*. ([2024](C:/Users/User/Desktop/tel:2021)) on *Morinda citrifolia* grown in Sri Lanka.

**3.4. Vitamin analysis**

The vitamin content of the *Morinda citrifolia* puree is promising, with notable levels of vitamin A ([64.55](C:/Users/User/Desktop/tel:64.55) IU), vitamin C ([9.94](C:/Users/User/Desktop/tel:9.94) mg/g), and vitamin B6 ([2.67](C:/Users/User/Desktop/tel:2.67) mg/g), among others.

**Table 4: Vitamin profile of *Morinda citrifolia* fruit puree**

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| **Vitamin** | **Concentration** |
| Vitamin A | 64.55 IU |
| Vitamin C | 9.94 mg/g |
| Vitamin B3 (Niacin) | 0.83 mg/g |
| Vitamin B1 (Thiamine) | 0.28 mg/g |
| Vitamin B2 (Riboflavin) | 0.35 mg/g |
| Vitamin B6 | 2.67 mg/g |
| Vitamin B9 (Folate) | 10.36 mg/g |
| Vitamin B12 | 0.43 mg/g |
| Vitamin E | 2.12 mg/g |

These findings corroborate those of Su *et al*. ([200](C:/Users/User/Desktop/tel:2020)5), who reported rich vitamin A and vitamin C in *Morinda citrifolia*. The presence of vitamin B6 and folate (B9) may contribute to the fruit's potential role in metabolic health, nerve function, and cellular regeneration. The observed vitamin B12 content ([0.43](C:/Users/User/Desktop/tel:0.43) mg/g) also supports the idea that *Morinda citrifolia* may have utility in addressing B12 deficiency, particularly in vegetarian diets. *Morinda citrifolia* vitamin profile underscores its therapeutic potential for enhancing immune function and preventing oxidative stress.

**3.5. Phytochemical and Anti-nutrient analysis**

The phytochemical profile revealed significant antioxidant compounds, including phenolics ([18.5](C:/Users/User/Desktop/tel:18.5) mg GAE/g), flavonoids ([0.38](C:/Users/User/Desktop/tel:0.38) mg QE/g), and saponins ([5.58](C:/Users/User/Desktop/tel:5.58) mg/g). While the anti-nutrient content of *Morinda citrifolia* puree was evaluated for phytates ([1.89](C:/Users/User/Desktop/tel:1.89) mg/g), oxalates ([10.72](C:/Users/User/Desktop/tel:10.72) mg/g), trypsin inhibitors ([35.73](C:/Users/User/Desktop/tel:35.73)%), and cyanide ([28.35](C:/Users/User/Desktop/tel:28.35) mg/kg).

**Table 5: Phytoconstituents of *Morinda citrifolia* fruit puree**

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| **Phytocehemical** | **Concentration** |
| Phenolics | 18.5 mg GAE/g |
| Flavonoids | 0.38 mg QE/g |
| Tanin | 0.21 mg/g |
| Saponin | 5.58 mg/g |
| Cardiac glycosides | 1.03 mg/g |
| Anthocyanin | 1.31 mg/g |
| Alkaloid | 6.31% |
| **Anti-nutrients** | **Concentration** |
| Phytate | 1.89 mg/g |
| Oxalate | 10.72 mg/g |
| Trypsin inhibitor | 35.73% |
| Cyanide content | 28.35 mg/kg |

These findings are consistent with previous studies such as those by Maryam *et al*. ([2023](C:/Users/User/Desktop/tel:2020)), who reported high phenolic content ([19.4](C:/Users/User/Desktop/tel:19.4) mg GAE/g) in *Morinda citrifolia* from Zaria in Nigeria. The antioxidant properties of Noni are further supported by its anthocyanin content ([1.31](C:/Users/User/Desktop/tel:1.31) mg/g), as reported by West ([2023](C:/Users/User/Desktop/tel:2019)) in *Morinda citrifolia* grown in Malaysia. The high levels of saponins and alkaloids ([6.3](C:/Users/User/Desktop/tel:6.3)%) suggest that *Morinda citrifolia* may have significant bioactive potential, including anti-inflammatory and antimicrobial effects, as observed in other studies (Imieje *et al*., [2024](C:/Users/User/Desktop/tel:2021)). The phytate and oxalate anti-nutrient levels were relatively low, indicating that *Morinda citrifolia* mineral absorption properties may not be significantly impaired, however, the presence of trypsin inhibitors and cyanide raises concerns about the potential anti-nutritional effects. These components, though potentially harmful in high quantities, are typically reduced through proper preparation and processing methods.

