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RESEARCH ARTICLE

Oxidative stress inhibition, antioxidant performance and bioactive phytochemical profile of *Hyptis suaveolens*

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ABSTRACT

Oxidative stress arises when the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS) surpasses the capacity of biological systems to neutralize them or repair the damage through antioxidant activities. Despite the natural antioxidant defense and repair mechanisms present in humans and other organisms, continuous exposure to free radicals inevitably causes biological harm that cannot be entirely mitigated. In a recent study, the extract of *Hyptis suaveolens* was examined for its inhibition of oxidative stress, secondary metabolites, antioxidant properties, and antibacterial effects against *Staphylococcus aureus* (NCIB 8588), *Bacillus cereus* (NCIB 6349), *Klebsiella pneumoniae* (NCIB 418), and *Pseudomonas aeruginosa* (NCIB). The investigation revealed that the leaf extracts enhanced DPPH scavenging activity, albeit to a lesser extent than ascorbic acid. At concentrations of 50 and 100µg/ml, ascorbic acid exhibited scavenging activities of 40.50 ± 2.20% and 50.00 ± 2.22%, respectively, whereas *Hyptis suaveolens* leaf extract displayed activities of 05.34 ± 1.03% and 14.73 ± 3.30%. The extracts (50mg/100g and 100mg/100g) significantly increased plasma membrane redox system (PMRS) activity compared with the control group. After inducing oxidative stress in erythrocytes, the extract-maintained glutathione (GSH) levels and significantly inhibited malondialdehyde (MDA) formation compared to the H2O2 group. Furthermore, the study demonstrated that the plant extract inhibited bacterial growth, rendering the bacteria vulnerable. These findings suggest that the ingredients present in the plant leaf extract hold promise for potential use in chemotherapy.

Keywords: antioxidant, glutathione, *Hyptis suaveolens*, oxidative stress, malondialdehyde

INTRODUCTION

Oxidative stress arises when the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS) surpasses the capacity of biological systems to neutralize them or repair the damage through antioxidant defenses. Under normal conditions, small amounts of ROS/RNS are produced during cellular respiration, mitochondrial function, and immune activity, where they also serve as important signaling molecules. However, excessive production or weakened antioxidant defenses can result in damage to lipids, proteins, and nucleic acids, impair mitochondrial function, initiate inflammatory processes, and ultimately cause cell death (D'Ascenzo & Colussi, 2025; Rahayu et al., 2024). Major sources of ROS include mitochondrial electron transport chain leakage, NADPH oxidase activity, peroxisomal oxidation, and environmental factors such as radiation, pollutants, heavy metals, and xenobiotics. Antioxidant defenses counteract this stress and include enzymatic systems such as superoxide dismutase, catalase, and glutathione peroxidase, as well as non-enzymatic components such as *glutathione*, vitamins C and E, flavonoids, and phenolic compounds (D'Ascenzo & Colussi, 2025; Sood et al., 2025).

Recent studies emphasize oxidative stress as a central molecular mechanism driving aging and age-related functional decline (Iakovou et al., 2022). Over time, oxidative damage accumulates due to environmental factors such as UV radiation, pollution, and poor diet, combined with a gradual reduction in antioxidant defenses. This process promotes cellular senescence and the development of the senescence-associated secretory phenotype (SASP). However, findings from animal models suggest that enhancing antioxidant capacity does not consistently prolong lifespan, highlighting that oxidative stress is only one element within the broader, multifactorial biology of aging (Iakovou et al., 2022). Oxidative stress is also strongly linked to neurodegenerative diseases—including Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis (ALS)—as well as acute neurological injuries such as stroke and traumatic brain injury. Its contribution involves mechanisms such as mitochondrial dysfunction, protein misfolding, lipid peroxidation, DNA damage, glial activation, and inflammation (D'Ascenzo & Colussi, 2025).

