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Original Article

In vitro investigation on *Pennisetum purpureum* leaf extracts grown in Indonesia of phytochemical components, optical characteristics, and antioxidant-antibacterial activities

Investigação in vitro em extratos de folhas de *Pennisetum purpureum* cultivados na Indonésia: componentes fitoquímicos, propriedades ópticas e atividades antioxidantes-antibacterianas

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Abstract

Medicinal plants hold significant cultural significance and play a crucial role in the advancement of potentially safe drugs for the therapy of disease worldwide. *Pennisetum purpureum* or elephant grass has been used for traditional medications in Indonesia without understanding the phytochemicals of those plants. Herein, our report revolves around the qualitative and quantitative examination of phytochemical components, optical properties, antioxidants, and antibacterial assessments of solvent fractions derived from *Pennisetum purpureum* leaf. The *Pennisetum purpureum* leaf was successfully soaked with ethanol, n-hexane, and chloroform. The study aimed to assess the total phenolic content (TPC), total flavonoid content (TFC), and total alkaloid content (TAC) within different of extracts. The optical properties of extract were analyzed by absorption light and photoluminescent. Moreover, evaluation of antioxidant activities of extracts through DPPH free radical scavenging and FRAP assays, followed by an evaluation of their effectiveness in antibacterial therapy against different bacterial strains. The qualitative and quantitative phytochemical of *Pennisetum purpureum* presented as highest in ethanol TPC (85.5 mg GAE/g extracts), TFC (87.9 mg QE/g extracts), and TAC (86.2 mg ATE/g extracts) as compared to other solvents extract. *Pennisetum purpureum* extract had antioxidant capacity against DPPH radical and FRAP assay. Furthermore, each of the samples displayed antibacterial effectiveness that was dependent on the dosage towards different strains of bacteria. Our findings clearly demonstrated that *Pennisetum purpureum* leaf extracts grown in Indonesia containing alkaloid, flavonoid, glycoside, saponin, steroids, tannin, and terpenoids that support its capability as antioxidant and antibacterial.

Keywords: *Pennisetum purpureum*, phytochemical constituents, optical properties, antioxidant.

Resumo

As plantas medicinais possuem importante significado cultural e desempenham um papel crucial no avanço de medicamentos potencialmente seguros para o tratamento de doenças em todo o mundo. *Pennisetum purpureum*, ou capim-elefante, tem sido usado na medicina tradicional na Indonésia, sem o entendimento dos fitoquímicos dessas plantas. Este relatório enfoca o exame qualitativo e quantitativo de componentes fitoquímicos, propriedades ópticas, antioxidantes e avaliações antibacterianas de frações de solventes derivadas da folha de *Pennisetum purpureum*. A folha de *Pennisetum purpureum* foi embebida com sucesso em etanol, n-hexano e clorofórmio. O estudo teve como objetivo avaliar o teor de fenólicos totais (CPT), o teor de flavonoides totais (CFT) e o teor de alcaloides totais (CAT) em diferentes extratos. As propriedades ópticas do extrato foram analisadas por absorção de luz e fotoluminescência. Além disso, avaliação das atividades antioxidantes dos extratos por meio de eliminação de radicais livres DPPH e ensaios FRAP, seguida de avaliação de sua eficácia na terapia antibacteriana contra diferentes cepas bacterianas. O fitoquímico qualitativo e quantitativo de *Pennisetum purpureum* apresentou-se mais alto em etanol TPC (85,5 mg GAE/g extratos), TFC (87,9 mg QE/g extratos) e TAC (86,2 mg ATE/g extratos) em comparação com outros extratos solventes. O extrato de *Pennisetum purpureum* apresentou capacidade antioxidante contra o radical DPPH e ensaio FRAP. Além disso, cada uma das amostras apresentou eficácia antibacteriana que dependia da dosagem para diferentes cepas de bactérias. Nossas descobertas demonstraram claramente que o extrato de *Pennisetum purpureum* contém alcaloides, flavonoides, glicosídeos, saponinas, esteroides, taninos e terpenoides que suportam sua capacidade como antioxidante e antibacteriano.

