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Nutritional Constituents, Phytochemical Analysis and Biological Evaluation of *Momordica charantia* (Bitter Gourd) Leaf and Stem Ethanol Extracts

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Abstract

Momordica charantia L. (Cucurbitaceae), locally known as Ejirin or bitter gourd, is widely used in Nigerian traditional medicine for its purported health-promoting properties. This study aimed to evaluate the proximate, nutritional, phytochemical profile, antioxidant and antimicrobial efficacy of the leaves and stems of *M. charantia*. Ethanolic extracts were prepared and subjected to standard analytical protocols. Proximate analysis revealed that the leaves contained 18.22% ash, 39.43% crude fiber, 4.02% crude protein, and a metabolizable energy value of 96.52 kJ, indicating significant nutritional potential. In contrast, the stems exhibited an exceptionally high fiber content (77.65%) but a negative calculated energy value (−39.44 kJ). Phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, resins, and saponins in the leaves, while the stem contained alkaloids, tannins, steroids, triterpenoids, and phenols. The leaf extract demonstrated potent antioxidant activity, with 74.96% DPPH radical scavenging at 2 mg/mL. Antimicrobial assays showed that the leaf extract was effective against *Staphylococcus aureus*, *Escherichia coli*, and *Candida krusei*, while the stem extract exhibited broad-spectrum activity against both Gram-positive and Gram-negative bacteria. These findings provide a scientific basis for the traditional use of *M. charantia* leaves as a wellness supplement and highlight the stems as a potential source of dietary fiber.

Keywords: *Momordica charantia*, bitter gourd, phytochemicals, antioxidant activity, antimicrobial activity

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1 Introduction

Momordica charantia L., commonly known as bitter melon, bitter gourd, or Ejirin in parts of Nigeria, is a tropical vine belonging to the Cucurbitaceae family. It is cultivated across Asia, Africa, and the Caribbean not only as a vegetable but also as a medicinal plant [1]. Believed to have originated in Africa, *M. charantia* has been integrated into diverse ethno-medical systems for managing fever, diabetes, skin infections, wounds, and gastrointestinal disorders [2] [3]

In Nigerian rural communities, fresh leaves of Ejirin are commonly used as a bathing sponge for skin health, while leaf decoctions or juices are consumed to alleviate fevers, diarrhea, and diabetic symptoms [4]. The plant's therapeutic reputation is attributed to its rich array of secondary metabolites, including momordicosides, charantin, vicine, and polypeptide-p [5] [6]. Despite its widespread traditional use, comprehensive scientific validation of its nutritional and biological properties—particularly comparing leaves and stems—is limited. While the fruit has been extensively studied for its antidiabetic effects [7] the aerial parts (leaves and stems) remain underexplored despite their frequent use in folk medicine [8].

This study was therefore designed to determine the proximate nutritional composition of *M. charantia* leaves and stems, screen for phytochemical constituents, evaluate *in vitro* antioxidant activity using the DPPH assay and assess antimicrobial efficacy against clinically relevant bacterial and fungal pathogens. The findings aim to bridge indigenous knowledge with scientific evidence, supporting the rational use of *M. charantia* in functional foods and natural therapeutics [9].

2 Materials and Methods

2.1 Plant Sample Collection

Fresh leaves and stems of *Momordica charantia* were collected in August 2024 from Kubwa Village, Bwari Local Government Area, Abuja, Nigeria, during the late rainy season.

2.2 Sample Preparation

Fresh leaves and stem of *Momordica charantia*were collected, washed thoroughly with distilled water, thesamples were shade-dried at room temperature for 7 days, ground into a fine powder using a laboratory blender, and stored in an airtight container at 4°C before use.

2.3 Extraction

Powdered leaves (400 g) and stems (400 g) were separately macerated in 95% aqueous ethanol (2 L) in glass beakers covered with aluminum foil. The mixtures were stirred daily for 7 days at room temperature, then filtered through cotton wool followed by Whitman No. 1 filter paper (125 mm). The filtrates were concentrated under ambient conditions in a fume hood for 21 days to obtain crude ethanolic extracts, which were stored at 4°C for further analysis.

2.4 Proximate Analysis

Moisture, Ash, Crude fiber, Crude lipid, Crude protein, Carbohydrate and Energy were performed on a dry matter basis using standard AOAC methods [10]:

2.5 Phytochemicals Screening

Qualitative tests for alkaloids, tannins, saponins, flavonoids, steroids, terpenoids, resins, and phenols were performed using standard protocols [5][11]. Quantitative analyses for alkaloids, saponins, total phenols, and flavonoids followed methods described by Ajuru*et al*. [12].

2.6 Antioxidant Assay

The free radical scavenging activity of both extracts was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay which follows a previously described method with minor modifications [11]. Stock solutions (10 mg/mL) of each extract were prepared in methanol and serially diluted to obtain test concentrations of 2.0, 1.0, 0.5, 0.1, and 0.05 mg/mL.