In Alzheimer's disease, biomarkers such as F2-isoprostanes—markers of lipid peroxidation—and presenilin-1 (PSEN1) mutations have been linked to oxidative stress, disease progression, and cognitive decline. Elevated levels of F2-isoprostanes in the cerebrospinal fluid and brain are associated with increased neuronal damage. Similarly, in gliomas, recent bibliometric analyses highlight research hotspots including ROS dosage, inflammatory signaling, apoptosis, ferroptosis, and the tumor microenvironment. Oxidative stress in this context plays a dual role: it contributes to tumor development by driving DNA damage and mutations, but it can also be exploited therapeutically, for instance by inducing ROS accumulation or ferroptosis (Zeng et al., 2025).

Hyptis suaveolens (L.) Poit., commonly called bush mint or pignut, is a rapidly growing aromatic herb belonging to the family Lamiaceae. It is widely distributed in tropical and subtropical regions and has a long history of use in traditional medicine. In recent years, the plant has attracted growing scientific interest due to its rich phytochemical profile and broad pharmacological potential. The species is a notable source of bioactive compounds, including essential oils, tannins, saponins, phenols, flavonoids, terpenoids, alkaloids, and sterols. Contemporary studies highlight its antimicrobial, antioxidant, and agricultural applications, though concerns about its invasive nature have also been raised (Worku, 2024). These phytoconstituents are associated with diverse biological activities, including antioxidative, anti-inflammatory, antispasmodic, antiseptic, anticancer, antiulcer, antiviral, antifungal, antidiabetic, antifertility, diaphoretic, dermatological, antirheumatic, gastroprotective, immunomodulatory, and analgesic effects.

Interest in *H. suaveolens* continues to grow because of its broad spectrum of traditional and experimentally validated properties (Worku, 2024; Dossa et al., 2024). Ethnobotanical surveys and reviews document its traditional use in various cultural contexts, often as herbal teas, topical preparations for wounds and skin infections, analgesics, and remedies for gastrointestinal ailments. These practices vary according to plant part and mode of preparation, with teas and topical extracts being most frequently reported (Dossa et al., 2024). While ethnobotanical knowledge provides valuable guidance for pharmacological screening, many of these uses remain insufficiently supported by modern clinical and toxicological research.

MATERIALS AND METHODS

Collection and Extraction of Plant Material

Fresh leaves of *Hyptis suaveolens* were authenticated at the University of Ilorin Botanical Garden and the International Institute of Tropical Agriculture (IITA), Ibadan, following the approval of the International Committee for Botanical Nomenclature (ICBN). The leaves were tagged, placed in polythene bags, and stored for subsequent use. They were air-dried in the shade at room temperature before extraction, which was carried out using a method previously described by Banso & Banso (2023) and Banso et al. (2024a).

Phytochemical Screening

Qualitative Analysis

Preliminary phytochemical tests were performed on the ethanol leaf extract to determine the presence of secondary metabolites.

Test for General Glycosides

One gram of powdered leaf sample was divided into two portions. Five millilitres of dilute sulfuric acid were added to one portion, and both were heated for 5 minutes before filtration. The filtrates were treated with 5% sodium hydroxide, followed by heating with Fehling's solution for 3 minutes. A reddish-brown precipitate confirmed the presence of glycosides (Banso et al., 2024b).

Test for Saponins

A 0.5 g portion of the extract was dissolved in 10 ml of distilled water and shaken vigorously. The formation of stable persistent froth indicates the presence of saponins (Godlewska et al., 2022).

Assay for Alkaloids

A few drops of Mayer's reagent were added to the extract the formation of a creamy or white precipitate indicates the presence of alkaloids (Ajayi & Ojelere, 2021). Addition of 1 ml of BiI_7K_4 solution to 2 ml of the extract produced an orange precipitate, confirming alkaloids.while the addition of 1 ml of Mayer's reagent to 2 ml of the extract resulted in a cream-colored precipitate, indicating alkaloids. Addition of Wagner's reagent (iodine–potassium iodide solution) to 2 ml of the extract produced a dark precipitate, confirming alkaloids.

