

Determination of Phytochemical Profile and Antioxidant Potential of *Ocimum Gratissimum* Leaf Extract

Olayemi, R F^{1*}, Jawonisi, I O² & Jasper, E E³

^{1,2}Department of Applied Chemistry, College of Science and Technology, Kaduna Polytechnic, Kaduna, Nigeria.

³Department of Chemistry, Faculty of Science, Dennis Osadebay University, Asaba, Delta State

DOI: <https://doi.org/10.51584/IJRIAS.2026.11080071>

Received: 19 August 2026; Accepted: 24 August 2026; Published: 07 September 2026

ABSTRACT

Ocimum gratissimum is a popular aromatic plant extensively used in traditional medicine because of its wide range of therapeutic properties, which are attributable to the array of complex phytochemicals present in the plant. The study investigated the phytochemical composition and antioxidant potential in aqueous, ethanolic and acetone leaf extracts. Quantitative phytochemical analysis was carried using standard analytical techniques to determine the total phenolics, flavonoids, alkaloids, saponins and terpenoids. Fourier Transform Infrared (FTIR) spectroscopy was employed to identify the major functional groups present in the extracts. Antioxidant activity was evaluated using the β -carotene-linoleic acid and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays. FTIR analysis revealed characteristic functional groups associated with the bioactive compounds in all the extract. Ethanolic extract exhibited the highest flavonoid (147.24 mg QE/g), alkaloid (5.87 mg atropine/g) and terpenoid (158.81 mg linalool/g) contents. Acetone extract showed the highest total phenolic (34.25 mg GAE/g) and saponin (65.85 mg EE/g) contents, whereas the Aqueous extract contained considerable quantities of the tested phytochemicals, 30.06 ± 0.00 (mg GAE/g), 65.93 ± 0.01 (mg QE/g), 2.06 ± 0.02 (mg Atropine /g), 48.27 ± 0.03 (mg EE/g) and 134.62 ± 0.02 (mg linalool/g) phenolics, flavonoids, alkaloids, saponins and terpenoids respectively. Both antioxidant assays demonstrated concentration-dependent free radical scavenging activity in the three extracts, with the DPPH assay showing stronger activity (with $IC_{50} = 5.33, 7.5$ and $11.08 \mu\text{g/mL}$) than the β -carotene-linoleic acid assay ($IC_{50} = 9.77, 11.39$ and $13.92 \mu\text{g/mL}$) for Ethanolic, Acetone and Aqueous extracts respectively. The findings showed that *O. gratissimum* leaves are rich in bioactive secondary metabolites with significant antioxidant potential, supporting their traditional medicinal use and highlighting their potential as a natural source of antioxidant compounds for pharmaceutical and nutraceutical applications.

Keywords: Antioxidant; Extract; FTIR; Phytochemicals; *Ocimum gratissimum*; DPPH

INTRODUCTION

Ocimum gratissimum L is an aromatic, evergreen wild herbaceous plant with hairy leaves, scented flowers and a distinct mint flavour [1], which belongs to the Lamiaceae family. In West Africa, particularly in Nigeria, the plant is commonly grown for both culinary and medicinal purposes [4,5]. The medicinal potential of the plant is vast and varies by country. It is a well-known herb that is utilized in the medical system and has been used traditionally for the treatment of different health conditions [6,8].

Plants synthesize a wide variety of secondary metabolites known as phytochemicals. Although these compounds are not directly involved in the normal growth and development of the plants, they play important roles in attracting pollinators, and defense against environmental stress, pests and pathogens [9]. Many phytochemicals possess valuable biological activities, making medicinal plants an important source of therapeutic agents and functional food ingredients.

Beyond its culinary importance, *O. gratissimum* has attracted considerable scientific interest because of its rich phytochemical composition. Previous studies reported that the leaves contain bioactive compounds such as

phenolic compounds, flavonoids, alkaloids, terpenoids, saponins, steroids and essential oil [6]. Furthermore, nutritionally important minerals such as Potassium, Sodium, Calcium, Magnesium, Iron, Manganese, Zinc and Copper are also found in the leaves of *O.gratissimum* [20,22]. These compounds contribute to the plant's medicinal properties and are utilized as food additives, medications, insecticides, and fragrances [24].

The biological activities of *O. gratissimum* are largely due to its diverse bioactive compounds, many of which are capable of scavenging free radicals and reducing oxidative stress. Oxidative stress has been implicated in the development of several chronic diseases, including cardiovascular diseases, diabetes, neurodegenerative diseases and cancer. Consequently, identifying the phytochemical constituents and evaluating the antioxidant capacity of medicinal plants remain important areas of natural products research. Although several studies have investigated the medicinal properties of *O. gratissimum*, variation in geographical origin, environmental conditions and extraction solvents can influence the type and concentration of phytochemicals recovered. Therefore, the present study was designed to determine the phytochemical profile of aqueous, ethanolic and acetone extracts of *O. gratissimum* leaves, characterize the extracts using Fourier Transform Infrared Spectroscopy (FTIR), and evaluate their antioxidant potential using standard *in vitro* assays.

MATERIALS AND METHODS

Plant Material

Sample Collection, Identification and Preparation

Fresh leaves of *Ocimum gratissimum* were collected from a farm located in Igabi Local Government Area of Kaduna, Kaduna State, Nigeria. Botanical authentication was carried out at the Herbarium of Kaduna State University (KASU), where a voucher specimen (Voucher No. KASU/BSH/432) was deposited. The harvested leaves were thoroughly washed under running tap water to remove adhering soil particles and other contaminants before being air-dried at ambient temperature (28 °C) for five days. The dried leaves were separated from the stems and further dried in an oven at 40 °C for one hour to remove residual moisture. The dried material was pulverized using an electric blender, passed through a 1 mm mesh sieve to obtain a uniform particle size, and stored in an air-tight container until further analysis.

Extraction of *Ocimum gratissimum* leaf

One hundred grams (100 g) of the powdered leaf samples were subjected to successive solvent extraction by maceration using acetone, ethanol and distilled water. Each extraction was carried out for 48 hours with intermittent agitation to improve solvent penetration. The extracts were filtered and the respective solvents were removed using a rotary evaporator. The evaporation temperatures were maintained at 40 °C, 45 °C and 50 °C for acetone, ethanol and aqueous extracts, respectively. The concentrated acetone extract was further air-dried for four hours to eliminate residual solvent, whereas the ethanolic and aqueous extracts were oven-dried at their respective temperatures for four hours. The dried extracts were stored in air-tight containers until required for subsequent analyses.

Fourier- Transform Infrared (FTIR) Analysis

Fourier- Transform Infrared (FTIR) Spectroscopy was employed to identify the major functional groups present in the *O. gratissimum* extracts. The activity was carried out to provide information on the chemical constituents responsible for the biological activities of the plant in order to complement the phytochemical characterization.