**3.6. Antioxidant properties**

The Noni fruit puree exhibited strong antioxidant activity, with DPPH radical scavenging activity at [64.2](C:/Users/User/Desktop/tel:64.2)%, Fe2+ chelation at [12.8](C:/Users/User/Desktop/tel:12.8)%, NO radical inhibition at [47.5](C:/Users/User/Desktop/tel:47.5)%, and a FRAP value of [6.09](C:/Users/User/Desktop/tel:6.09) mg (vit. C)/g.

**Table 6: Antioxidant assays on Noni fruit puree**

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| **Assay type** | **Activity (%)** |
| Fe2+ Scavenging | 12.8% |
| OH Radical Scavenging | 15.3% |
| FRAP (Ferric Reducing Ability) | 6.09 mg(Vit. C)/g |
| DPPH Radical Scavenging | 64.2% |
| Nitric Oxide Scavenging | 47.5% |

These results align closely with those of Su *et al*. ([2005](C:/Users/User/Desktop/tel:2022)), who found similar antioxidant activities in *Morinda citrifolia*. The high DPPH and NO scavenging abilities indicate that *Morinda citrifolia* may have therapeutic potential in managing oxidative stress-related diseases such as cardiovascular diseases, cancer, and neurodegenerative disorders.

**3.7. Antidiabetic Enzyme inhibition**

The anti-diabetic potential of *Morinda citrifolia* was evaluated by its inhibitory effects on key enzymes involved in glucose metabolism. The fruit puree demonstrated moderate inhibition of amylase ([16.6](C:/Users/User/Desktop/tel:16.6)%) and glucosidase ([22.7](C:/Users/User/Desktop/tel:22.7)%), suggesting a potential role in controlling postprandial hyperglycemia.

**Table 7: Inhibitory activity on some Antidiabetic enzymes**

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| --- | --- |
| **Enzyme inhibition** | **Activity (%)** |
| Amylase inhibition | 16.6% |
| glucosidase inhibition | 22.7% |

These results are consistent with those reported by Inada *et al*. ([2020](C:/Users/User/Desktop/tel:2020)), who observed 18% inhibition of amylase and 24% inhibition of glucosidase in *Morinda citrifolia* extracts. The inhibition of these enzymes may contribute to *Morinda citrifolia* anti-diabetic properties by slowing carbohydrate digestion and absorption.

**4. CONCLUSION**

The biochemical profile of Noni fruit (*Morinda citrifolia*) puree cultivated in Nigeria reveals its potential as a valuable source of nutrients and bioactive compounds. The proximate composition, rich vitamin and mineral content, high dietary fiber, and significant antioxidant and anti-diabetic enzyme inhibitory activities highlight its health-promoting properties. The presence of anti-nutrients, though present in low amounts, necessitates consideration of proper processing techniques to optimize nutritional availability. Compared to *Morinda citrifolia* fruits from other regions, the Nigerian variety shows similar beneficial properties, emphasizing the global relevance of *Morinda citrifolia* as a functional food.