Test for Steroids and Terpenoids

Ten millilitres of the chloroform extract were evaporated, and the residue dissolved in 0.5 ml chloroform. For the Liebermann–Burchard test, 0.5 ml acetic anhydride and 2 ml concentrated sulfuric acid were added. A blue-green coloration confirmed steroids (Banso et al., 2024c), while red, pink, or violet coloration indicated terpenoids.

Phytochemical Screening

Test for tannins: About 0.5 g of the extract was dissolved in 10 ml of distilled water. A few drops of 5% ferric chloride solution were added, and the appearance of a blue-black or greenish-black precipitate confirmed the presence of tannins (Banu & Cathrin 2020).

Test for sesquiterpenoids:

To 0.5 ml of the aqueous leaf extract, 0.5 ml of methanol was added and mixed. Subsequently, 0.4 ml of 5% sulfuric acid and 0.5% ferric chloride were introduced, and the solution was stirred with a glass rod. The mixture was heated in a Grant model water bath for 1 minute. A green to black colour change in the presence of ferric chloride indicated sesquiterpenes (Banso et al., 2024c).

Quantitative Analysis

Determination of total phenolic content (TPC) and tannin content:

The Folin–Ciocalteu method was employed to determine the TPC and tannin content of the ethanolic leaf extract, with absorbance measured using a UV-Vis spectrophotometer (Paganotti & Barbeira, 2024).

Determination of total flavonoid content:

One millilitre of a 1 mg/ml extract was mixed with 4 ml distilled water in a 10 ml volumetric flask. To this mixture, 0.3 ml of 5% $AlCl_3$ solution was added, followed by 2 ml of 1 M NaOH. The volume was made up to 10 ml with 2.4 ml distilled water and mixed thoroughly. A blank was prepared by replacing the extract with

distilled water. Standard quercetin solutions (20, 40, 60, 80, and 100 µg/mL in methanol) were used for calibration. Absorbance of both test and reference solutions was recorded at 510 nm after 30 minutes using a UV-Vis spectrophotometer (Liu et al., 2022).

Antioxidant Activity

DPPH radical scavenging assay:

A stock solution of DPPH was prepared by dissolving 2.4 mg of DPPH in 100 ml methanol. Leaf extracts were diluted to concentrations of 50, 100, 150, 200, and 250 µg/mL in ethanol. For each concentration, 100 µl of the extract was added to 3 ml of DPPH solution in a 25 ml volumetric flask. Ascorbic acid standards (50–250 µg/mL in distilled water) were prepared in the same way. DPPH with methanol served as the blank. After 30 minutes of incubation, absorbance was measured at 515 nm with a UV-Vis spectrophotometer Kadare, S.B& Sigh, R.P (2023). Radical scavenging activity was calculated according to Kuniyal (2024)

"DPPH scavenging activity (%)"=(A_control-A_sample)/A_control ×100

where A_controlis the absorbance of the DPPH solution without extract, and A_sampleis the absorbance of the DPPH solution with extract.

Antibacterial Bioassay

The antibacterial activity of the leaf extract was evaluated against Staphylococcus aureus (NCIB 8588) Bacillus cereus (NCIB 6349), Klebsiella pneumoniae (NCIB 418), Klebsiella pneumoniae (NCIB 418) and Pseudomonas aeruginosa (NCIB 980) using the agar well diffusion method (Banso & Banso, 2023). Bacterial suspensions were adjusted to 1×10^6 CFU/mL (0.5 McFarland standard). The cultures were spread evenly on nutrient agar plates using a sterile glass spreader. Wells were made on the agar surface, and 200 µL of the extract (50 mg/mL in DMSO) was introduced into each well with a sterilized pipette (Rashna et al., 2001). Plates were left at room temperature for 1 hour to allow diffusion, then incubated at 37°C for 24 hours. Zones of inhibition were measured and compared with those produced by the positive control antibiotic (Amoxicillin). The minimum inhibitory concentration (MIC) was determined using the EUCAST-approved broth microdilution method. The extract was dissolved in 10% DMSO and subjected to serial twofold dilutions in Mueller-Hinton broth within a microtiter plate. The final inoculum in the test wells was adjusted to 5×10^6 CFU/ml. Amoxicillin at a standard concentration of 10 µg/mL served as the positive control (Islam et al., 2011).