Quantitative Phytochemical Analysis

Total Phenolic Content (TPC)

The total phenolic contents of the extracts were determined using Folin-Ciocalteu colorimetric method. The Folin-Ciocalteu reagent was prepared by measuring 2 mL of the reagent, adding distilled water and the volume made up to 20 mL in a measuring cylinder. Briefly, 10 mg of each extract was dissolved in 5 mL of methanol,

sonicated for 30 minutes at 40 °C and centrifuged at 1000 x g for 15 min. The resulting supernatant was used for analysis. Gallic acid was used as the reference standard, and calibration solutions ranging from 20-100 µg/mL were prepared. The reaction mixture consisted of diluted Folin-Ciocalteu reagent, extract solution and 7.5% Na₂CO₃. After incubation for 30 min at ambient temperature, absorbance was measured at 760 nm. The phenolic content was calculated from the gallic acid calibration curve and expressed as milligram of gallic acid equivalents per gram of dry extract (mg GAE/g) [25].

Total Flavonoid Content (TFC)

The Aluminum Chloride Colourimetric assay was employed to estimate the total flavonoid content. Quercetin served as the calibration standard at concentration of 20-100 µg /mL. Each extract was mixed with methanol were prepared in methanol, AlCl₃ and CH₃COONa before dilution with distilled water. The flavonoid concentration was expressed as milligrams of quercetin equivalents per gram of dry extract (mg QE/g). [26].

Total Alkaloid Content (TAC)

Total alkaloids were determined using bromocresol Green (BCG) complexation method with atropine as the reference standard. Phosphate buffer solution (pH 4.7), BCG reagent and atropine standard solutions (ranging from 20-100 µg /mL) were prepared according to the analytical procedure. Methanolic extracts obtained from Soxhlet extraction were acidified, filtered, washed with chloroform and neutralized before reaction with BCG reagent. The yellow complex formed was measured spectrophotometrically at 470 nm. Alkaloid content was calculated from the atropine calibration curve and expressed as milligrams atropine per gram of extract [27].

Total Saponin Content (TSC)

The total saponins content was determined using the vanillin-sulphuric acid method using escin as the standard, and calibration solutions of escin ranging from 20-100 µg/mL were prepared. Aliquots of each extract were mixed with vanillin reagent and sulphuric acid, followed by incubation in a water bath at 60 °C for 15 min. The reaction mixtures were immediately cooled in an ice bath before absorbance was measured at 540 nm. The results were expressed as milligram escin equivalents per gram of extract (mg EE/g) [28].

Total Terpenoid Content

Terpenoid content was estimated using a coulometric method involving methanol extraction, polyvinylpyrrolidone (PVPP) treatment and chloroform - sulphuric acid reaction. Linalool was used as the reference standard, and calibration solutions ranging from 20-100 µg /mL. were prepared. Following incubation, the coloured lower layer was diluted with methanol and absorbance recorded at 538 nm. Terpenoid content of the extracts were calculated from the calibration curve of linalool and expressed as milligrams linalool equivalents per gram of extract [29].

Antioxidant Assays

β-Carotene–Linoleic Acid Assay

The antioxidant capacity of the extracts was evaluated using the β-carotene–linoleic acid bleaching method. A β-carotene emulsion containing linoleic acid and Tween-20 was prepared, after which chloroform was removed under reduced pressure. Oxygen-saturated distilled water was added to produce a stable emulsion. Aliquots of the emulsion were mixed with different concentrations of the extracts (25-400 µg/mL), while butylated hydroxytoluene (BHT) was used as the positive control. The reaction mixtures were incubated at 50 °C for two hours, and absorbance measured at 470 nm. Percentage inhibition of β-carotene bleaching was calculated from the absorbance values obtained at the beginning and end of the incubation period [30].

$$\% \text{ inhibition} = \left(\frac{A_t}{A_0} \right) \times 100$$

Where A₀ and A_t are the absorbances of the test sample at time 0 and time t, respectively.

DPPH Radical Scavenging Assay

The free radical scavenging potential of the extracts was measured *in vitro* using DPPH assay according to the procedure reported by Silva *et al* [31] with slight modification. A 0.1 mM DPPH solution was prepared in 80 % ethanol and mixed with varying concentrations of the extracts. The reaction mixtures were incubated in the dark at ambient temperature for 30 minutes after which absorbance was taken at 517nm. Radical scavenging activity of the extracts were calculated as the % reduction in absorbance relative to the control.

$$\text{Scavenging Activity (\%)} = \frac{(\text{Abs. control} - \text{Abs. sample})}{\text{Abs. control}} \times 100$$

Statistical Analysis

All experiments were performed in triplicate, and results were expressed as the mean $\pm$ standard deviation (SD). Statistical analyses were carried out using GraphPad Prism version 8.

Differences among means were evaluated by one-way analysis of variance (ANOVA) followed by Tukey's multiple comparison test. Differences were considered statistically significant $p < 0.05$.

RESULTS AND DISCUSSION

Fourier- Transform Infrared (FTIR) Analysis

The FTIR spectra of the ethanolic, acetone and aqueous extracts of *O. gratissimum* leaf showed several characteristic absorption bands corresponding to functional groups commonly associated with bioactive phytochemicals.

The FTIR spectrum of the ethanolic extract (Figure1) showed a broad band centered at 3295 cm^{-1} corresponding to O-H stretching vibration of hydroxyl-containing compounds, including phenolics and flavonoids. Similar absorption bands at 2922 and 2855 cm^{-1} confirmed the presence of aliphatic C-H groups characteristic of terpenoids and related metabolites. A peak at 1635 cm^{-1} was assigned to aromatic C=C stretching vibrations, although contributions from the bending vibration of absorbed water cannot be excluded. Peaks observed at 1364, 1238, 1148, 1074 and 1033 cm^{-1} were attributed to C-H bending and C-O stretching vibrations associated with alcohols, phenols, ethers, esters and derivatives of carbohydrate. The presence of these functional groups suggests that ethanol efficiently extracted polar compounds particularly phenolics, and flavonoids which are known for their antioxidant properties.

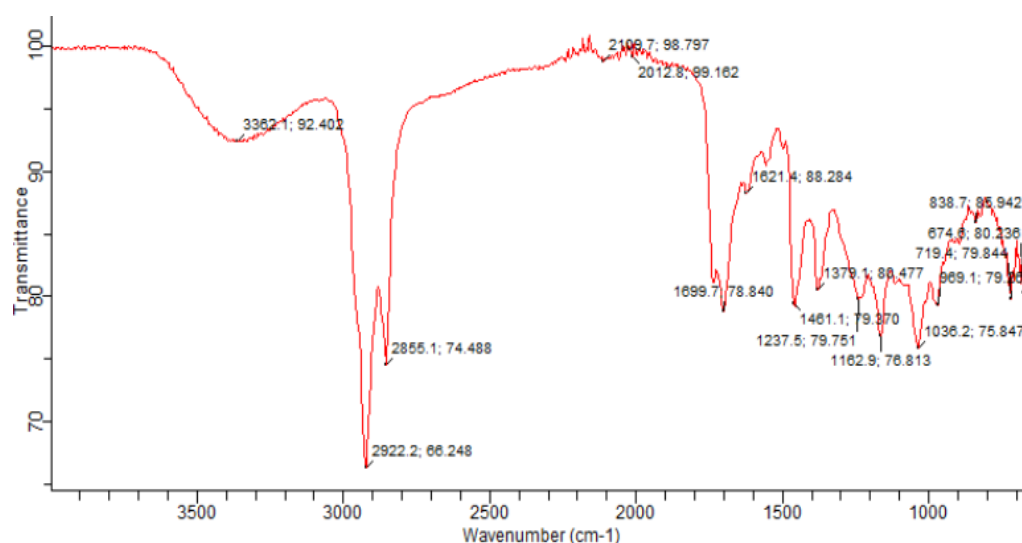


Figure 1: FTIR of Ethanolic Extract of *Ocimum gratissimum* Leaf

The FTIR spectrum of acetone extract (Figure 2) exhibited a broad absorption band at 3362 cm^{-1} , which is characteristic of O-H stretching vibrations of hydroxyl groups present in phenolic compounds, flavonoids and