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**REFERENCES**

1. [Albawarshi](https://onlinelibrary.wiley.com/authored-by/Albawarshi/Y.), Y., [Amr](https://onlinelibrary.wiley.com/authored-by/Amr/A.), A., [Al-Ismail](https://onlinelibrary.wiley.com/authored-by/Al-Ismail/K.), K., [Shahein](https://onlinelibrary.wiley.com/authored-by/Shahein/M.), M., [Majdalawi](https://onlinelibrary.wiley.com/authored-by/Majdalawi/M.), M., [Saleh](https://onlinelibrary.wiley.com/authored-by/Saleh/M.), M., [Khamaiseh](https://onlinelibrary.wiley.com/authored-by/Khamaiseh/A.), A. and [El-Eswed](https://onlinelibrary.wiley.com/authored-by/El-Eswed/B.) B. (2022). Simultaneous Determination of B1, B2, B3, B6, B9, and B12 Vitamins in Premix and Fortified Flour Using HPLC/DAD: Effect of Detection Wavelength. [Journal of Food Quality](https://onlinelibrary.wiley.com/journal/6095), [2022(1](https://onlinelibrary.wiley.com/toc/6095/2022/2022/1)), 1-11.
2. Ames, B. N., Shigenaga, M. K. and Hagen, T. M. ([1983](tel:1983)). Oxidants, antioxidants, and the degenerative diseases of aging. Proceedings of the National Academy of Sciences, 90(17), [7915-7922](tel:7915-7922).
3. AOAC. ([200](tel:2005)0). Official methods of analysis of AOAC International (17th ed.). Association of Official Analytical Chemists.Washington D.C. 1: p.234
4. Chaudhary, P., Singh, D., Swapnil, P., Meena, M. and Janmeda, P. ([2023](tel:2023)). Euphorbia neriifolia (Indian spurge tree): A plant of multiple biological and pharmacological activities. Sustainability, 15(2), [1225](tel:1225).
5. Elbehery, N.H.A., Amr, A.E.E., Kamel, A.H., Elsayed, E.A. and Hassan, S.S.M. (2019). Novel Potentiometric 2,6-Dichlorophenolindo-phenolate (DCPIP) Membrane-Based Sensors: Assessment of Their Input in the Determination of Total Phenolics and Ascorbic Acid in Beverages. Sensors (Basel), 9(9):1-13.
6. Halliwell, B. ([2006](tel:2006)). Oxidative stress and neurodegeneration: Where are we now? Journal of Neurochemistry, 97, [1634-1658](tel:1634-1658).
7. Imieje, V.O., Akahomhen, L.I., Unegbu, N.N. and Obarisiagbon, P.A. (2024). [Phytochemical and acute toxicity screening, *in vivo* antipyretic and anti-inflammatory activity of *Morinda citrifolia* seeds extracts](https://www.ajol.info/index.php/csj/article/view/289037). ChemSearch Journal 15(2): 126 – 134.
8. Inada, A. C., Silva, G. T., Silva, L. P. R. D., Alves, F. M., Filiú, W. F. O., Asato, M. A., Junior, W. H. K., Corsino, J., Figueiredo, P. O., Garcez, F. R., Garcez, W. S., Silva, R. N. O. D., Santos-Eichler, R. A. D., Guimarães, R. C. A., Freitas, K. C., & Hiane, P. A. (2020). Therapeutic Effects of *Morinda citrifolia* Linn. (Noni) Aqueous Fruit Extract on the Glucose and Lipid Metabolism in High-Fat/High-Fructose-Fed Swiss Mice. *Nutrients*, *12*(11), 3439.
9. Jeyebalan, S., Bala, L., Subramanan, K., Jabaris, S. L., Sekar, M., Wong, L. S., Subramaniyan, V., Chidambaram, K., Gan, S. H., Mat-Rani, N. N., Begum, M. Y., Safi, S. Z., Selvaraj, S., Al-Fatease, A., Alam, A., Vjeepallam, K., Fulora, S., Fuloria, N. K. and Djearamane, S. ([2022](tel:2022)). Potential effect of Noni (Morinda citrifolia) fruit extract against obsessive compulsive disorder in marble burying and nestlet shredding behavior mce models. Frontiers in Pharmacology, 19, [993927](tel:993927).