Palavras-chave: *Pennisetum purpureum*, constituintes fitoquímicos, propriedades ópticas, antioxidante.

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1. Introduction

Traditional healthcare practices, known as folkloric medicaments, encompass a wide range of healthcare practices. These methods involve using plant-based concoctions, animal-derived products (including organs, excretions, and secretions), natural minerals, and physical, manual, and spiritual therapies, which are employed independently or in various combinations to treat various diseases affecting humans and livestock in the global scale (Rondilla et al., 2021). Ancient Iranian medicine, Siddha medicine, Islamic medicine, Unani, and traditional Chinese, Korean, and African medical systems are among the notable traditional medicinal practices employed to provide symptomatic relief or address a variety of health issues (Wangkheirakpam, 2018). Folk medicine in Indonesia stands out for its distinctive methods of disease causation identification, unique diagnostic techniques, utilization of diverse medical resources, and application of unique treatment methods (Chahyadi et al., 2014). Indonesia boasts a wealth of plant and animal species and features diverse agroecological regions, playing a role in the dispersal and proliferation of its plant and animal species. (Rutgrink et al., 2018). Moreover, Indonesia is populated by indigenous communities that encompass a wide range of languages, cultures, and beliefs. Diversity has played a pivotal role in shaping the existing pluralistic traditional healthcare systems (Murray Li, 2000). For centuries, indigenous communities in Indonesia have harnessed plant- and animal-based preparations to prevent, treat, and eliminate various diseases which have almost 85% plant-depended formulations for their healthcare (Elfahmi et al., 2014). Therefore, the development of novel plants for healthcare should be studied deeply to find an identification of compounds in each plant.

The widespread application of herbal remedies in the improvement of various ailments be attributed to their cultural acceptance, cost-effectiveness, perceived efficacy, and limited potential for adverse reactions (Sujarwo et al., 2015). Moreover, the consistent utilization of plant-based formulations can be linked to the existence of bioactive secondary compounds that exhibit significant biological properties (Twaij and Hasan, 2022; Rodrigues et al., 2024). Some noteworthy instances agents of pharmaceuticals found such as azithromycin, aspirin, amphotericin B, atropine, acyclovir, pilocarpine, curcumin, capsaicin, digitoxigenin, artemisinin, vinblastine, tubocurarine, and various others which extracted from plants and are commercially available for medical use (Gonfa et al., 2021; Mathur and Hoskins, 2017) that has emphasized the crucial role by medicinal plants (MPs) and the associated indigenous wisdom in providing essential pharmaceutically active ingredients for the management of various illnesses. Recently, significant focus has been directed towards the examination of medicinal plants (MPs) species frequently recommended by traditional healthcare practitioners (THPs) or healers for the treatment of diverse ailments within various indigenous communities worldwide (Assan et al., 2009; Karaköse, 2022; Yaseen et al., 2015). Evaluation of the connection between existing knowledge of MPs held by THPs and the expected pharmacological properties of MPs using stringent scientific methodologies to introduce a greater number of safe and effective bioactive compounds into the drug discovery process is very important. Various plant-derived products were evaluated, including extracts, essential oils, and Isolated substances obtained from different botanical variety. A significant correlation was observed between folkloric practices of THPs and MPs pharmacological properties in bioactivities and phytoconstituents of plant taxa recognized as desirable outcomes in the treatment of diseases (Mogana et al., 2020; Gashaye and Birhan, 2023).

Pennisetum purpureum commonly known as Napier grass or Elephant grass, belongs to the Poaceae family (also known as *Gramineae*), is predominantly found in African tropical grasslands and continues to be present in many tropical and subtropical regions like Indonesia (Reddy et al., 2012). These grass species are characterized by robust perennial stems that require very few nutrients for their growth and typically grow to heights exceeding 3 meters with the highest biomass yield among other herbaceous plants and are employed as cattle fodder in Indonesia (Setiani et al., 2022; Nugroho et al., 2020). More importantly, the folkloric use of *Pennisetum purpureum* for treating infections may be linked to its significant antimicrobial properties. Although *Pennisetum purpureum* is used for infection treatment, there has been no investigation into its phytochemical constituents, antioxidant properties, or antibacterial activities, especially *Pennisetum purpureum* that grown in Indonesia. Thus, in this study, we present our findings on the phytochemical constituents, antioxidant properties, and antibacterial activities of *Pennisetum purpureum* in Indonesia.