Human Red Blood Cell (HRBC) Suspension Preparation and HRBC Membrane Stabilization

Preparation of Solutions and HRBC Suspension

Preparation of Solutions

Alsever's solution was prepared by dissolving 2 g dextrose, 0.8 g sodium citrate, 0.05 g citric acid, and 0.42 g sodium chloride in 100 ml of distilled water. Hyposaline (0.36 g NaCl/100 ml) and isosaline (0.85 g NaCl/100 ml) solutions were similarly prepared. All solutions were sterilized by autoclaving before use.

Collection and Preparation of HRBC Suspension

Human blood was collected from healthy volunteers, and 2 mL of whole blood was mixed with 2 ml Alsever's solution to prevent coagulation. The mixture was centrifuged at 3000 rpm for 5 min, and the supernatant was discarded. The pellet was washed 2–3 times with isosaline until the supernatant became clear. The remaining red cells were resuspended in isosaline to yield a 10% human red blood cell (HRBC) suspension, which was stored at 4 °C until use.

Determination of Plasma Membrane Redox System (PMRS) Activity

The activity of the plasma membrane redox system (PMRS) was determined by measuring the reduction of ferricyanide, following the classical approach described by Avron and Shavit (1963) and adapted in recent work (Asadipour et al., 2024; Mishra, 2025). Briefly, 0.20 mL of packed red blood cells (PRBCs) from each extract-treated dilution and from the control group was suspended in phosphate-buffered saline (PBS) containing 5 mM glucose and 1 mM freshly prepared potassium ferricyanide, adjusting to a final volume of 2.0 mL. The suspension was incubated at 37 °C for 30 minutes and centrifuged at 1,800 rpm. The resulting supernatant was reacted with 4,7-diphenyl-1,10-phenanthroline disulfonic acid disodium salt to quantify

ferrocyanide, measuring absorbance at 535 nm (ε = 20,500 M^{-1}·cm^{-1}). PMRS activity was expressed as µmol ferrocyanide·mL^{-1} HRBC·30 min^{-1}.

Induction of Oxidative Stress

Oxidative stress was induced in both the extract-treated groups and the hydrogen peroxide (H_2O_2) control group, using a modified protocol of Stocks and Dormandy (1971). In brief, 0.50 mL of human red blood cell (HRBC) suspension was incubated with 0.50 mL of 200 mmol H_2O_2 under gentle continuous shaking for 30 minutes. After incubation, the mixture was agitated briefly and immediately used for the determination of malondialdehyde (MDA) and reduced glutathione (GSH). This H_2O_2-induced peroxidation model remains widely applied in recent erythrocyte oxidative stress studies (Orrico et al., 2023; Jarosiewicz, 2025).

Determination of Malondialdehyde (MDA) Content

The malondialdehyde (MDA) concentration in erythrocytes was determined using the thiobarbituric acid reactive substances (TBARS) method originally described by Esterbauer and Cheeseman, with modifications consistent with recent applications (Hermandez-Camba et al., 2024; Brignot et al., 2025; Kong et al., 2025). In brief, 0.2 mL of packed red blood cells was suspended in 3 mL of phosphate-buffered saline (PBS) containing 0.5 mM glucose. From this suspension, 0.2 mL was transferred into a new tube and treated with 1 mL of 20 % trichloroacetic acid (TCA), mixed, and centrifuged at 2,000 rpm. The resulting supernatant was reacted with 2 mL of 0.67 % thiobarbituric acid (TBA) solution. Samples were then heated at > 90 °C for 20 minutes, rapidly cooled in ice, and the absorbance was measured at 532 nm. The MDA concentration was calculated using an extinction coefficient of 156,000 M^{-1}·cm^{-1} and expressed as nmol mL^{-1} of packed red blood cells.

