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Original Article

Comparative Assessment of the Therapeutic Efficacy of Selected Pashanbheda Plants

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ABSTRACT

Background: The process of formation or appearance of a urinary stone anywhere in the renal tract is known as urolithiasis. Several plants are used and sold as 'Pashanbheda' in different parts of the world. In this work we have selected three medicinal plants which are considered as Pashanbhed. The plants were *Bergenia ligulata, Bergenia ciliata,* and *Aerva lanata* each with unique phytochemical profiles and therapeutic benefits. **Objectives:** The present work aims to analysis of these three species and evaluate the antiurolithiatic potential of these plants. This approach will provide an insight to find which plant exhibit maximum antiurolithiatic potential. **Materials and Methods:** To achieve this methanolic extract of plant was prepared. Antioxidant activity estimated by monitoring DPPH assay. Phytochemical profiling, Phenolic and flavonoid content also be estimated to monitor the antioxidant potential of these plants. The qualitative and quantitative estimation of phytochemical constituents carried out by HPLC analysis. **Results:** By comparing the results of phytochemical estimation, DPPH assay, TPC determination, TFC estimation and HPLC analysis our study shows that out of these three plants *Bergenia ligulata* considered to possess maximum antiurolithiatic potential. **Conclusion:** This work provides a comparative evaluation of three medicinal plants *Bergenia ligulata, Bergenia ciliata*, and *Aerva lanata* all traditionally referred to as Pashanbheda, despite significant taxonomical and phytochemical differences. Unlike previous studies that examine these plants individually, this study offers a systematic, side-by-side assessment of their antioxidant activity, phytochemical content, and antiurolithiatic potential using standardized methodologies. The study integrates DPPH-based antioxidant assays, total phenolic and flavonoid quantification, and HPLC profiling, providing a more comprehensive approach for determining the most potent antiurolithiatic species. It highlights *Bergenia ligulata* as the species with maximum antiurolithiatic potential.

Keywords: *Aerva lanata*, *Bergenia ciliata*, *Bergenia ligulata*, DPPH assay, HPLC, TFC, TPC, Urolithiasis.

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INTRODUCTION

Urolithiasis, also known as kidney or renal stones, is a widespread disorder characterized by the development of solid crystalline deposits within the urinary system (Bernela *et al*., 2012; Keshavarzi *et al*., 2016; Qian *et al*., 2022). These stones may originate in the kidneys, ureters, bladder, or urethra, and their presence often results in severe pain, obstruction of the urinary tract, and, in some cases, life-threatening complications. Globally, urolithiasis affects nearly 12% of the population and is associated with a high recurrence rate within five to ten years (Sulaiman *et al*., 2016). Stone formation is a multistage process influenced by biochemical, environmental, and physiological factors that promote crystal nucleation, growth, and aggregation in renal tissues (Bernela *et al*., 2012). Calcium oxalate and calcium phosphate stones account for approximately 80% of all cases, while uric acid and cystine stones comprise the remaining types (Sulaiman *et al*., 2022). The prevalence varies geographically, with higher incidence in Western and Middle Eastern populations compared to African and Asian regions (Waghmare, 2020). Overall, the condition disproportionately affects males, with a rate of 124 per 100,000 compared to 36 per 100,000 in females (Adepu, 2013).

Conventional management of urolithiasis typically involves pharmaceutical therapy, dietary regulation, and surgical interventions. However, synthetic drugs may cause adverse effects, and procedures such as lithotripsy are often associated with high recurrence rates (Bagul, 2003). These limitations have increased

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interest in plant-based therapies as safer and more sustainable alternatives. Numerous medicinal plants used in Ayurveda, Unani, and Traditional Chinese Medicine have demonstrated antiurolithiatic potential through mechanisms such as diuresis, litholysis, antioxidant activity, anti-inflammatory action, and inhibition of crystal formation (Bhandari *et al*., 2008; Qian *et al*., 2022; Keshavarzi *et al*., 2016).