alcohols. Strong absorption band at 2922 and 2855 cm^{-1} were assigned to asymmetric and symmetric C-H stretching vibrations of aliphatic methylene and methyl groups, indicating the presence of terpenoids and other hydrogenated monoterpenoids. A distinct peak observed at 1699 cm^{-1} corresponded to C=O stretching vibration of carbonyl-containing compounds such as aldehydes, ketones, ester, or carboxylic acids. The absorption band at 1621 cm^{-1} was attributed to aromatic C=C stretching vibrations, suggesting the presence of aromatic compounds particularly flavonoids. Additional bands at 1238, 1163 and 1036 cm^{-1} were assigned to C-O stretching vibrations of alcohols, esters, ethers and phenolic compounds. These absorption bands collectively indicated that the acetone extract contained several classes of bioactive compounds that may contribute to its biological activities. Selvaraju *et al* [32] also identified C=O, O-H, C-N, and C=C functional groups in the spectrum of *O. gratissimum* plant by FTIR.

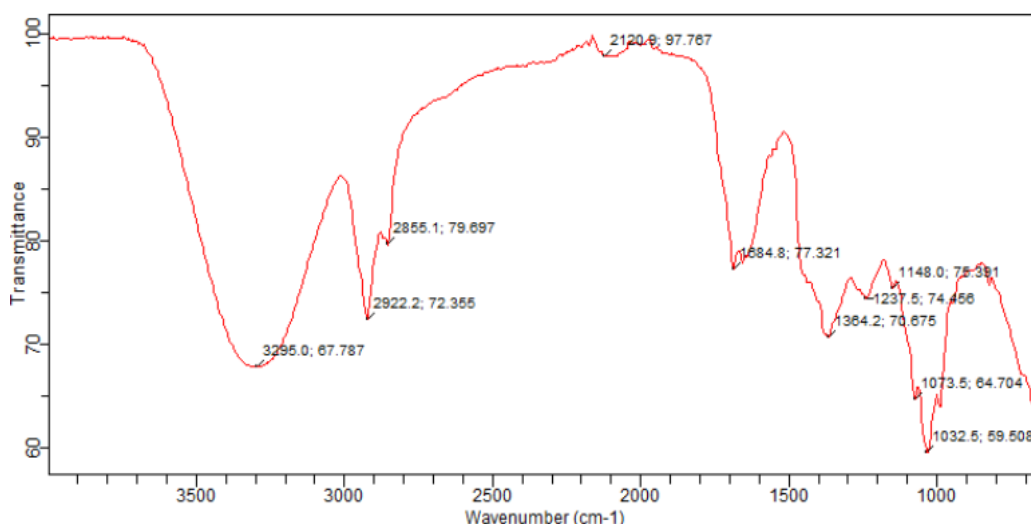


Figure 2: FTIR of Acetone Extract of *Ocimum gratissimum* Leaf

The aqueous extract (Figure 3) displayed a broad absorption band at 3266.9 cm^{-1} indicating O-H stretching vibrations arising from phenolic compounds alcohols and hydrogen-bonded water molecules. The absorption band at 2922.2 cm^{-1} corresponded to aliphatic stretching C-H vibrations, while the weak peak at 2109.1 cm^{-1} may be assigned to C=C or C≡N stretching vibrations, although, it could also represent weak combination bands. The peak at 1638.8 cm^{-1} was attributed to aromatic C=C stretching vibrations or H-O-H bending of adsorbed water, suggesting the presence of flavonoids and other phenolic constituents. An additional absorption band at 1543.1 cm^{-1} was characteristic of amide II vibrations, indicating trace amounts of proteins and amino acid derivatives. Peaks at 1397.8 and 1017.6 cm^{-1} were assigned to CH₃ bending and C-O stretching vibrations of alcohols, ethers, carbohydrates and phenolic compounds, while the bands at 874.6 and 872.3 cm^{-1} were attributed to aromatic C-H out-of plane bending. These findings demonstrated that the aqueous extract was rich in highly polar phytochemicals and other water-soluble constituents [33,34].

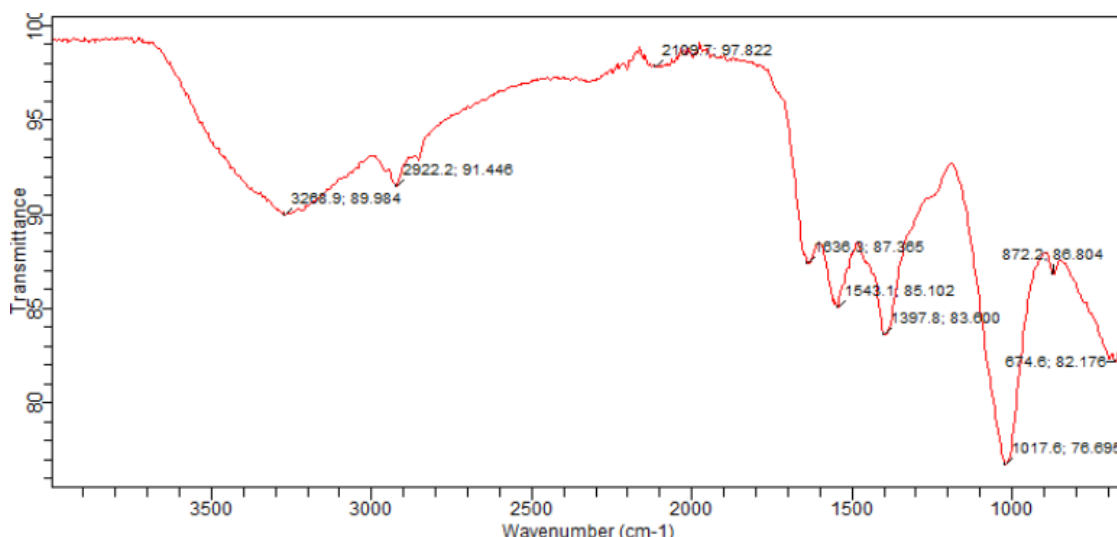


Figure 3: FTIR of Aqueous Extract of *Ocimum gratissimum* Leaf

Comparison of the three extracts revealed both similarities and differences in their chemical composition. Hydroxyl (O-H) and aliphatic C-H stretching bands were present in all extracts, indicating that phenolic compounds, flavonoids and terpenoids constitute common classes of metabolites in *O. gratissimum*. However, the acetone extract exhibited a more pronounced carbonyl (C=O) absorption band, suggesting a greater extraction of carbonyl-containing compounds. The ethanolic extract showed relatively stronger O-H and C-O absorption bands, reflecting its greater efficiency in extracting phenolic compounds, flavonoids and glycosides. In contrast, the aqueous extract displayed broader O-H absorption together with the presence of an amide II band, indicating the extraction of highly polar metabolites, including carbohydrates and small quantities of nitrogen-containing compounds. Thus, the FT-IR spectra validated the presence of various phytochemicals which in turn established the medicinal potentiality of *O. gratissimum* leaves. For example, O-H group has got the ability of forming hydrogen bonds probably indicating inhibitory activity against free radicals.