Determination of Reduced Glutathione (GSH) Levels

The concentration of reduced glutathione (GSH) was assessed following a modified procedure based on the methods of Beutler and Sedlak et al. (as adapted in more recent literature, e.g., Gok et al., 2024). The principle of the assay relies on the reduction of 5,5′-dithiobis-(2-nitrobenzoic acid) (DTNB) by sulfhydryl (–SH) groups, yielding the yellow 5-thio-2-nitrobenzoic acid (TNB) anion. In brief, 0.1 mL of sample was mixed with 0.9 mL phosphate-buffered saline (PBS). Then 1 mL of 20% trichloroacetic acid (TCA) was added, and the mixture was allowed to stand for 20 min, followed by centrifugation at 3000 rpm for 10 min. From the supernatant, 0.25 mL was collected and brought to 1.0 mL with PBS (i.e. plus 0.75 mL PBS). Subsequently, 2.0 mL of 0.0006 M DTNB solution was added, and the reaction mixture was incubated for 10 min. Absorbance was measured at 412 nm using a UV–VIS spectrophotometer. GSH concentration was calculated using the molar extinction coefficient (ε = 13,100 M^{-1}·cm^{-1}) and expressed as mg/mL of packed red blood cells (PRBCs) (Poimenova et al., 2024; Sattar et al., 2024).

Data Analysis

Analysis of variance (ANOVA) followed by Tukey's multiple range post-hoc test was performed using SPSS software version 20.0 (IBM Corp., Armonk, NY, USA). A p-value less than 0.05 was considered statistically significant.

RESULTS

Phytochemical Screening

The phytochemical analysis of *Hyptis suaveolens* leaves revealed the presence of alkaloids, tannins, general glycosides, steroids, and terpenoids, while saponins and sesquiterpenes were absent (Table 1).

Table 1. Total secondary metabolites in leaf extract of *Hyptis suaveolens*

Secondary metabolites	Quantity (mg/100g) ±SD
Alkaloids	9.5±2.0
Tannins	13.0±3.0
General glycosides	16.5±1.0
Saponins	8.5±2.0
Steroids	10.5±1.0
Terpenoids	17.0±3.0

Sesquiterpenes	ND

SD = Standard deviation, ND = Not detected

Quantitative Estimation of Secondary Metabolites

The quantified levels of major secondary metabolites in the leaf extract were as follows: alkaloids (9.5.5 ± 2.0 mg/100 g), tannins (13.0 ± 3.0 mg/100 g), general glycosides (16.5 ± 1.0 mg/100 g), steroids (10.5 ± 2.0 mg/100 g), and terpenoids (17.0 ± 3.0 mg/100 g) (Table 2).

DPPH Radical Scavenging Activity

The extract exhibited concentration-dependent antioxidant activity (Table 3). At concentrations of 50, 100, 150, 200, and 250 µg/ml, the scavenging activity of ascorbic acid was 40.50 ± 2.20µg/ml, 50.00 ± 2.22 µg/ml, 65.50 ± 1.80 µg/ml, 80.75 ± 2.53 µg/ml, and 90.64 ± 1.45 µg/ml, respectively. Corresponding values for *Hyptis suaveolens* extract were 05.34 ± 1.03 µg/ml, 14.73 ± 3.30 µg/ml, 23.43 ± 2.34 µg/ml, 35.00 ± 3.18 µg/ml, and 43.33 ± 2.43 µg/ml.

Antimicrobial Activity

The antimicrobial assay demonstrated inhibition zones ranging between 14.5 ± 0.5 mm and 16.4 ± 2.4 mm (Table 4 and Figure 1). Inhibition zones of 14.5±0.5mm, 15.8±0.3mm, 19.0±3.1mm and 16.4±2.4mm were recorder against *E. coli*, *S. aureus*, *E. faecalis* and *B. Subtilis* respectively.