Among these, the group of plants collectively referred to as Pashanbheda literally meaning "stone-breaker" holds a prominent place in traditional medicine. The most widely recognized species include *Bergenia ligulata, Bergenia ciliata*, and *Aerva lanata. Bergenia ligulata*, a perennial herb native to the Himalayan region at altitudes of 1000-3000 m, is considered a high-value medicinal plant and is traditionally used for dissolving kidney and bladder stones. Its rhizomes contain diverse phytoconstituents such as coumarins, Bergenin, flavonoids, benzenoids (e.g., arbutin), lactones, and various minerals that contribute to its wide pharmacological profile, including diuretic, anti-inflammatory, hepatoprotective, antioxidant, antiviral, antimicrobial, and antiurolithiatic activities (Koul *et al*., 2020; Ragavendran *et al*., 2011; Sadat *et al*., 2015).

Bergenia ciliata, another important species known as Pashanbheda, is distributed across Afghanistan, Tibet, Bhutan, and the Indian Himalayan ranges. Traditionally regarded as a "miracle herb," it is used for treating urinary, gastrointestinal, pulmonary, hepatic, gynecological, and inflammatory disorders. Its methanolic extracts have shown significant antibacterial, antitussive, antioxidant, and enzyme-inhibitory activities, supporting its ethnomedicinal applications (Sharif, 2022; Singh, 2007; Sinha *et al*., 2001).

Aerva lanata, commonly known as Gorakha Ganga, is another key Pashanbheda plant widely mentioned in Ayurvedic, Siddha, and Unani systems. Distributed across India, Africa, and Australia, it exhibits multiple pharmacological properties including antimicrobial, hepatoprotective, antiurolithiatic, anti-inflammatory, immunomodulatory, antidiabetic, antiasthmatic, and nephroprotective activities (Sulaiman *et al*., 2022; Tiwari *et al*., 2017; Verma *et al*., 2014). Owing to its safety, availability, and efficacy, *Aerva lanata* continues to be an important herbal remedy in traditional medical practice.

Given the traditional significance and pharmacological potential of these Pashanbheda species, the present study undertakes a comparative evaluation of *Bergenia ligulata, Bergenia ciliata*, and *Aerva lanata*. Phytochemical profiling, estimation of antioxidant activity, total flavonoid content, total phenolic content, and HPLC analysis were conducted to assess their relative efficacy. The findings indicate that *Bergenia ligulata* exhibits the most potent bioactive profile among the three species.

MATERIALS AND METHODS

Plant Extracts Preparation

Plant samples of *Bergenia ciliata, Bergenia ligulata*, and *Aerva lanata* were procured from the local medicinal plant market and authenticated prior to analysis. The rhizomes of *Bergenia ciliata* were air-dried at room temperature, pulverized using a mechanical grinder, and sieved through muslin cloth to obtain a uniform particle size. A 10 g portion of the powdered sample was extracted with 70% methanol using a Soxhlet apparatus. The extract was concentrated under reduced pressure in a rotary evaporator, which was stored at 4°C until further use.

Ethical Statement

This study is based on experimental data generated using plant materials. No studies involving human participants or animals were conducted by the authors, and ethical approval was therefore not required.

Qualitative Analysis

Phytochemical analysis for the methanolic extract of the plant samples was carried out to determine the presence of phenols, flavonoid, alkaloids, tannin and saponin were carried out according to standard procedure.

Total Phenol Content (TPC)

The Total Phenolic Content (TPC) of the *Bergenia ciliata* methanolic extract was determined using the Folin-Ciocalteu method, Different concentrations of the plant extract were prepared (ranging from 100 to 1000 µg/mL) by dilution with deionized water. For each concentration, 5 mL of deionized water and 0.5 mL of 10% Folin-Ciocalteu reagent were added. The mixtures were allowed to stand for 5 min at room temperature. Subsequently, 2 mL of 7.5% Sodium Carbonate (Na_2CO_3) solution was added to each tube. Deionized water was added to adjust the final volume to 10 mL. the reaction mixtures were incubated at room temperature for 30 min. After incubation, the absorbance was measured at 760 nm using a UV-visible spectrophotometer.