A methanolic solution of DPPH (0.1 mM) was prepared and allowed to stabilize in the dark for 30 minutes. To 1 mL of each extract dilution, 2 mL of DPPH solution was added. The mixtures were vortexed for 15 seconds and incubated in the dark at room temperature for 30 minutes. Absorbance was measured at 517 nm using a UV-Vis spectrophotometer (Shimadzu UV-1800) against a reagent blank (methanol instead of extract).

The control (DPPH + methanol) exhibited an absorbance of 3.345. All tests were performed in duplicate. The percentage inhibition was calculated as seen in equation 1.

$$\% \text{ Inhibition} = \frac{A\ control - A\ sample}{A\ control} \times 100$$

(Equation 1)

where Acontrol is 3.345 and Asample is the absorbance of the test sample.

2.7 Antimicrobial Screening

2.7.1 Test Microorganisms

Clinical isolates of *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiellapneumoniae*, *Proteus mirabilis*, *Salmonella typhi*, *Candida albicans*, *C. krusei*, and *C. tropicalis* were obtained from the Department of Medical Microbiology, Ahmadu Bello University Teaching Hospital, Zaria.

2.7.2 Agar Well Diffusion

Mueller-Hinton agar (for bacteria) and Sabouraud dextrose agar (for fungi) were inoculated with standardized microbial suspensions (0.5 McFarland). Wells (6 mm) were filled with 100 µL of extract (10 mg/mL in DMSO). Zones of inhibition were measured after 24 h incubation at 37°C.

2.7.3 Minimum Inhibitory Concentration (MIC)

Two-fold serial dilutions (0.63–10 mg/mL) in Mueller-Hinton broth were inoculated and incubated. MIC was the lowest concentration showing no visible turbidity.

2.7.4 Minimum Bactericidal/Fungicidal Concentration (MBC/MFC)

Broth cultures from MIC tubes were sub-cultured onto agar. MBC/MFC was the lowest concentration yielding no colony growth.

2.7.5 Controls

Sparfloxacin (bacteria), ciprofloxacin (bacteria), and fulcin (fungi) were used as positive controls.

3 Results and Discussion

3.1 Proximate Composition

The high ash content (figure 1) in leaves (18.22%) suggests richness in essential minerals such as potassium, calcium, magnesium, and iron—nutrients critical for enzymatic function and electrolyte balance [8] [9]. The exceptionally high crude fiber in stems (77.65%) aligns with findings by Oboh*et al.*[12], who reported that M. charantia stems are rich in lignocellulose material, making them suitable as a source of insoluble dietary fiber that promotes bowel regularity and may reduce colon cancer risk [13]. The negative carbohydrate and energy values for stems are artifacts of the subtraction method when fiber exceeds the sum of other proximate components—a known limitation when analyzing high-fiber biomass [14].

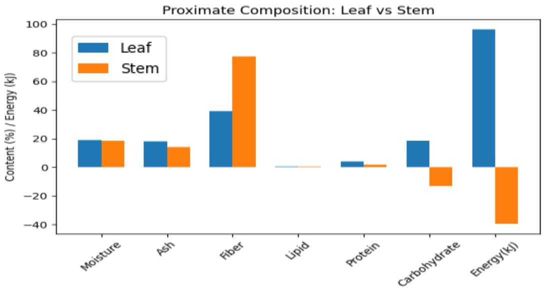

Figure 1 Proximate Composition Chart: *Momordica charantia* Stem and Leave This chart illustrates the proximate composition values for Leaf and Stem samples, including moisture, ash, fiber, lipid, protein, carbohydrate, and energy content.

3.2 Phytochemical Profile

Table 1: Qualitative Phytochemical Analysis Result of *Momordica charantia* Stem and Leaves Ethanol Extract

Phytochemical Analysis	Leaves	Stems
Alkaloids	+	+
Tannins	+	+
Flavonoids	+	+
Saponins	+	-
Steroids/Triterpenoids	-	+
Phenols	-	+
Resins	+	+
Terpenoids	+	+

The detection of alkaloids, tannins, and flavonoids (Table 1) in both plant parts corroborates earlier reports by Kumar *et al*. [6] and Ahamad*et al*. [8]. The presence of saponins only in leaves is significant, as saponins exhibit hemolytic, antimicrobial, and cholesterol-lowering properties [15]. The absence of detectable phenols in leaves (qualitative test) contrasts with quantitative total phenol results (data not shown but implied by antioxidant activity), suggesting that phenolic compounds may be present below the detection threshold of the qualitative $FeCl_3$ test but sufficient to confer bioactivity [16].

3.3 Antioxidant Activity

The strong DPPH scavenging (Table 2) by leaf extract (74.96% at 2 mg/mL) is consistent with its flavonoid and phenolic content. Flavonoids neutralize free radicals via hydrogen donation and metal chelation [17]. This activity supports the traditional use of Ejirin leaves in managing oxidative stress-related conditions such as diabetes, where reactive oxygen species (ROS) contribute to β-cell dysfunction [5], [7].