Overall, the FTIR analysis confirmed that the solvent employed influenced both the composition and abundance of phytochemicals extracted from *O.gratissimum* leaves. Although all the three solvents recovered similar classes of secondary metabolites, differences in band intensity and peak positions suggest variations in extraction efficiency arising from solvent polarity. These findings support the quantitative phytochemical results obtained in the present study and provide spectroscopic evidence for the presence of compounds associated with the antioxidant activity of the plant.

In an FTIR studies on *O. gratissimum* leaves aqueous extract undertaken by Raju *et al.* [35] revealed the following functional groups with their corresponding intensity peaks. The characteristic band at 3809 cm⁻¹ (O-H group) for H₂O, 2924 cm⁻¹ (O-H stretching) for carboxylic acid, 2852 cm⁻¹ (C-H stretching) for alkanes and alkynes, 1737 and 1631 cm⁻¹ (C=O stretching) for amides and esters respectively, 1444 cm⁻¹ (C-H bending) for aromatic compound, 1325, 1265, 1155 and 1101 cm⁻¹ (C-X stretching) for alkyl halides and 1020 cm⁻¹ (glycogen- acetol and carbohydrate) for carbohydrate and ketone were exhibited by the sample.

In a related study conducted by Krishnan *et al.* [36], FT-IR analysis of *O. gratissimum* leaves showed the presence of some functional groups with corresponding intensity peaks. Amine and amino functional group frequencies were between peaks 844.82-1068.56 cm⁻¹ representing aliphatic and aromatic primary amines. The peaks 648.08-785.03 cm⁻¹ were assigned to *cis*-disubstituted alkenes, whereas 1211.30 and 1394.53 cm⁻¹ formed the NH- alkaloids. Meanwhile, the peaks 3662.62 and 3728.40 cm⁻¹ represented O-H stretching or hydrogen bonding for alcohols and phenols. The C-H stretching at 2351.23 and 2314. 58 cm⁻¹ was assigned to alkanes and C-H bending denoted for alkynes, while the peak 1166.93 cm⁻¹ formed the flavonoids. The peaks 524.64 and 586.36 cm⁻¹ represented the C-H (CH₂X) stretching assumed to be alkyl halide. The carbonyl group (C=O) of amides and esters was assigned to C=O stretching of the peak 1735.93 cm⁻¹ whereas the peaks 1512.19 -1593.3 formed the nitro compounds. The spectral studies of FT-IR analysis in their study generally revealed the presence of functional groups representing alcohols, phenols, alkanes, carboxylic acids, aldehydes, alkenes, nitro compounds, alcohols, carboxylic acids, esters, ethers, aliphatic amines and alkyl halides.

Phytochemical Analysis Results

The quantitative phytochemical composition of the ethanolic, acetone and aqueous extracts of *O.gratissimum* leaves is presented in Table 1. In the Table, considerable variations were observed in the concentrations of the phytochemicals among the three extraction solvents, demonstrating that solvent polarity influenced extraction efficiency significantly.

The ethanolic extract contained the highest flavonoid concentration, indicating that ethanol was particularly effective in extracting these polyphenolic compounds. Flavonoids are recognized as potent natural antioxidants capable of scavenging reactive oxygen species, chelating transition metals and inhibiting lipid peroxidation. Their high abundance in the ethanolic extract may therefore contribute significantly to the antioxidant activity observed in the present study. Ethanol also produced the highest alkaloid and terpenoid contents, suggesting that these classes of secondary metabolites possess greater solubility in hydroalcoholic media than in either acetone or water. Similar observations have been reported in previous studies where ethanol extracted higher

concentrations of alkaloids from *O. gratissimum* than aqueous and several other organic solvents [37].

The acetone extract contained the highest concentrations of total phenolic compounds (34.25 ± 0.08 mg GAE/g) and saponins (65.85 ± 0.03 mg EE/g), whereas the ethanolic extract yielded the highest of flavonoids (147.24 ± 0.03 mg QE/g), alkaloids (5.87 ± 0.06 mg atropine equivalent/g) and terpenoids (158.81 ± 0.02 mg linalool equivalent/g). In contrast, the aqueous extract consistently recorded the lowest concentrations of phenolics, flavonoids, alkaloids and saponins, although it contained appreciable amounts of terpenoids. These findings indicate that the nature of the extraction solvent significantly affects both the quantity and diversity of phytochemicals recorded from *O. gratissimum* leaves.

The higher phenolic content observed in the acetone extract may be due to the intermediate polarity of acetone, which enhances the extraction of both moderately polar and less polar phenolic compounds. Acetone has been reported to penetrate plant tissues effectively and dissolve a broad range of phenolic constituents, thereby increasing extraction efficiency. Since phenolic compounds possess strong reducing and free radical scavenging properties, their high concentration suggests that the acetone extract may exhibit considerable antioxidant potential.

Table 1: Phytochemical Profile of Leaf Extracts of *Ocimum gratissimum*

Phytochemical	Concentration (mg/g)		
	Ethanolic	Acetone	Aqueous
Phenolics (mg GAE/g)	32.10 ± 0.08	34.25 ± 0.08	30.06 ± 0.00
Flavonoids (mg QE/g)	147.24 ± 0.03	137.4 ± 0.02	65.93 ± 0.01
Alkaloids (mg Atropine /g)	5.87 ± 0.06	4.98 ± 0.02	2.06 ± 0.02
Saponins (mg EE/g)	62.67 ± 0.02	65.85 ± 0.03	48.27 ± 0.03
Terpenoids (mg linalool/g)	158.81 ± 0.02	121.38 ± 0.02	134.62 ± 0.02

Solvent polarity plays a crucial role in determining extraction efficiency. Ethanol and aqueous ethanol mixtures, generally yield higher extract recoveries from plant matrices. Ethanol exhibits both hydrogen-bond donor and acceptor properties, which enables it to interact with a wider range of polar and moderately polar chemical constituents. As a result, ethanol enhances the solvation of diverse phytochemical classes and promotes cell-wall swelling and diffusion. Moreover, solvent physical characteristics particularly dielectric constant, viscosity, and surface tension collectively influence the solvent's ability to penetrate the plant matrix and desorb intracellular compounds, thereby determining overall extraction efficiency [38]

Although water extracted lower quantities of most phytochemicals, the aqueous extract still contained measurable concentrations of all the investigated metabolites. This finding confirms that water is capable of extracting highly polar bioactive compounds, although its extraction efficiency is generally lower than that of organic solvents. The comparatively lower phytochemical yield obtained with water may be attributed to the limited solubility of several secondary metabolites, particularly flavonoids, alkaloids and certain phenolic compounds in highly polar solvents.