Total Flavonoid Content (TFC)

Determination of total flavonoids content was based on aluminium chloride method. The aluminium chloride colorimetric assay provides a spectrophotometric, quantitative estimation of flavonoid content, expressed as Quercetin Equivalents (QE). The Total Flavonoid Content (TFC) of the methanolic extract of *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata* was determined using the Aluminum Chloride ($AlCl_3$) colorimetric method. The plant extract was prepared at various concentrations ranging from 50 to 1000 µg/mL in methanol. To 1 mL of each sample, 0.1 mL of 10% aluminum chloride ($AlCl_3$) solution and 0.1 mL of potassium acetate solution were added. The mixture was diluted to a final volume of 3 mL with 70% methanol. The

reaction mixtures were incubated at 37°C for 30 min. After incubation, the absorbance was measured at 420 nm using a UV-visible spectrophotometer.

DPPH Radical Scavenging Assay

The antioxidant activity of the methanolic extract of *Bergenia ciliata* was evaluated using the DPPH (2,2-Diphenyl-1-Picrylhydrazyl) free radical scavenging assay. 0.1 mM solution of DPPH was prepared in methanol and used as the control. Various concentrations of the plant extract ranging from 50 to 1000 µg/mL were prepared in Dimethyl Sulfoxide (DMSO). Each test tube contained 2.7 mL of 0.1 mM DPPH solution and 1 mL of plant extract at the desired concentration. ascorbic acid was used as the standard reference antioxidant under identical conditions. After thorough mixing, the reaction mixtures were incubated at 25°C in the dark for 30 min. The absorbance was then measured at 517 nm using a UV-visible spectrophotometer.

$$\text{Antioxidant activity \%} = \frac{Absorbance\ of\ Control - Absorbance\ of\ Sample}{Absorbance\ of\ Control} \times 100$$

HPLC Analysis

For HPLC Analysis sample preparation 1 mg/mL standard was prepared using HPLC water and plant sample was prepared using 70% methanol. The samples were filtered using 0.45 um membrane filter to remove particulate matter before injecting into HPLC system. The analysis was carried out on a reversed-phase C18 column (250 mm × 4.6 mm, 5 µm particle size). The mobile phase consisted of acetonitrile and HPLC-grade water in the ratio of 75:25 (v/v). The flow rate was maintained at 0.8 mL/min, and the column temperature was set at 40°C. The total run time for the analysis was 10 min. A UV detector was used for detection, with the detection wavelength optimized based on the absorption maxima of the major phytochemicals of interest (commonly between 220-280 nm depending on the standard compounds used such as Bergenin, Gallic acid, or Quercetin).

Statistical analysis

He results were analyzed using the Statistical analysis. All the data are expressed as Mean±SEM (n=3).

RESULTS

Table 1 represents the phytochemical analysis of *Bergenia ligulata, Bergenia ciliata*, and *Aerva lanata* revealed the presence of several bioactive compounds associated with anti-urolithiatic activity. Alkaloids, flavonoids, phenolic compounds were detected in *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata*. Tannins were detected in *Bergenia ligulata* and *Aerva lanata* but absent in *Bergenia ciliata*. Saponins were identified only in *Bergenia ligulata.*

Table 2 represents the antioxidant activities of the selected plants. The DPPH free-radical scavenging assay is widely used to evaluate the antioxidant strength of plant extracts (Brand-Williams *et al.*, 1995). A higher percentage inhibition indicates stronger antioxidant capacity. *Bergenia ligulata* demonstrates strong DPPH radical scavenging even at low concentrations. *Bergenia ciliata* shows high activity at medium and high concentrations. *Aerva lanata* displays dose-dependent activity but remains weak at low concentrations.

The TPC values of the three species demonstrated significant variations (Table 3). Among the tested plants *Aerva lanata* exhibited the highest phenolic content, with values increasing from 79.12 mg GAE/g at 50 µg/mL to 533.52 mg GAE/g at 550 µg/mL. *Bergenia ligulata* showed moderate phenolic accumulation, ranging from 86.72 to 155.12 mg GAE/g. In contrast, *Bergenia ciliata* exhibited the lowest TPC among the three, ranging from 47.12 mg GAE/g at 100 µg/mL to 114.32 mg GAE/g comparatively lower than *Aerva lanata* and *Bergenia ligulata*.