2. Materials and Method

2.1. Chemicals and reagents

2.1.1. Chemicals

A variety of chemical substances, including ethanol, n-hexane, chloroform, methanol, sodium hydroxide, concentrated sulfuric acid, trichloroacetic acid, potassium iodide, potassium ferricyanide [$K_3Fe(CN)_6$], disodium hydrogen phosphate, monosodium hydrogen phosphate, Gallic acid (GA), Folin-Ciocalteu Reagent (FCR), sodium carbonate, 2,2-diphenyl-1-picrylhydrazyl (DPPH), ascorbic acid (AA), bromocresol green (BCG), quercetin (Q), and atropine (AT) were purchased from Sigma-Aldrich (St. Louis, MO, USA) or Acros Organics (Geel, Belgium). These chemicals were of analytical grade and were directly employed in the study without any purification procedures.

2.1.2. Reagents for antibacterial culture

BBL™ Brucella Broth and Difco™ Lactobacelli MRS Broth, anaerobic jar, anaerobe blood agar plate (BAP) was obtained from Becton Dickinson (BD) Biosciences, Franklin Lakes, USA. *Lactobacillus Reuteri (L.Reuteri)*, and *Escherichia Coli (E.Coli)* were served from the American Type Culture Collection (ATCC).

2.2. Collection of Pennisetum purpureum

In the current research, we employed *Pennisetum purpureum* specimens sourced from Sidoarjo, located in East Java, Indonesia. Subsequently, a voucher specimen was meticulously prepared and has been stored in the laboratory of the Department of Physics at Universitas Negeri Surabaya.

2.3. Extraction and photochemical

The leaves of *Pennisetum purpureum* were cleansed and subjected to a 10-day air-drying process in a well-ventilated area within our laboratory room located in the Department of Physics at Universitas Negeri Surabaya. This drying process continued until a consistent mass was achieved. Afterward, the dried leaf was carefully ground into a relatively uniform powder characterized by small grain-size particles. Subsequently, 200 g of powdered *Pennisetum purpureum* leaf were successively immersed in ethanol, n-hexane, and chloroform. These soaking procedures were carried out in aluminum foil-sealed beakers, each containing a solvent volume that was ten times the mass of the powdered leaf. These mixtures were agitated at regular intervals while maintaining a temperature of approximately 25 °C. After a span of a week, the mixture was filtered through filter paper and the extraction solvents were subsequently reclaimed using a rotary evaporator equipped with a vacuum system to obtain the crude extracts. The dried products were weighed, and the percentage yields were calculated using the following Formula 1:

$$The\ yield\ of\ crude\ extract\ (\%) = \frac{Weight\ of\ dry\ extracts}{Weight\ dry\ Pennisetum\ purpureum} x\ 100 \quad (1)$$

Furthermore, the *Pennisetum purpureum* leaf was subjected to screening to determine the consequence of secondary metabolite presence or absence, employing established standard methods. The identification and quantification of various secondary metabolites in *Pennisetum purpureum* relied on observable indicators such as the formation of precipitates or foam, the emergence of new colored compounds, and other characteristic features associated with the phytochemicals being studied.

2.4. Determination of phenolic content in Pennisetum purpureum extracts

The TPC of *Pennisetum purpureum* was evaluated by the Folin-Ciocalteu method, as indicated in previous studies (Amin et al., 2006; Saeed et al., 2012). Briefly, 5 mL of FCR was prepared into 1 mL of *Pennisetum purpureum* extract and added in tubes. After 5 min, a 10% Na_2CO_3 solution (4 mL) was introduced into the mixture, which was then vortexed and kept at 37 °C about 45 min. Following that, triplicate samples were analyzed using a UV-Vis at 760 nm, and the total phenolic content (TPC) of *Pennisetum purpureum* was calculated based on a previously established calibration curve for methanolic Gallic Acid (GA). This calculation was determined using the relationship c(V/m), which links the concentration (c) of GA (in mg/mL), the volume (V) of the extract (in mL), and the mass (m) of the extract (in g).