In a related study conducted by Enenebaeku *et al* [39], aqueous extract of *O.gratissimum* revealed the presence of tannins, phenols and alkaloids. Total phenolics (8.47 ± 1.33 mg GAE/g) and total alkaloids (270 ± 0.05 mg TAE/g) were reported. These values were less than the values in this study (30.06 ± 0.00 mg GAE/g) and (2.06 ± 0.02 mg atropine/g) for total phenolics and total alkaloids respectively. In another study conducted by Zareiyan and Khajehsharifi [40], methanolic extract of *O.gratissimum* recorded total flavonoids ($151.9 \mu\text{g QE/mg}$) and total phenolics ($63.03 \mu\text{g GAE/mg}$) as against 147.24 ± 0.00 mg QE/g) and (32.10 ± 0.08 mg GAE/g) for total flavonoids and total phenolics respectively recorded in this study.

Ahmed *et al* [41] reported (17.36 and 2.58) %, (0.38 and 0.11) %, and (43.33 and 12.83) % for total phenolics, alkaloids, tannins in ethanolic and aqueous extracts respectively. However, the total flavonoids content

recorded a higher value 111.87 % in aqueous extract as compared to 96.94 % recorded for ethanolic extract. In a related study, aqueous leaf extract of *O. gratissimum* afforded concentrations of alkaloids (4.66 mg/g), saponins (2.40 mg/g) and tannins (6.80 mg/g). In addition, ethanolic extract of *O. gratissimum* leaves recorded total phenolics content of 56.59 mg ac. Galic/100mg; total flavonoids content of 13.71 mg Eq Quer/100 mg and total tannins content of 8.6 mg Eq Cat/100mg [42]. Related research reported 0.0313, 0.034 and 0.016% alkaloid, flavonoid and saponin respectively, in addition to 10.2mg/g tannins and 5.86 mg/g total phenolics from ethanolic extract of *O.gratissimum* leaves [43]. Meanwhile aqueous extract of *O.gratissimum* as reported by Jumare [44] revealed 3.67, 4.17 and 2.03 mg/100g of saponin, flavonoids and alkaloids respectively. Also, aqueous extract of *O.gratissimum* leaves gave 2.2 and 8.8 mg/100g saponin and flavonoids respectively in another study [45].

The reason for these differences could be due to extraction and processing methods, soil condition, location, climatic conditions, seasonal changes and genetic diversity as production of these secondary metabolites changes dynamically based on the pressures on ecosystems. Furthermore, different methods and solvents were used by various authors.

Overall, the quantitative phytochemical analysis showed that *O.gratissimum* leaves are a rich source of biologically active secondary metabolites. The observed differences among the extracts highlight the influence of solvent polarity on phytochemical recovery, with ethanol proving most effective for extracting flavonoids, alkaloids and terpenoids, whereas acetone was more efficient for phenolics and saponins. The abundance of these bioactive constituents provides a scientific basis for the antioxidant potential and traditional therapeutic applications of *O.gratissimum*.

Antioxidant Activity Results

The antioxidant activity of methanolic, acetone and aqueous leaf extracts of *O. gratissimum* using the β -carotene-linoleic acid and DPPH assays, with BHT serving as the reference antioxidant is shown in Table 2. In both assays, the extracts exhibited concentration-dependent activity, with percentage inhibition increasing progressively as the extract concentration increased from 5 to 25 μ g/mL.

Table 2: Antioxidant Activity of Leaf Extracts of *O.gratissimum*

% Inhibition								
β -Carotene-Linoleic Acid Assay					DPPH Assay			
Conc (μ g/mL)	Ethanolic	Acetone	Aqueous	BHT	Ethanolic	Acetone	Aqueous	BHT
5	45.02 $\pm$ 0.01	43.45 $\pm$ 0.02	42.05 $\pm$ 0.03	55.17 $\pm$ 0.01	50.15 $\pm$ 0.01	48.02 $\pm$ 0.02	45.22 $\pm$ 0.01	57.02 $\pm$ 0.01
10	49.77 $\pm$ 0.02	47.46 $\pm$ 0.02	45.18 $\pm$ 0.02	67.15 $\pm$ 0.00	55.22 $\pm$ 0.03	52.25 $\pm$ 0.01	48.05 $\pm$ 0.02	68.19 $\pm$ 0.01
15	55.15 $\pm$ 0.01	54.65 $\pm$ 0.02	50.21 $\pm$ 0.02	74.56 $\pm$ 0.01	60.13 $\pm$ 0.02	57.05 $\pm$ 0.02	52.72 $\pm$ 0.02	75.66 $\pm$ 0.00
20	63.28 $\pm$ 0.02	59.70 $\pm$ 0.02	58.49 $\pm$ 0.03	88.67 $\pm$ 0.01	68.44 $\pm$ 0.01	62.25 $\pm$ 0.02	59.45 $\pm$ 0.02	89.77 $\pm$ 0.01
25	70.55 $\pm$ 0.01	64.05 $\pm$ 0.03	60.05 $\pm$ 0.02	96.15 $\pm$ 0.02	72.95 $\pm$ 0.01	68.18 $\pm$ 0.02	62.85 $\pm$ 0.01	98.05 $\pm$ 0.00
IC ₅₀ (μ g/mL)	9.77	11.39	13.92	2.27	5.33	7.5	11.08	1.62

In the β -carotene-linoleic acid assay, all the extracts exhibited concentration-dependent antioxidant activity. The percentage inhibition increased progressively from 5 to 25 μ g/mL. The methanolic extract increased from 45.02 $\pm$ 0.01 % to 70.55 $\pm$ 0.01 %, while the acetone extract increased from 43.45 $\pm$ 0.02 % to 64.05 $\pm$ 0.03 %. The aqueous extract showed the lowest activity, increasing from 42.05 $\pm$ 0.03 % to 60.05 $\pm$ 0.02 %. The reference antioxidant (BHT) demonstrated the highest inhibition all through the concentration range increasing from 55.17 $\pm$ 0.01 % to 96.15 $\pm$ 0.02 %

The order of antioxidant activity observed was BHT > ethanolic extract > acetone extract > aqueous extract. The observed pattern is also supported by the IC₅₀ values, where lower IC₅₀ value indicate greater antioxidant effectiveness. The IC₅₀ values recorded were 9.77, 11.39 and 13.92 µg/ml for ethanolic, acetone and aqueous extracts respectively, while BHT had the lowest value (2.27 µg/mL).

A similar trend was observed in the DPPH assay. The percentage inhibition increased with increasing concentration for all the three extracts. The ethanolic extract showed the highest activity increasing from 50.15±0.01 % at 5 µg/ml to 72.95±0.01% at 25 µg/ml. Acetone extract followed with percentage inhibition values ranging from 48.02±0.02 % to 68.18±0.02 %, over the same concentration range, whereas aqueous extract recorded 45.22±0.01 % to 62.85±0.01 %, over the same concentration range. The strongest activity was exhibited by the BHT with inhibition increasing from 57.02±0.01 % to 98.05±0.00 %. The IC₅₀ results further confirm this pattern. The methanolic extract had the lowest IC₅₀ value (5.33 µg/mL) among the extracts, followed by acetone (7.50 µg/mL) and aqueous (11.08 µg/mL) while BHT had an IC₅₀ value of 1.62 µg/mL. So, the overall antioxidant effectiveness in the DPPH assay followed the same order as for the β-carotene-linoleic acid assay.