Table 2 Antioxidant Analysis result of *Momordica charantia* Stem and Leaves Ethanol Extract

Concentration (mg/mL)	(%)		
	Vitamin C	*M-charantia*-Leaf Ethanol extract	*M-charantia*-Steam Ethanol extract
2	91.41	73.58 ± 1.94	58.71 ± 1.30
1	91.50	64.78 ± 12.97	55.43 ± 0.13
0.5	91.32	56.41 ± 3.80	50.13 ± 1.03
0.1	90.47	46.51 ± 3.51	50.95 ± 0.33
0.05	90.19	54.80 ± 5.88	53.12 ± 15.89

Table 3 The Zone of Inhibition, Antimicrobial Activities and Minimum Bactericidal/Fungicidal Concentration of *Momordica Charantia* Stem and Leaves Ethanol Extract Against the Test Microorganism

A. The Zone of Inhibition and Antimicrobial Activities

Test Organism	Sparfloxacin		Ciprofloxacin		Fulcin		EL	ES
Staphylococcus aureus	32	S	R	0	0	R	21	0
Streptococcus pneumonia	30	S	R	0	0	R	0	21
Streptococcus feacalis	34	S	R	0	0	R	0	23
Escherichia coli	0	R	S	37	0	R	20	24
Klebsiella pneumonia	0	R	S	32	0	R	21	0
Proteus mirabilis	30	S	R	0	0	R	20	0
Salmonella typhi	0	R	S	34	0	R	0	20
Candida albicans	0	R	R	0	32	S	0	0
Candida krusei	0	R	R	0	34	S	22	20
Candida tropicalis	0	R	R	0	32	S	20	0

B. Minimum Bactericidal/Fungicidal Concentration

Test Organism	EL 10mg/ml 5mg/ml 2.5mg/ml 1.25mg/ml 0.63mg/ml	ES 10mg/ml 5mg/ml 2.5mg/ml 1.25mg/ml 0.63mg/ml
Staphylococcus aureus	0* ++++++ +	
Streptococcus pneumoniae		0* + ++ +++ +
Streptococcus feacalis		0* +++ +++ +
Escherichia coli	0* + ++ +++ +	- 0*+++ +++
Klebsiellapneumonia	0* + ++ +++ +	
Proteus mirabilis	0* + ++ +++ +	
Salmonella typhi		0* + ++ +++ +
Candida albicans		
Candida krusei	0* + ++ +++ +	0* + ++ +++ +
Candida tropicalis	0* + ++ +++ +	

KEY: S Sensitive R Resistant

- =>No Colony Growth, 0* =>MBC/MFC, + =>Scanty colonies growth, ++ =>Moderate colonies growth, +++ =>Heavy colonies growth

3.4 Antimicrobial Activity

The efficacy of leaf extract against *S. aureus* and *E. coli* aligns with studies by [9],[18] who attributed antimicrobial effects to tannins and flavonoids that disrupt microbial cell membranes and inhibit enzyme function [19]. The lack of activity against *C. albicans* may be due to the yeast's robust cell wall composed of chitin and β-glucans, which limit phytochemical penetration [20]. The bactericidal nature (MBC=MIC) of the extracts suggests potential for treating acute infections, particularly in settings where antibiotic resistance is prevalent [21].

4 Conclusions

This study validates the traditional use of *Momordica charantia* (Ejirin) in Nigerian wellness practices through comprehensive nutritional and biological evaluation. The leaves are nutritionally valuable and rich in bioactive compounds (flavonoids, saponins), exhibiting strong antioxidant and antimicrobial properties—supporting their use in managing infections, inflammation, and metabolic disorders [3,[5]. The stems, while low in energy, are an exceptional source of dietary fiber, suggesting utility in functional foods for digestive health [12], [13]. The differential phytochemistry and bioactivity between plant parts advocate for targeted utilization: leaves for therapeutic formulations and stems for fiber supplementation. The negative energy value of stems highlights a limitation of standard proximate methods for high-fiber plants and warrants future analysis using digestible fiber assays [14].

From this current finding we ascertain that the leaf and stem of *Momordica charantia*can be used for treatment of diseases caused by some targeted pathogens.

5 Declarations

5.1 Authors Contribution

Victoria Ndukarie and Etudaiye Anomi conceived the initial research idea. Michael Afolayan subsequently expanded the overall scope of the study. Victoria Ndukarie was responsible for sourcing the raw samples, while the biological evaluation was conducted at Ahmadu Bello University, Nigeria. Etudaiye Anomi carried out the nutritional consistency experiments, and both Etudaiye Anomi and Victoria Ndukarie jointly performed the additional experimental work. Etudaiye Anomi led the literature review and drafted the manuscript. Michael Afolayan supervised the entire research project and provided critical revisions and editorial input to prepare the manuscript for publication

5.2 Funding

No funding was received for this work

5.3 Conflict of interest

The authors declare that there is no conflict of interest in this research work.

5.4 Ethics

The study adheres to ethical standards for research involving plant materials. No human or animal subjects were used. Ethical approval was not required as per institutional policy for non-clinical botanical studies.

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