2.5. Determination of flavonoid content in Pennisetum purpureum extracts

The colorimetric test with aluminum chloride was used to determine the total flavonoid content (TFC) content of *Pennisetum purpureum* using quercetin as the reference. The results were expressed as mg quercetin equivalents per 100 g of dry material (Ayele et al., 2022). Briefly, different amounts of *Pennisetum purpureum* were combined with 1 mL of quercetin, 4 mL of distilled water, and 0.3 mL of $NaNO_2$ before being placed in an incubator for 5 min. Next, 10% aluminum chloride (0.3 mL) and 1 M NaOH (2 mL) were introduced into the mixture, and a UV-Vis spectrophotometer measurement was conducted at 510 nm. Finally, TFC for the triplicate *Pennisetum purpureum* extract was determined using a regression equation derived from a pre-established calibration curve of quercetin.

2.6. Determination of alkaloid content in Pennisetum purpureum extracts

The BCG ion-pair formation assay, with minor adjustments, was employed to determine the total alkaloid content (TAC) of *Pennisetum purpureum* extract, expressed as mL of atropine equivalents per 100 g of dry samples. The fundamental principle relies on the interaction between the negatively charged BCG and the alkaloid, resulting in the formation of a fluorescent, active ion-pair complex. Briefly, 10 mg of *Pennisetum purpureum* extract was dissolved in 10 mL of 2 M HCl, combined with 5 mL of phosphate buffer (pH = 4.7), and 5 mL of BCG, followed by thorough mixing. Subsequently, 4 mL of chloroform was introduced, and the resulting solution, which had a yellow color, was collected, and further supplemented with chloroform to reach a final volume of 10 mL. Finally, the absorbance of each sample was measured at 470 nm, and the TAC was calculated using a calibration curve previously established for atropine.

2.7. Absorbance of Pennisetum purpureum extract by UV–Vis spectrophotometry and photoluminescence spectrophotometry

The optical absorption of *Pennisetum purpureum* extract was recorded by a UV-Vis within the range of 200-800 nm. Fluorescence intensity of *Pennisetum purpureum* extract was determined using a photoluminescence spectrometer with excitation wavelength (400 nm) and scanned range from 410-800 nm.

2.8. Analysis of antioxidant activity

2.8.1. Test for radical scavenging by DPPH

The antioxidant capacity of the *Pennisetum purpureum* extract was assessed using the straightforward and reliable DPPH free radical assay (Ngoua-Meye-Misso et al., 2018). First, a stock solution was created by dissolving 10 mg of *Pennisetum purpureum* extract in 25 mL of ethanol. Following that, a range of working concentrations for the *Pennisetum purpureum* extract and the standard ascorbic acid (AA) were prepared by dilution from their respective stock solutions. Then, in assessing radical scavenging activity, 3 mL of a 1 M DPPH solution was combined with 4 mL of *Pennisetum purpureum* extract and atropine solution (all test samples were prepared in triplicates).

The mixture was then incubated at 37 °C for 30 min, and the absorbance was measured at 517 nm using a UV-Vis spectrophotometer. The percentage of DPPH radical scavenging potential for the test samples was calculated using the following Formula 2:

$$DPPH\ radical\ scavenging\ activity\ (\%) = \frac{Absorbance\ of\ control - Absorbance\ of\ sample}{Absorbance\ of\ control} x\ 100 \quad (2)$$