The greater activity observed for the ethanolic extract compared with acetone and aqueous extracts may be an indication that methanol was more effective at extracting the antioxidant constituents such as flavonoids terpenoids saponins responsible for the observed activity. The differences between the extracts also suggest that the antioxidant activity of *O. gratissimum* leaves depend on the extraction solvent and the phytochemical extracted. Overall, the results demonstrated that *O. gratissimum* leaf extracts possess appreciable antioxidant activity in both assay systems.

Although BHT produced higher inhibition values at all concentrations tested, the extracts demonstrated appreciable antioxidant activity, indicating their ability to inhibit oxidative reactions and scavenge free radicals. The concentration-dependent increase observed in both assays suggests that the antioxidant constituents present in *O.gratissimum* become more effective as their concentration increases. Such behaviour is characteristic of plant extracts rich in phenolic compounds and flavonoids, which donate hydrogen atoms or electrons to neutralize free radicals and terminate oxidative chain reactions. The substantial amounts of phenolics, flavonoids and terpenoids identified in the phytochemical analysis are therefore likely to be responsible for the antioxidant activity observed in the present study.

The DPPH assay produced a lower IC₅₀ value (5.33 µg/mL) than the β-carotene-linoleic acid assay (9.77 µg/mL), indicating greater antioxidant effectiveness in scavenging DPPH free radicals. Since a lower IC₅₀ value reflects stronger antioxidant activity, the results suggest that the extract was more efficient at donating hydrogen atoms or electrons to stable free radicals than at preventing lipid peroxidation in the β-carotene-linoleic acid system. The difference may be attributed to the varying reaction mechanisms involved in the two assays, as DPPH primarily measures free radical scavenging capacity, whereas the β-carotene-linoleic acid assay evaluate the ability of antioxidants to inhibit oxidative degradation of lipids.

The antioxidant activity demonstrated by *O.gratissimum* leaf extract is consistent with its phytochemical composition. Phenolic compounds, flavonoids and terpenoids are recognized as major natural antioxidants because of their ability to stabilize reactive oxygen species and reduce oxidative stress. The anti-oxidative effects of these phytochemicals could be accomplished through a variety of mechanisms, including scavenging free radicals, chelating metal ions, or blocking enzyme systems that generate free radicals [41]. The synergistic action of these phytochemicals may account for the strong antioxidant potential observed in this study.

Overall, the results confirm that *O. gratissimum* possess significant antioxidant activity, although its activity remained lower than that of the synthetic antioxidant BHT. The concentration-dependent inhibition observed in both assays, together with the relatively low IC₅₀ values, provides experimental evidence that the plant is a rich source of natural antioxidant compounds. These findings support the traditional use of *O.gratissimum* in herbal medicine and suggest that its bioactive constituents may have potential applications in the development of natural antioxidant formulations for pharmaceutical, nutraceutical and food preservation purposes.

The DPPH IC₅₀ of 5.33 µg/mL recorded for the ethanolic extract in this study was lower than the 6.175 and

37.92 $\mu\text{g/mL}$ reported for ethanolic leaf extracts of *O. gratissimum* [42; 46]. Similarly, the aqueous extract in the present study gave an IC_{50} of 11.08 $\mu\text{g/mL}$, which is also lower than the 40.21 and 83.00 ± 1.17 $\mu\text{g/mL}$ reported for an aqueous leaf extract of *O. gratissimum* [47;48].

These comparisons suggest that the extracts investigated in the present study possess strong DPPH radical scavenging activity especially the methanolic extract. The differences between the previous reports and the present findings may be linked to variations in extraction solvents, extraction conditions, geographical origin of the plant, harvest time, phytochemical composition and assay procedures.

LIMITATIONS OF THE STUDY

Although the spectrophotometric analysis effectively quantified broad classes of secondary metabolites, it gave an aggregate measurement and lacks capacity to isolate individual compound's molecular structure. The Folin-Ciocalteu method is prone to interference from non-phenolic reducing agents (reducing sugars, ascorbic acid and certain amino acids) present in crude plant extracts which can overestimate total phenolic content. Also, the antioxidant evaluations were limited to *in-vitro* chemical models (β -carotene-Linoleic acid and DPPH assays). These methods though reliable for radical scavenging and lipid peroxidation, they do not account for cellular bioavailability, metabolic biotransformation or specific *in vivo* mechanism of action. In addition, bioactivity assays cannot distinguish whether the effect is from a single dominant phytochemical or a synergistic interaction among many compounds as crude plant extracts contain a complex mixture of compounds. The choice of extraction solvent inherently limits the yield because polar solvents miss non-polar compounds and vice versa. Phytochemical profile of crude plant extracts changes drastically based on sample and environmental variations such as location, plant maturity stage, time of harvest, soil composition, post-harvest handling among others.

To address these limitations, further research should focus on chromatographic identification and structural elucidation of the extract using GC-MS or HPLC-MS/MS to isolate the specific compounds responsible for the observed activity. To evaluate toxicity, metabolic pathways and pharmacokinetic profile of the extracts, cellular antioxidant activity and *in vivo* animal models should be conducted. These would provide deeper insight into the mechanisms of action, safety and therapeutic efficacy of the extracts.

CONCLUSION

The study showed that *O. gratissimum* leaves possess significant antioxidant potential, driven by a rich profile of quantitatively verified secondary metabolites especially phenolics and flavonoids.

Quantitative phytochemical analysis further revealed that the extraction solvent significantly influenced the recovery of these metabolites. FTIR analysis confirmed the presence of characteristic functional groups associated with these important secondary metabolites.

The extracts exhibited a robust radical scavenging activity against DPPH and inhibited lipid peroxidation effectively in the β -carotene-linoleic acid system. These findings underscored the potential of the leaf extracts as a valuable source of natural, accessible, cheaper antioxidants for pharmaceutical, nutraceutical or industrial applications. While further chromatographic isolation and *in vivo* biological validations are required to clarify individual active compounds and safety profiles, the quantitative and functional data established herein provide strong foundational baseline for the therapeutic utilization of this plant species.

REFERENCES

1. Bhavani T, Mohan RR, Mounica C, Nyamisha J, Krishna AG, Prabhavathi P, Raja RR, Baba KK. Phytochemical screening and antimicrobial activity of *Ocimum gratissimum*: Review. Journal of Pharmacognosy and Phytochemistry. 2019;8(2):76–79.
2. Akara EU, Emmanuel O, Ude VC, Uche-Ikonne C, Eke G, Ugbogu EA. *Ocimum gratissimum* leaf extract ameliorates phenylhydrazine-induced anaemia and toxicity in Wistar rats. Drug Metabolism and Personalized Therapy. 2021; 36:311–320. doi:10.1515/dmpt-2020-0185 PMID: 34821128.