The Total Flavonoid Content (TFC) of plant extracts of *Bergenia ligulata, Bergenia ciliata,* and *Aerva lanata* was depicted in Table 4. The samples were determined at concentrations ranging from 50-550 µg/mL, expressed in milligram Quercetin Equivalents (QE) per gram extract. The TFC showed a concentration-dependent increase in all three species. Among the tested plants, *Bergenia ligulata* exhibited the highest flavonoid content, *Aerva lanata* recorded intermediate values. In contrast, *Bergenia ciliata* consistently showed the lowest flavonoid levels. Since the aluminium chloride method provides only bulk estimation, further advanced profiling using HPLC would be valuable to identify individual flavonoids responsible for the observed pharmacological effects.

HPLC Analysis

The HPLC analysis was carried out to identify and quantify the major bioactive compounds Gallic acid, Bergenin, and Quercetin in the selected medicinal plants. Figures 1A-1C shows the standard calibration curves of all three markers showed good linearity, validating the method for reliable qualitative and quantitative estimation.

The HPLC analysis established a linear standard calibration curve for Gallic acid, confirming the reliability of the method. Table 5 represent the concentration of Gallic acid in all three plant samples. When plant extracts were analyzed under the same conditions, distinct differences in Gallic acid content were observed. Among the tested plants, *Bergenia ligulata* showed a strong correlation with the standard Gallic acid profile, indicating a high content of Gallic acid. *Aerva lanata* also exhibited the presence of Gallic acid, though in moderate amounts. In contrast, *Bergenia ciliata* showed comparatively lower Gallic acid levels. These results suggest that *Bergenia ligulata* contains the highest concentration of Gallic acid among the studied plants, followed by *Aerva lanata*, while *Bergenia ciliata* contains only trace amounts. Table 6 shows the concentration of Bergenin present

in all three plant samples. The standard calibration curve of Bergenin (Figure 1A) demonstrated good linearity, validating the HPLC method for quantitative estimation. When the plant extracts were analyzed, *Bergenia ligulata* and *Bergenia ciliata* showed a clear presence of Bergenin. *Bergenia ligulata* displaying the highest content among the tested plants. These findings suggest that Bergenin is predominantly concentrated in *Bergenia ligulata*, followed by *Bergenia ciliata*, while *Aerva lanata* contains very low concentration of Bergenin.

The standard calibration curve of Quercetin exhibited excellent linearity, confirming the reliability and accuracy of the HPLC method employed for quantification (Figure 1C). Table 7 represent the concentration of Quercetin present in three plant sample with different concentrations. Upon analysis of the plant extracts, *Aerva lanata* showed a consistent and comparatively higher concentration of Quercetin than the other two plants. This finding is in strong agreement with previous HPLC-based reports demonstrating that *Aerva lanata* is rich in flavonoids, including Quercetin and its derivatives (Pieczykolan *et al*., 2022). *Bergenia ciliata* also exhibited detectable but comparatively lower levels of Quercetin, which is consistent with earlier studies reporting moderate flavonoid content in this species (Pant *et al*., 2021). In contrast, *Bergenia ligulata* showed only trace amounts of Quercetin, supporting previous observations that this plant contains lower levels of free flavonols such as Quercetin (Singh *et al*., 2012). These results clearly indicate that *Aerva lanata* is the richest source of Quercetin among the tested plants, followed by *Bergenia ciliata*, while *Bergenia ligulata* contains only minor quantities. The use of HPLC for precise quantification of Quercetin is well established and validated in phenolic compound analysis (Khoddami *et al*., 2013).