2.8.2. Test for radical scavenging by FRAP

The antioxidant efficacy of the *Pennisetum purpureum* extract was evaluated using the Ferric Reducing Antioxidant Power (FRAP) assay (El Jemli et al., 2016). To a solution containing 1% potassium ferricyanide [$K_3Fe(CN)6$] (2.5 mL) in 0.2 M sodium phosphate buffer with a pH of 6.6 (2.5 mL), 2.5 mL of *Pennisetum purpureum* extract at various concentrations was added. The mixture was thoroughly mixed (vortexed) and then incubated at 50 °C. Then, after 20 min, the solution was further treated with trichloroacetic acid (2.5 mL) and then centrifuged at 3000 rpm for 10 min. Following centrifugation, 2.5 mL of the supernatant was retrieved and combined with 0.1% ferric chloride solution (0.5 mL) and distilled water (2.5 mL). The absorbance of the resultant-colored solution was measured at 700 nm using a UV-Vis spectrophotometer. Likewise, the absorbance of distilled water and AA was determined, serving as the control and reference standard, respectively. The percentage of FRAP reduction potential for the test samples was calculated as follows Formula 3:

$$FRAP(\%) = \frac{Absorbance\ of\ control - Absorbance\ of\ blank}{Absorbance\ of\ sample} x\ 100 \quad (3)$$

2.9. Antibacterial assay

A solitary colony of *Escherichia coli* (*E. coli*; as a gram-negative bacterium) and *Staphylococcus aureus* (*S. aureus*; as a gram-positive bacterium) was utilized for this study. These microorganisms were cultured on Muller-Hinton agar. The minimal inhibitory concentration (MIC; µg/mL) is characterized as the lowest concentration of *Pennisetum purpureum* extract that entirely halted bacterial growth, achieved through the standard method of serial dilution by a factor of two in 96-well micro-test plates. The bacteria growth was monitored via spectrophotometry.

2.10. Statistical analysis

A minimum of three independent tests were carried out to validate the statistical significance of the variations among the groups using Student's t-test. Significant differences were denoted in the figures when the p-value (ρ) was less than 0.05.

3. Results and Discussion

The extract yields of *Pennisetum purpureum* leaf extracts were obtained after extraction process using ethanol, n-hexane, and chloroform as solvent. These results showed that polar solvent (ethanol) has highest extract yield than semipolar (chloroform) or non-polar (n-hexane) solvent with 15.5%, 6.3%, and 7.5%, respectively as presented in Table 1. This result is similar reported to Jack and co-worker's studies that the extract yield percentage of *Pennisetum purpureum* shoot extract is in the order polar (methanol) > non-polar (n-hexane) (Ojo et al., 2022). The *Pennisetum purpureum* extractant with polarity solvent is an important factor in improving the recovery of phenolic and flavonoid chemicals. Moreover, plants contain secondary metabolite, including phenolic and flavonoid content, to support their function, such as pharmacological effect (El Mannoubi, 2023; Velu et al., 2018; Yeshi et al., 2022; Tungmunnithum et al., 2018), which indicates that the highest phenolic and flavonoid content follows the extract with the highest yield percentage.

The secondary metabolite is divided into groups based on the chemical structure including alkaloid, flavonoid, glycoside, saponin, steroids, tannin, and terpenoids (Twaij and Hasan, 2022). The phytochemical of *Pennisetum purpureum* leaf extracts in various reagents confirmed the presence of alkaloids, flavonoids, glycosides, saponin, steroids, and terpenoids. However, tannin was not confirmed in any *Pennisetum purpureum* extracts (Table 2).

Table 1. The yields of *Pennisetum purpureum* leaf extracts.

Extract	Weight of extract (g)	Yield (%)
Ethanol	26.5	15.5
n-Hexane	13.2	6.3
Chloroform	15.8	7.5

Table 2. Qualitative of phytochemical properties of *Pennisetum purpureum* leaf extracts.

Phytochemical	Reagent	Yield (%)		
		Ethanol	n-Hexane	Chloroform
Alkaloid	Wagner's test	+++	-	++
Flavonoid	H_2SO_4 test	+++	-	++
Glycoside	Killer-Killiani test	++	-	+
Saponin	Forth test	+++	-	++
Steroids	Salkowski's test	++	+	++
Tanin	Ferric Chloride test	-	-	-
Terpenoids	Salkowski's test	++	+	+++

Note: (-), not detected (ND); (+), present; (++), moderately present and (+++), highly present.