3. Imosemi IO. A review of the medicinal values, pharmacological actions, morphological effects and toxicity of *Ocimum gratissimum* Linn. European Journal of Pharmaceutical and Medical Research. 2020;7(7):29-40.
4. Edo GI, Samuel PO, Ossai S, Nwachukwu SC, Okolie MC, Oghenegueke O, Asaah EU, Akpogheli PO, Ugbune U, Owheruo JO, Ezekiel GO. Phytochemistry and pharmacological compounds present in scent leaf: A review. Food Chemistry Advances. 2023;3:100300.
<https://doi.org/10.1016/j.focha.2023.100300>
5. Abu ML. A review of the efficiency of *Ocimum gratissimum* as a vegetable condiment. African Journal of Agriculture and Food Science. 2024;7(2):219–230. DOI:10.52589/AJAFS-CKSMJ20Q
6. Okoye CI, Adamu BB, Abubakar ZI, Idris HA, Maidawa GL, Mustapha FA, Ayegba SO, Abdallah HY. Medical and pharmacological properties of *Ocimum gratissimum* (Scent Leaf): A Review. The Journal of Health Metabolism and Nutrition Studies. 2024; 3(3):181. DOI:10.70382/bejhmns
<https://berkeleypublications.com/bjhmns/article/view/130>
7. Battacharya R, Bose D, Maqsood Q, Gulia K, Khan A. Recent advances on the therapeutic potential with *Ocimum* species against COVID-19: A review. South African Journal of Botany. 2024;164:188–199. <https://doi.org/10.1016/j.sajb.2023.11.034>.
8. Dos-Santos JPC, Rodrigues H, de CM, Resende HE, Barbosa BB, Rosa LP, de A, Nominato LT. *Ocimum gratissimum* Lineu: A review of its pharmacological effects and medicinal uses. Brazilian Journal of Health Review.2021;4(6):28716–32. <https://doi.org/10.34119/bjhrv4n6-410>
9. Proshkina E, Plyusnin S, Babak T, Lashmanova E, Maganova F, Koval L, Platonova E, Shaposhnikov M, Moskalev A. Terpenoids as potential geroprotectors. Antioxidants. 2020;9:529. <https://doi.org/10.3390/antiox9060529>
10. Ajayi AM, Ben-Azu B, Onasanwo SA, Adeoluwa O, Eduviere A, Ademowo OG. Flavonoid-rich fraction of *Ocimum gratissimum* attenuates lipopolysaccharide- induced sickness behavior, inflammatory and oxidative stress in mice. Drug Research. 2019; 69:151–158. DOI -10.1055/a-0654-5042
11. Casanova LM, da-Silva D, Sola-Penna M, Camargo LM, Celestrini D, Tinoco LW, Costa SS. Identification of chicoric acid as a hypoglycemic agent from *Ocimum gratissimum* leaf extract in a biomonitoring in vivo study. Fitoterapia. 2014;93:132–141. <https://doi.org/10.1016/j.fitote.2013.12.024>
12. Adebisin I, Kolapo K, Amoka S, Olubunmi O, Olomoko C, Balogun A, Ganiyu L. Phytochemical analysis and antibacterial efficacy of *Ocimum gratissimum* extracts on multidrug-resistant bacteria. International Journal of Medical Laboratory Research. 2023;8(3):23–31. <https://doi.org/10.35503/IJMLR.2023.8304>
13. Induar S, Parida S, Mohapatra R. A complete overview of *Ocimum* species: King of herbs sadhni. African Journal of Biological Sciences. 2024;6:2348–2369. <https://doi.org/10.33472/AFJBS.6.5.2024.2348-2369>.
14. Chinko BC, Orlu CN. Antipyretic and anti-inflammatory effects of *Ocimum gratissimum* in male wistar rats. South Asian Research Journal of Natural Products.2023;6:28–38.
15. Shaw HM, Wu JL, Wang MS. Antihypertensive effects of *Ocimum gratissimum* extract: Angiotensin-converting enzyme inhibitor in vitro and in vivo investigation. Journal of Functional Foods.2017;35:68–73. <https://doi.org/10.1016/j.jff.2017.05.033>
16. Shen N, Wang T, Gan Q, Liu S, Wang L, Jin B. Plant flavonoids: Classification, distribution, biosynthesis, and antioxidant activity. Food Chemistry. 2022;132531. <https://doi.org/10.1016/j.foodchem.2022.132531>
17. Nganteng DND, Melong R, Mbiekop EP, Maffo T, Allémann É, Delie F, Wafo P, TchaleuBN, Dzoyem JP. Chemical constituents and cytotoxic activity of *Ocimum gratissimum*. L South African Journal of Botany. 2022;150:330–333. <https://doi.org/10.1016/j.sajb.2022.07.029>.
18. Onyebuchi C, Kavaz D. Effect of extraction temperature and solvent type on the bioactive potential of *Ocimum gratissimum* L extracts. Scientific Reports.2020;10:21760. <https://doi.org/10.1038/s41598-020-78847-5>
19. Irondi EA, Agboola SO, Oboh G, Boligon AA. 2016. Inhibitory effect of leaves extracts of *Ocimum basilicum* and *Ocimum gratissimum* on two key enzymes involved in obesity and