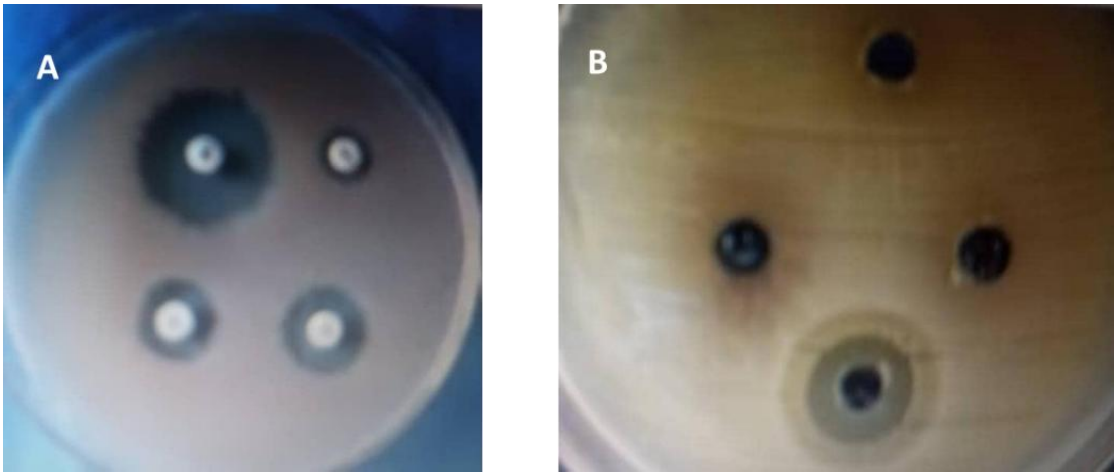

Figure 1. Zones of inhibition produced by extract against A), *E. faecalis* and B), *B. subtilis*

Table 2. Antimicrobial activity of leaf extract of *Hyptis suaveolens*

	Leaf extract (50mg/ml)	Standard antibiotic
	Diameter of zone of inhibition (mm)±SD	
Bacterial strain	Ethanol extract	Amoxicillin
S. aureus	14.5±0.5	32.7±0.1
B.cereus	15.8±0.3	38.6±2.2
K. pneumoniae	19.0±3.1	40.3±2.1
P. aeruginosa	16.4±2.4	39.5±3.0

Oxidative Stress

The dose–response of *Hyptis suaveolens* leaf extract on erythrocytes subjected to oxidative stress with hydrogen peroxide revealed a concentration-dependent modulation of plasma membrane redox system (PMRS) activity, glutathione (GSH) content, and malondialdehyde (MDA) levels (Table 3 & 4). Exposure to H_2O_2 alone markedly increased MDA (19.50 nmol/mL) and depleted GSH (0.93 µg/mL), indicating severe oxidative damage. In contrast, the untreated control erythrocytes maintained low MDA (0.23 nmol/mL) and high GSH (26.85 µg/mL), with basal PMRS activity (2.85 µmol ferrocyanide·mL^{-1} HRBC·30 min^{-1}). Treatment with *H. suaveolens* extract significantly enhanced PMRS activity across all tested concentrations, with the highest

stimulation observed at 100 µg/mL (3.60 µmol ferrocyanide·mL^{-1} HRBC·30 min^{-1}). GSH levels also increased, peaking at 30.40 µg/mL at 100 µg/mL extract, suggesting restoration of antioxidant defense. MDA content, a marker of lipid peroxidation, was reduced compared to H_2O_2 treatment, though values varied with concentration. At 100 µg/mL, MDA was 0.41 nmol/mL, markedly lower than the H_2O_2 group, while at 12.5 µg/mL, MDA rose to 0.78 nmol/mL, indicating less effective protection at lower doses. Overall, the extract demonstrated a dose-dependent protective effect, with higher concentrations (50–100 µg/mL) showing superior efficacy in enhancing PMRS activity, replenishing GSH, and suppressing lipid peroxidation compared to lower concentrations.