DISCUSSION

The abundance of alkaloids in *Aerva lanata* indicates potential anti-urolithiatic action, as alkaloids are reported to inhibit crystal aggregation (Waghmare, 2020) and exert analgesic effects (Yoodee *et al*., 2025), thereby reducing the risk of stone formation. Flavonoids were present in all three species, supporting their role as antioxidants in reducing oxidative stress and inhibiting calcium oxalate deposition in renal tissues (Yoodee *et al*., 2025; Chen *et al*., 2023). Phenolic compounds present in all three plants, further enhance antioxidant defence and protect renal tissue from oxidative injury associated with urolithiasis (Li *et al*., 2014; Kruk *et al*., 2022). Tannins are known to chelate calcium ions, which can limit stone nucleation and growth (Rice-Evans *et al*., 1999). Saponins in *B. ligulata*, suggesting a role in disrupting mucoproteins that bind to crystals, thereby preventing stone formation (Lee *et al*., 2012). Overall, the phytochemical profile highlights that *B. ligulata* and *Aerva lanata* is particularly rich in alkaloids, whereas and *Bergenia ciliata* demonstrate a narrow spectrum of active constituents including tannins, saponins, flavonoids and phenols, The combined antioxidant, diuretic, and crystal-inhibiting properties of these phytochemicals provide a strong biochemical basis for the traditional use of these plants in the management of Urolithiasis.

Table 1: Phytochemical analysis for *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata*.

Sl. No.	Phytochemicals	Test	*Bergenia ligulata*	*Bergenia ciliata*	*Aerva lanata*
1.	Alkaloids	Hagers Test	+	+	+
		Mayers test	+	+	+
2.	Test for flavonoids	Alkaline reagent test	+	+	+
3	Test for phenols	Ferric chloride test	+	+	+
4	Test for Tannins	Ferric chloride test	+	-	+
5	Test for saponins	Foam test	+	-	-

Table 2: Estimated antioxidant activity of *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata* by DPPH assay.

Concentration of plant extract (µg)	Ascorbic Acid (% Inhibition)	*Bergenia ligulata*	*Bergenia ciliata*	*Aerva lanata*
50	57.98±0.430	92.53±0.215	62.84±0.475	10.23±0.300
100	85.06±0.150	91.74±0.201	89.19±0.516	53.52±0.316
250	93.96±0.233	83.49±0.295	92.06±0.954	87.24±0.350
400	94.40±0.125	72.13±0.592	91.05±0.393	91.44±0.257
550	94.36±0.322	89.58±0.390	90.87±0.512	91.94±0.570

Table 3: Estimated Total phenol content present in *Bergenia ligulata, Bergenia ciliata, Aerva lanata*.

Concentration of plant extract (µg)	Total Phenol Content (mg GAE/g) *Bergenia ligulata*	Total Phenol Content (mg GAE/g) *Bergenia ciliata*	Total Phenol Content (mg GAE/g) *Aerva lanata*
50	-	-	79.12±0.400
100	91.52±0.360	47.12±0.190	93.52±0.170
250	86.72±0.332	61.12±0.340	248.72±0.119
400	129.12±0.341	97.52±0.200	370.32±0.363
550	155.12±0.200	114.32±0.296	533.52±0.350

Table 4: Estimated Total flavonoid content present in *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata*.

Concentration of Rhizome extract (µg/mL)	Total Flavonoid Content (mg QE/g) *Bergenia ligulata*	Total Flavonoid Content (mg QE/g) *Bergenia ciliata*	Total Flavonoid Content (mg QE/g) *Aerva lanata*
50	23.27±0.434	5.61±0.175	19.38±0.255
100	91.05±0.410	20.50±0.196	72.16±0.155
250	198.20±0.160	86.61±0.360	192.72±0.145
400	408.83±0.370	169.99±0.370	405.50±0.367
550	617.72±0.165	237.72±0.347	539.39±0.325

The results of DPPH analysis are in line with reports that Bergenia species are rich in phenolics such as Bergenin, catechin, and Gallic acid, which are responsible for strong antioxidant behavior and antiurolithiatic potential (Brand-Williams *et al.*, 1995; Govindarajan, *et al.*, 2008). Our data strongly supports that *Bergenia ligulata* is the most potent antioxidant among the three plants**,** even at low concentrations. This explains its superior antiurolithiatic activity**,** since oxidative stress is a major factor in kidney stone formation (Patel *et al.*, 2012). The strong antioxidant and phytochemical profile of *Bergenia ligulata* correlates with literature identifying it as the most therapeutically active Pashanbheda species.