Similar results with extract yield, extraction process using polar solvent have phytochemical yield is higher than non-polar solvent. This result also showed that alkaloid, flavonoid, saponin, and terpenoid groups are the highest phytochemical found in *Pennisetum purpureum* extracts. Alkaloids are especially well-known for their use as anti-inflammatory, cardioprotective, and anesthetics (Heinrich et al., 2021). Flavonoids are a diverse group of polyphenolic chemicals with antiviral, anticancer, anti-inflammatory, antioxidant, and cardioprotective qualities that are important in the treatment of many various disorders (Tungmunnithum et al., 2018; Salim et al., 2022). Saponins are amphiphilic molecules with multiple biological activities, including fungicidal, antimicrobial, antiviral, anti-inflammatory, anticancer, antioxidant, and immunomodulatory effects which are composed of carbohydrates and either triterpenoid or steroid aglycone moieties (Juang and Liang, 2020).

Next, we further evaluate total phenolic content (TPC), total flavonoid content (TFC), and total alkaloid content (TAC) contained in *Pennisetum purpureum* extracts. As shown in Table 3, TPC, TFC, and TAC in ethanol extract have the highest value, 85.5 mg GAE/g, 87.9 mg QE/g, and 86.2 mg ATE/g, respectively, compared to n-hexane and chloroform. These results are consistent with extract and phytochemical yield analysis as mentioned above, which might be due to the polarity of ethanol being higher than other solvents. The polarity of the solvent used in extraction plays a crucial role in enhancing the dissolution of phenolic and flavonoid compounds, solvents with higher polarity tend to extract larger quantities of phenolic compounds.

Then, the optical profile of *Pennisetum purpureum* extracts was studied with UV-Vis absorption, as depicted in Figure 1a. The characteristic absorption of *Pennisetum purpureum* has occurred at a wavelength of 405 nm, suggesting *Pennisetum purpureum* extract has the capability to absorb light intensity. The charge carrier dynamics were further investigated by measuring the emission spectra with photoluminescence (PL) spectroscopy. As depicted in Figure 1b, the *Pennisetum purpureum* extract displayed distinct emission peaks at slight to blue-shifted at 400 nm with a high intensity of about 175 after being excited at 400 nm, observed significant quenching emission.

The assessment of the antioxidant capability of plant extracts frequently relied on the DPPH radical scavenging assay, known for its brevity and effectiveness (Khanal et al., 2022). The potency of *Pennisetum purpureum* extract as a free radical scavenger was investigated using DPPH and FRAP assay. DPPH assay will be detected from the purple color of the DPPH radical became yellow due to the donor hydrogen or electrons from the extract and standard ascorbic acid (AA) (Mughal et al., 2024). FRAP assay was measured from ability the extract to reduce Fe(III) in potassium ferricyanide (yellow color) to Fe(II) (light green). As shown in Figure 2a, *Pennisetum purpureum* extract had antioxidant capacity against DPPH radical and Fe(III) in potassium ferricyanide. The percentage radical scavenging of *Pennisetum purpureum* extract increased, in line with increasing concentration. Interestingly, the result of *Pennisetum purpureum* ethanol extract has a similarity with AA as control at 320 ppm concentration (Figure 2b). *Pennisetum purpureum* extract has the capability to reduce Fe(III) in potassium ferricyanide. However, the increasing concentration of extract did not affect the reduction of power (Figure 2c and d). These results indicate that a small concentration of *Pennisetum purpureum* extract has the ability to reduce Fe(III) in potassium ferricyanide.