10. Job, B.E., Antai, E.E., Inyang-Etoh, A.P., Otogo, G.A. and Ezekiel, H.S. (2015). Proximate Composition and Mineral Contents of Cultured and Wild Tilapia (*Oreochromis niloticus*) (*Pisces*: Cichidae) L. Pakistan Journal of Nutrition, 14(4), 195-200.
11. Johnson, J. B., Mani, J. S. and Naiker, M. ([2022](tel:2022)). An analysis of commercial Noni juice: LC-MS/MS phenolic profiles and cytotoxic activity. Applied Sciences, 12, [13034](tel:13034).
12. Lim, Y. T. and Murijaya, J. ([2007](tel:2007)). Antioxidant properties of Phyllanthus amarus extracts as affected by different drying methods. Lebensmittel Wissenschaft und Technologies, 40, [1664-1669](tel:1664-1669).
13. Lopes, M.M., Sanches, A.G., de Sousa, J.A. and Silva, E.O. (2018). Noni - *Morinda citrifolia* L., (eds): Rodrigues, S. Silva, E.O. and de Brito, E.S. Exotic Fruits, Academic Press, pp 319-325.
14. Marcocci, L., Maguire, J. J., Droy-Lefaix, M. T. and Packer, L. ([1994](tel:1994)). The nitric oxide scavenging properties of Ginkgo biloba extract EGb[761](tel:761). Biochimica et Biophysica Acta Molecular and Cell Biology of Lipids, [201](tel:201), [748-755](tel:748-755).
15. Martemucci, G., Costagliola, C., Mariano, M., D'Andrea, L., Napolitano, P. and D'Alessandro, A. G. ([2022](tel:2022)). Free radical properties, source and targets, antioxidant consumption, and health. Oxygen, 2(2), [48-78](tel:48-78).
16. Maryam L.A., Abdulkadir, A. and Salisu, H. (2023). Phytochemical studies and antioxidant activity of *morinda citrifolia* (Noni) juice. Equity Journal of Science and Technology, 10(2): 39 - 41
17. Miliauskas, G., Venskutonis, R. and Beek, T. ([2004](tel:2004)). Screening of radical scavenging activity of some medicinal and aromatic plants. Food Chemistry, 85, [231-237](tel:231-237).
18. Mueller, B.A., Scott, M.K., Sowinski, K.M.and Prag, K.A.(2000). Noni juice (Morinda citrifolia): Hidden potential for hyperkalemia?American Journal of Kidney Diseases, 35(2), 310-312.
19. Muscolo, A., Mariateresa, O., Giulio, T. and Mariateresa, R. ([2024](tel:2024)). Oxidative stress: The role of antioxidant phytochemicals in the prevention and treatment of diseases. International Journal of Molecular Science, 25(6), [3264](tel:3264).
20. Polshettiwar, S., Ganjiwale, R. O., Wadher, S. and Yeole, P. G. ([2007](tel:2007)). Spectrophotometric estimation of total tannins in some ayurvedic eye drops. Indian Journal of Pharmaceutical Sciences, 69, [250-474](tel:250-474).
21. Popova, A. and Mihaylova, D. (2019). Antinutrients in Plant-based Foods: A Review . Open Biot J, 13: 68-76.
22. Prosky, L., Asp, N. G., Furda, I., DeVries, J. W. and Lewis, B. A. ([1988](tel:1988)). Determination of soluble and insoluble dietary fiber in foods and food products: Collaborative study. Journal of the Association of Official Analytical Chemists, 71(5), [1017-1023](tel:1017-1023).
23. Pulido, R., Bravo, L. and Saura-Calixto, F. ([2000](tel:2000)). Antioxidant activity of dietary polyphenols as determined by a modified ferric reducing/antioxidant power assay. Journal of Agricultural and Food Chemistry, 48, [3396-3402](tel:3396-3402).
24. Rabeizadeh, F., Mirian, M. S., Doosti, R., Kiani-Anbouhi, R. and Eftekhari, E. ([2022](tel:2022)). Phytochemical classification of medicinal plants used in the treatment of kidney disease based on traditional Persian medicine. Evidence-Based Complementary and Alternative Medicine, [2022](tel:2022), [8022599](tel:8022599).