Table 3. Dose response o leaf extract of *Hyptis suaveolens* on the activity of plasma membrane redox system, malondialdehyde content and glutathione content in erythrocyte subjected to oxidative stress with hydrogen peroxide

Sample	Concentration (µg/mL)	PMRS (µmol ferrocyanide. mL^{-1} HRBC. 30min^{-1})	GSH(µg/mL)	MDA (nmol/mL)
H_2O_2			19.50	0.93
Control		2.85	26.85	0.23
	100	3.60	30.40	0.41
	50	3.38	27.00	0.47
	25	3.24	23.10	0.42
	12.5	3.20	22.96	0.78

Table 4. DPPH scavenging activity of ascorbic acid and leaf extract of *Hyptis suaveolens*

Concentration (µg/ml)	DPPH scavenged by ascorbic acid (%) ± SD	DPPH scavenged by leaf extract (%) ± SD
50	40.50±2.20	05.34±1.03
100	50.00±2.22	14.73±3.30
150	65.50±1.80	23.43±2.34
200	80.75±2.53	35.00±3.18
250	90.65±1.45	43.33±2.43

SD = Standard deviation

DISCUSSION

The phytochemical analysis of *Hyptis suaveolens* leaf extract revealed the presence of tannins, alkaloids, tannins, general glycosides, steroids and terpenoids, but saponins and sesquiterpenes were absent. These findings align with the report of Bjorkman et al. (2011), who noted that certain secondary metabolites may only be localized in specific plant parts and that environmental stress can influence their abundance. Several agronomic factors, including the developmental stage of the plant, the specific organ under study, fertilization, and soil pH, can significantly affect both the quality and quantity of secondary metabolite production. In addition, variations in phytochemical content and composition are often determined by environmental and genetic factors (Bjorkman et al., 2011).

The present study demonstrated that the DPPH scavenging activity of *Hyptis suaveolens* leaf extract increased with rising extract concentration, though its antioxidant potential was lower than that of ascorbic acid. Antioxidants function by inhibiting molecular oxidation, thereby preventing oxidative chain reactions. The antioxidant capacity of *Hyptis suaveolens* leaves can be attributed to the presence of flavonoids, phenolics, tannins, and glycosides. Among these, phenolic compounds are particularly important due to their redox properties, which play a central role in neutralizing peroxides. Phenolics are capable of donating hydrogen atoms, thereby reducing the stable purple DPPH radical to the colourless DPPH-H form. This reaction is visually confirmed by the fading of the purple coloration in DPPH solution (Asmamaw & Yalemtsehay, 2017).

Furthermore, *Hyptis suaveolens* leaf extracts exhibited antibacterial activity against *S. aureus* (NCIB 8588), *B. cereus* (NCIB 6342), *K. pneumoniae* (NCIB 418) and *P. Aeruginosa* (NCIB 950). The varying sizes of inhibition

zones across test organisms suggest differences in susceptibility to the extract. These findings agree with of Banso et al. (2024), who reported that antimicrobial efficacy often varies with the target species. Additionally, Banso et al. (2021) emphasized that factors such as initial microbial density, growth rate, and the diffusion capacity of the antimicrobial compound can affect inhibition zone size. The pharmacological potential of the extract may be linked to its phytochemical constituents, which are recognized as important sources of bioactive agents (Banso et al., 2024d).

CONCLUSION

The study highlights that oxidative stress, driven by excess ROS and RNS, can overwhelm natural antioxidant defenses, leading to cellular damage. The investigation into *Hyptis suaveolens* leaf extract demonstrated promising biological activities: although its free radical scavenging ability was lower than that of ascorbic acid, it significantly enhanced plasma membrane redox system activity, maintained glutathione levels, and reduced lipid peroxidation under oxidative stress conditions. Moreover, the extract exhibited antibacterial effects against multiple pathogenic strains, indicating a dual role in both oxidative stress mitigation and microbial inhibition. Overall, these findings suggest that *Hyptis suaveolens* contains bioactive compounds with potential therapeutic applications, particularly in chemoprevention and antimicrobial strategies, warranting further exploration for pharmaceutical development.

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AUTHORS CONTRIBUTION

All the authors equally contributed to this work. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICAL APPROVAL

Not applicable.

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AVAILABILITY OF DATA AND MATERIALS

All datasets analyzed and described during the present study are available from the corresponding author upon reasonable request.

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