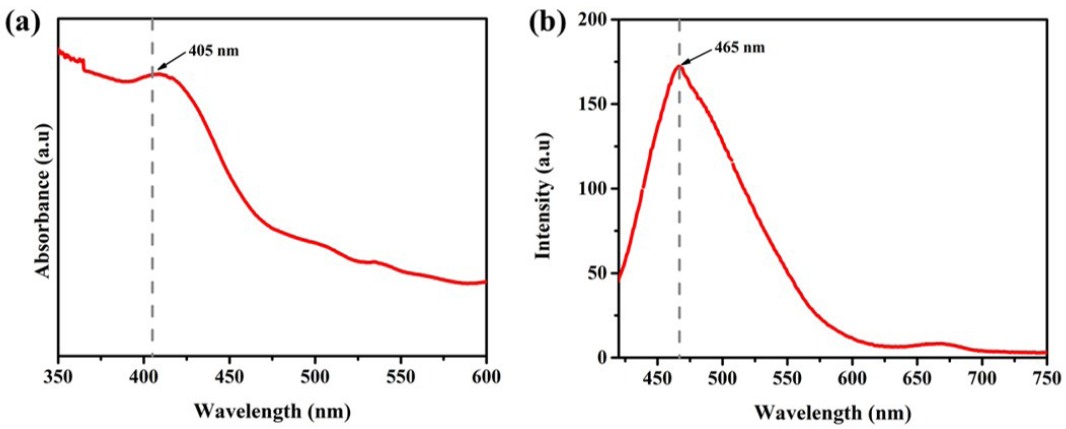

Figure 1. Optical properties of *Pennisetum purpureum* extract under **(a)** UV-Vis and **(b)** PL spectra.

Table 3. The yields of *Pennisetum purpureum* leaf extracts.

Extract	TPC (mg GAE / g)	TFC (mg QE /g)	TAC (mg ATE/g extracts)
Ethanol	85.5	87.9	86.2
n-Hexane	15.8	20.4	23.6
Chloroform	43.5	40.8	45.5

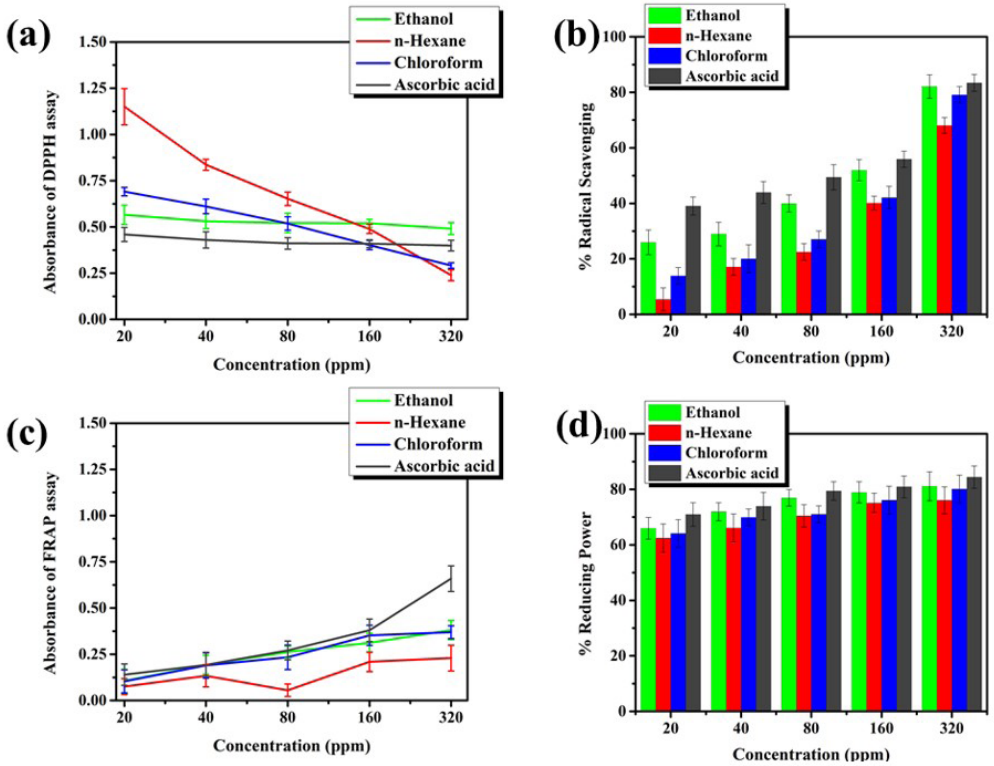

Figure 2. DPPH assay (**a**), radical scavenging activity (**b**), FRAP assay (**c**), and percent reducing power (**d**) of *Pennisetum purpureum* extract.