- hypertension in vitro. Journal of Intercultural Ethnopharmacology. 2016;5: 396–402.
doi: [10.5455/jice.20160814112756](https://doi.org/10.5455/jice.20160814112756)
20. Alexander P. Phytochemical screening and mineral composition of the leaves of *Ocimum gratissimum* (Scent Leaf). International Journal of Applied Sciences and Biotechnology. 2016; 4(2):161–165.
<https://doi.org/10.3126/ijasbt.v4i2.15101>
21. Igbinosa EO, Uzunugbe EO, Igbinosa IH, Odjadjare EE, Igiehon NO, Emuedo OA. In vitro assessment of antioxidant, phytochemical and nutritional properties of extracts from the leaves of *Ocimum gratissimum* (Linn). African Journal of Traditional and Complementary Alternative Medicine. 2013;10 :292 <https://doi.org/10.4314/ajtcam.v10i5.11>
22. Adebola A. Proximate composition and mineral contents of *Ocimum gratissimum* leaves (African Basil). International Journal of Technoledge. 2017;5(11).
23. Mgbemena NM, Amako NF. Comparative analysis of the phytochemicals, proximate and mineral compositions of scent leaf (*Ocimum gratissimum*) and bitter leaf (*Vernonia amygdalina*) leaves. International Journal of Biochemistry Research and Review2020;29(7):1–9.
DOI:[10.9734/ijbcr/2020/v29i730200](https://doi.org/10.9734/ijbcr/2020/v29i730200)
24. Bilanda DC, Sandy Y, Kandeda AK, Taiwe GS, Dzeufiet PDD, Dimo T, Kamtchouing P. *Ocimum gratissimum* leaves aqueous extract can minimize middle cerebral artery occlusion and reperfusion-induced injury in rat's brain. Journal of Complementary and Alternative Medical Research. 2022;19(4):19-30. <https://doi.org/10.9734/JOCAMR/2022/v19i4398>.
25. Martins GR, Monteiro AF, do-Amaral, FRL, da-Silva AS. A validated folin-ciocalteu method for total phenolics quantification of condensed tannin-rich açai (*Euterpe oleracea Mart.*) seeds extract. Journal of Food Science and Technology. 2021;58(12):4693-4702. <https://doi.org/10.1007/s13197-020-04959-5>.
26. Shraim AN, Ahmed TA, Rahman MM, and Hijji YM. Determination of total flavonoid content by aluminium chloride assay. A critical evaluation *LWT*. 2021; 150:111932.
<https://doi.org/10.1016/j.lwt.2021.111932>.
27. Shamsa F, Monsef H, Ghamooshi R, and Verdian-rizi M. Spectrophotometric determination of total alkaloids in some Iranian medicinal plants. Thai Journal of Pharmaceutical Sciences. 2008; 32(1):17-20. DOI: <https://doi.org/10.56808/3027-7922.2196>
28. Tan SP, Vuong QV, Stathopoulos CE, Parks SE, Roach PD. Optimize aqueous extraction of saponins from bitter melon for production of a saponin-enriched bitter melon powder. Journal of Food Science. 2014;79: E1372–E1381. <https://doi.org/10.1111/1750-3841.12514>
29. Ghorai N, Chakraborty S, Gucchait S, Saha SK, and Biswas S. Estimation of total terpenoids from plant materials using a chemical method. Phytochemical Analysis. 2021;23(6):620-623.
30. Miraliakbari H, Shahidi F. Antioxidant activity of minor components of tree nut oils. Food Chemistry. 2008;111(2):421-427. <https://doi.org/10.1016/j.foodchem.2008.04.008>.
31. Silva FAM, Borges F, Guimaraes C, Lima JLFC, Matos C, Reis S. Phenolic acids and their derivatives: Studies on the relationship among structure, radical scavenging activity, physicochemical parameters. Journal of Agricultural and Food Chemistry. 2000; 48:2122-2126. <https://doi.org/10.1021/jf9913110>.
32. Selvaraju R, Sakuntala P, Jaleeli KA. GC–MS and FTIR analysis of chemical compounds in *Ocimum gratissimum* plant. Biophysics. 2021;66(3):401-408. <https://doi.org/10.1134/S0006350921030167>.
33. Mariswamy Y, Edward GJ, Marimuthu A. FTIR Spectroscopic studies on *Aerva lanata* (L.) Juss.Ex Schult. Asian Journal of Pharmaceutical and Clinical Research. 2012; 5(2):82-86.
34. Anil Kumar VS, Babu KVD, Salini R, Eapen RJ, Deepa MS. FTIR spectroscopy data as a fingerprint of *Withania somnifera* root tissues: a case study with accessions of the species from Kerala, South India. Indo American Journal of Pharmaceutical Research. 2016; 6(6):5748-5756.
<https://doi.org/10.1044/1980-IAJPR.160630>
35. Selvaraju R, Sakuntala, P Jaleeli, KA. FT-IR Spectroscopic Analysis of *Ocimum gratissimum* Leaves. International Journal of Emerging Technologies in Engineering Research (IJETER).2017; 5(4) :131-133.
36. Krishnana, R Devika, KS Jerry, CJ. FTIR analysis and evaluation of phytochemicals from various solvent extracts of *Ocimum gratissimum* L. and *Ocimum sanctum* L. South Asian Journal of Experimental Biology. 2023;13 (4): 263-268 [https://doi.org/10.38150/sajeb.13\(4\).p263-268](https://doi.org/10.38150/sajeb.13(4).p263-268).
37. Sharma AD, Kaur I, Angish S, Thakur A, Sania S, Singh A. Comparative phytochemistry, antioxidant,

- antidiabetic, and anti-inflammatory activities of traditionally used *Ocimum basilicum* L. *Ocimum gratissimum* L. and *Ocimum tenuiflorum* L. BioTechnologia. 2022;103(2):131.
DOI:[10.5114/bta.2022.116206](https://doi.org/10.5114/bta.2022.116206)
38. Shi L, Zhao W, Yang Z, Subbiah V, Suleria H A R. Extraction and characterization of phenolic compounds and their potential antioxidant activities. Environmental Science and Pollution Research. 2022; 29(54): 81112–81129. <https://doi.org/10.1007/s11356-022-23337-6>
39. Enenebeaku U, Ahamefule K, Asiwe E, Ugenyi A, Iheme P, Eboh O, Iheanacho G, Opara P. Exploring the phytochemistry and in vitro antioxidant potentials of hot water extract of *Ocimum gratissimum* (Scent Leaf). Journal of Pharmacognosy and Phytochemistry. 2024; 13(3):326–332. DOI: [10.22271/phyto.2024.v13.i3d.14976](https://doi.org/10.22271/phyto.2024.v13.i3d.14976)
40. Zareiyan F, Khajehsharifi H. In-vitro phytochemical analysis of essential oil and methanolic and hydromethanolic extracts of *Ocimum gratissimum*. Journal of Plant Biochemistry and Biotechnology. 2022; 31:894–906. <https://doi.org/10.1007/s13562-022-00768-3>.
41. Ahmed A, Dikwa KB, Onusiriuka BC, Dan V. Comparative assessment of phytochemical and proximate composition of *Ocimum basilicum* and *Ocimum gratissimum* leaves extracted with ethanol and aqueous solvents. Science World Journal 2026; 21(2):677-680
<https://doi.org/10.4314/swj.v21i2.31>
42. Kpètèhoto HW, Amoussa AMO, Johnson RC, Houéto EEM, Mignanwandé FMZ, Yédomonhan H, Loko F, Bankolé H, Lagnika L. Phytochemical analysis and antioxidant potential of *Ocimum gratissimum* Lin (Lamiaceae) commonly consumed in the Republic of Benin. Journal of Applied Biology and Biotechnology 2019;7(04):75–83. DOI: 10.7324/JABB.2019.70412
43. OC, Obajimi OO, Adeniji AR, Adekale OA. Evaluation of Phytochemical Content and Antioxidant Potential of *Ocimum gratissimum* and *Telfairia occidentalis* Leaves. Asian Journal of Research in Medical and Pharmaceutical Sciences. 2019;7(1): 1-11 DOI: 10.9734/AJRIMPS/2019/v7i130110
44. Jumare FM. Qualitative and quantitative phytochemical screening of Nigerian indigenous *Ocimum gratissimum* Linn (clove scented basil leaves). ATBU. Journal of Science Technology & Education (JOSTE). 2018; 6(4); 338-344.
45. Ibeabuchi CG, Patrick-Iwuanyanwu KC, Eugene N, Oyeike EN, Akaninwor JO. Qualitative and quantitative phytochemical screening and antioxidant capacity of *Zingiber officinale*, *Ocimum gratissimum* and their mixture. Journal of Public Health and Toxicological Research. 2023; 1(1):11-18
46. Agarwal K, Varma R. Studies on antioxidant activity and phytochemical screening of selected medicinal plant *Ocimum gratissimum* L. International Journal of Pharmaceutical Sciences and Research. 2014; 5(8): 3520-28. doi: 10.13040/IJPSR.0975-8232.5(8).3520-28
47. Akintunde AO, Ogah AM, Ndubuisi-Ogbonna LC, Olumide MD, Banjoko OJ. Antimicrobial and antioxidant potentials of aqueous extracts of *Ocimum gratissimum* leaves. Journal of Applied Animal Science, 18(1): 9–18. https://he02.tcithaijo.org/index.php/jaas_muvs/article/view/274101
48. Gontijo DC, Fietto LC, Milk JPV. Phytochemical assessment and antioxidant, antimutagenic and toxicological activity of *Ocimum gratissimum* L. leaf aqueous extract. Brazilian Journal of Medicinal Plants. 2014; 16(4):874-880 https://doi.org/10.1590/1983-084X/12_002