The highest value of phenolic content in *Aerva lanata* shows that it is highly enriched in phenolic compounds. Similar findings were reported previously, where *Aerva lanata* was highlighted as a rich source of polyphenols with strong antioxidant potential (Khan, 2013; Chewchinda *et al.*, 2019). The results for *Bergenia ligulata* are in agreement with earlier studies, which demonstrated that *Bergenia ligulata* contains notable but moderate levels of phenolics contributing to its traditional medicinal value (Pieczykolan *et al.*, 2022). Reduced phenolic content in *Bergenia ciliata* are consistent with previous reports (Pant *et al.*, 2021). These differences may be attributed to species-specific metabolic pathways, environmental influences, and solvent extraction efficiencies, aligning with earlier phytochemical characterizations of these plants.

The results of flavonoid content estimation indicate that *Bergenia ligulata* is comparatively richer in flavonoids, which may contribute to its stronger pharmacological potential (Pant *et al.*, 2021). The higher flavonoid concentration in *Bergenia ligulata* aligns well with its long-standing reputation as Pashanbheda a classical Ayurvedic drug for kidney stone management (Roychoudhury *et al.*, 2022; Verma *et al.*, 2014). Recent evidence confirms that its bioactive compound Bergenin interferes with calcium oxalate crystal deposition and protects renal tissue from oxidative injury, thereby validating its traditional use against Urolithiasis (Pant *et al.*, 2021). Similarly, *Aerva lanata* which showed intermediate TFC in this study, has been experimentally proven to possess strong antiurolithiatic activity (Mandal *et al.*, 2018; Dinnimath *et al.*, 2017). Taken together, these findings suggest that the quantitative richness of flavonoids in *Bergenia ligulata* and *Aerva lanata* likely underlies their superior antiurolithiatic efficacy.

The analysis of HPLC studies reveals that among the plants investigated, *Bergenia ligulata* exhibited the highest content of Gallic acid and Bergenin, both of which are well-established antioxidant and therapeutic phenolic compounds. The high abundance of these bioactive constituents strongly supports the traditional use of *Bergenia ligulata* as Pashanbhed, a classical antiurolithiatic herb in Ayurveda. Previous phytochemical and pharmacological studies have also confirmed that *Bergenia ligulata* is particularly rich in Bergenin and Gallic acid, which contribute significantly to its antioxidant, anti-inflammatory, and antiurolithiatic activities. In contrast, *Bergenia ciliata* showed only low levels of Gallic acid and Bergenin, indicating a comparatively weaker phytochemical profile, which is consistent with earlier reports describing lower concentrations of these marker phenolics in this species (Sinha *et al.*, 2001; Pant *et al.*, 2021). *Aerva lanata* exhibited a moderate amount of Gallic acid along with detectable levels of Bergenin; however, it was particularly rich in Quercetin, a flavonoid known for its strong antioxidant,

Table 5: HPLC profile for Gallic acid in *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata*.

Concentration (µg)	Std Gallic acid	Plant extract		
	Concentration (µg)	*Bergenia ligulata*	*Bergenia ciliata*	*Aerva lanata*
10	14.446	11.30	-	-
20	17.773	18.1	11.780	23.241
40	37.734	37.223	11.784	-
60	58.864	56.38	-	25.838
80	79.734	78.30	15.665	28.965
100	102.021	101.2	16.134	34.584

Table 6: HPLC profile for Bergenin in *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata*.

Concentration (µg)	Bergenin	Plant extract		
	Concentration(µg)	*Bergenia ligulata*	*Bergenia ciliata*	Aerva lanata
10	11.258	0.411	-1.418	-
20	19.310	0.214	-0.594	0.917
40	36.693	2.380	-1.390	1.322
60	64.284	5.038	1.894	2.345
80	78.456	9.339	10.803	2.707
100	98.301	12.249	11.942	3.496

Table 7: HPLC profile for Quercetin in *Bergenia ligulata, Bergenia ciliata* and *Aerva lanata*.