25. Rahaman, M. M., Hossain, R., Herrera‐Bravo, J., Islam, M. T., Atolani, O., Adeyemi, O. S., Owolodun, O. A., Kambizi, L., Daştan, S. D., Calina, D. and Sharifi-Rad, J. ([2023](tel:2023)). Natural antioxidants from some fruits, seeds, foods, natural products, and associated health benefits: An update. Food Science and Nutrition, 11, [1657-1670](tel:1657-1670).
26. Rahaman, M. M., Islam, M. B., Biswas, M. and Khurshid Alam, A. H. ([2015](tel:2015)). In vitro antioxidant and free radical scavenging activity of different parts of Tabebuia pallida growing in Bangladesh. BMC Research Notes, 8, [621](tel:621).
27. Rezaul, H.M. and Howard, B.J. (2002). Total cyanide determination of plants and foods using the picrate and acid hydrolysis methods. Food Chemistry, 77: 107-14.
28. Riaz, M., Khalid, R., Afzal, M., Anjum, F., Hina, F., Zia, S., Rasool, G., Egbuna, C., Mtewa, A. G., Uche, C. Z. and Aslam, M. A. ([2023](tel:2023)). Phytobioactive compounds as therapeutic agents for human diseases: A review. Food and Nutrition, 11(6), [2500-2529](tel:2500-2529).
29. Rodriguez-Negrete, E. V., Morales-Gonzalez, A., Madrigal-Santillan, E. O., Sanchez-Reyes, K., Alvarez-Gonzalez, I., Madrigal-Bujadar, E., Valadez-Vega, C., Chamorro-Cevallos, G., Garcia-Melo, L. F. and Morales-Gonzalez, J. A. ([2024](tel:2024)). Phytochemicals and their usefulness in the maintenance of health. Plants, 13(4), [523](tel:523).
30. Salmerón-Manzano, E., Garrido-Cardenas, J. A. and Manzano-Agugliaro, F. ([2020](tel:2020)). Worldwide research trends on medicinal plants. International Journal of Environmental Research and Public Health, 17(10), [3376](tel:3376).
31. Samaniego, I., Espín, S., Quiroz, J., Ortiz, B., Carrillo, W., García-Viguera, C. and Mena, P. ([2020](tel:2020)). Effect of the growing area on the methylxanthines and flavan-3-ols content in cocoa beans from Ecuador. Journal of Food Composition and Analysis, 88, [889-1575](tel:889-1575).
32. Samarasinghe, H.G.A.S., Gunathilake, K.D.P.P. and Illeperuma, D.C.K. (2024). Proximate composition, bioactive constituents, and therapeutic potentials of pasteurized Noni juice derived from *Morinda citrifolia* (L.) growing in Sri Lanka. Ceylon Journal of Science 53(1), 87-96.
33. Sharma, S., Rajput, R. and Patel, S. ([2018](tel:2018)). Proximate composition and antioxidant activity of Noni fruit from Fiji. Journal of Tropical Agriculture, 56(4), [209-215](tel:209-215).
34. Singleton, V. L., Orthofer, R. and Lamuela-Raventos, R. M. ([1999](tel:1999)). Analysis of total phenols and other oxidation substrates and antioxidants by means of the Folin-Ciocalteau reagent. Methodology in Enzymology, [299](tel:299), [152-178](tel:152-178).
35. Sofowora, A. ([2006](tel:2006)). Medicinal plants and traditional medicine in Africa. John Wiley and Sons.
36. Su, B-N., Pawlus, A.D., Jung, H-A., Keller, W.J., McLaughlin, J.L. and Kinghorn, A.D. (2005). Chemical Constituents of the Fruits of *Morinda citrifolia* (Noni) and Their Antioxidant Activity. Journal of Natural Products, 68(4), 592-595.
37. Wayenbergh, E.V., Verheijen, J., Langenaeken, N.A., Foubert, I. and Courtin, C.M. (2023). A simple method for analysis of vitamin A palmitate in fortified cereal products using direct solvent extraction followed by reversed-phase HPLC with UV detection. Food Chemistry, 404(A), 134584.
38. West, B. (2023). Antioxidant Activity of Noni Juice in Vitro and in Human Volunteers. Journal of Food Research, 12(2):29-29