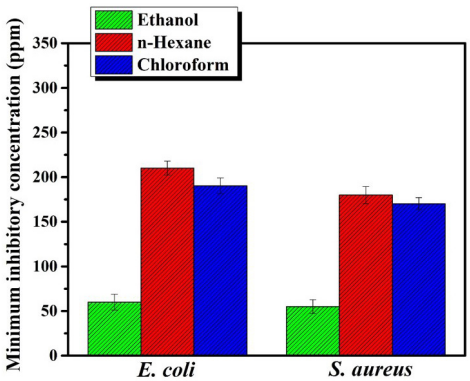

Figure 3. Antibacterial analysis of *Pennisetum purpureum* extract towards different type of bacterium.

Antioxidant activity of *Pennisetum purpureum* extract might be due to its phytochemical that is somewhat polar and contains hydroxyl groups, which have the ability to neutralize the adverse impacts of reactive oxygen species (ROS) like oxidative stress within cells by absorbing and quenching (Molla Yitayeh and Monie Wassihun, 2022; Mughal et al., 2024).

Plants can be valuable as economical and dependable sources of antibacterial agents, with substantial evidence indicating their antimicrobial potential, primarily through crude extracts (Namukobe et al., 2021; Chhetry et al., 2022; Birhan et al., 2023). Apart from the antioxidant assay, this study also investigated the effects of *Pennisetum purpureum* extract as antibacterial against *Escherichia coli* (*E. coli* as a gram-negative) and *Staphylococcus aureus* (*S. aureus* as a gram-positive). As depicted in Figure 3, all the solvents *Pennisetum purpureum* extract could inhibit the bacteria growth, which *Pennisetum purpureum* ethanol extract has the lowest minimum inhibitory concentration (MIC; 65 ppm) compared to other solvents, suggesting that abundance of phytochemicals with polar characteristics, which are recognized for their antibacterial properties. Overall, the extract from *Pennisetum purpureum* demonstrated a favorable inhibitory impact on the growth of all the tested bacterial strains. The notable suppression of bacterial growth by *Pennisetum purpureum* may be linked to the high concentration of secondary metabolites such as flavonoids, alkaloids, phenols, terpenoids, tannins, and other compounds known for their strong antibacterial properties (Mujeeb et al., 2014; Haleem et al., 2022). The above-mentioned secondary metabolites might initiate disruptive electrostatic interactions between their hydroxyl groups and cellular components, leading to the lysis of bacterial cells (Hadadi et al., 2020). Therefore, the growth-inhibiting properties of the unrefined extracts against the tested strains validate the traditional use of *Pennisetum purpureum* in treating various diseases caused by the production and/or buildup of reactive oxygen species (ROS) and pathogenic bacterial strains.

4. Conclusion

The *Pennisetum purpureum* was successfully macerated with ethanol, n-hexane, and chloroform. Numerous secondary metabolites were identified within the crude extracts through qualitative phytochemical analysis, including alkaloid, flavonoid, glycoside, saponin, steroids, tannin, and terpenoids. The strong correlation between the ability of *Pennisetum purpureum* extract to quench the DPPH radical and reduce Fe^{3+} and their respective values for TPC, TFC, and TAC was observed. The significant antioxidant potential of the *Pennisetum purpureum* extract can be attributed to the presence of flavonoids, alkaloids, and phenolic compounds. Moreover, the extract displayed notable inhibitory effects on the growth of the tested bacterial strains. Overall, our findings clearly demonstrated that *Pennisetum purpureum* leaf extracts grown in Indonesia containing phytochemical compound including alkaloid, flavonoid, glycoside, saponin, steroids, tannin, and terpenoids that support its capability as antioxidant and antibacterial.

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