Concentration (µg)	Quercetin	Plant extract		
	Concentration(µg)	*Bergenia ligulata*	*Bergenia ciliata*	*Aerva lanata*
10	10.482	-	6.647	7.421
20	20	-	-	8.171`
40	19.637	6.620	6.630	8.942
60	61.077	6.623	6.640	9.577
80	83.744	-	6.760	10.330
100	97.265	6.635	-	11.365

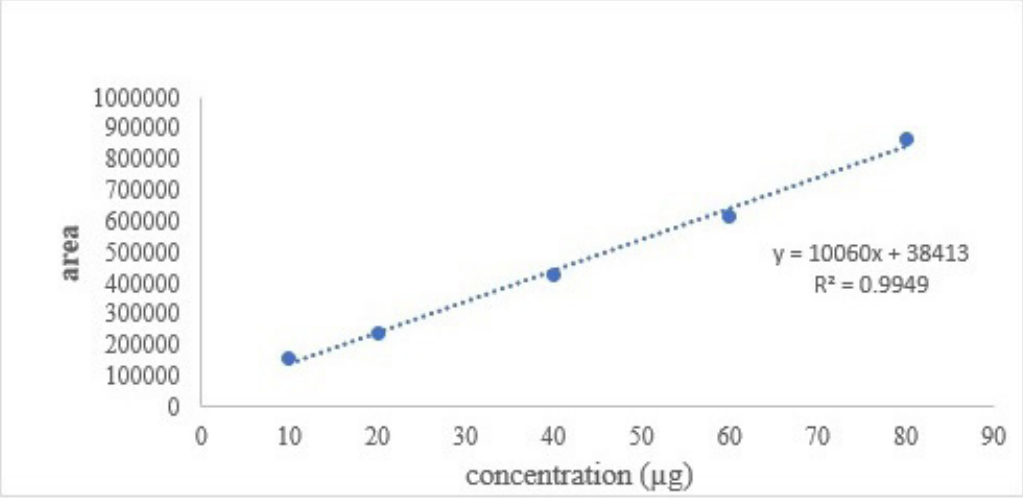

Figure 1A: Calibration curve for the standard Bergenin through HPLC analysis.

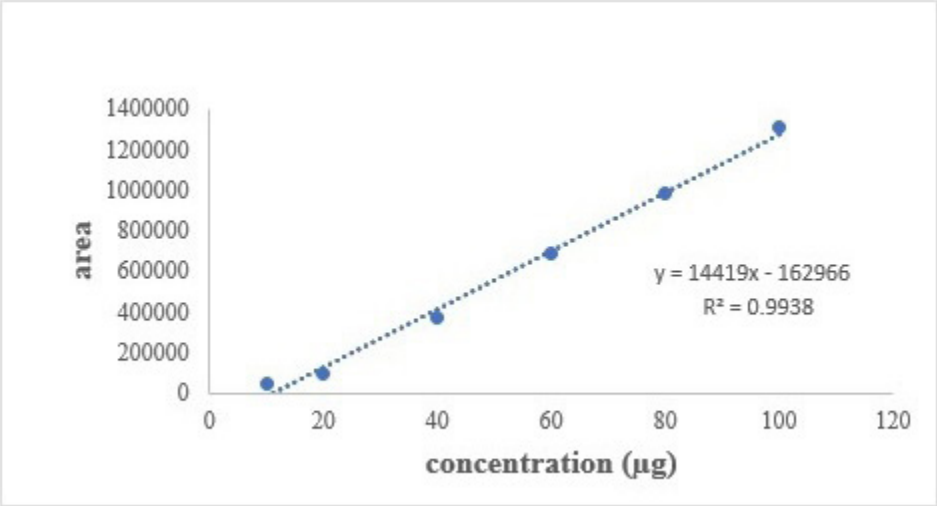

Figure 1B: Calibration curve for the standard Gallic acid through HPLC analysis.

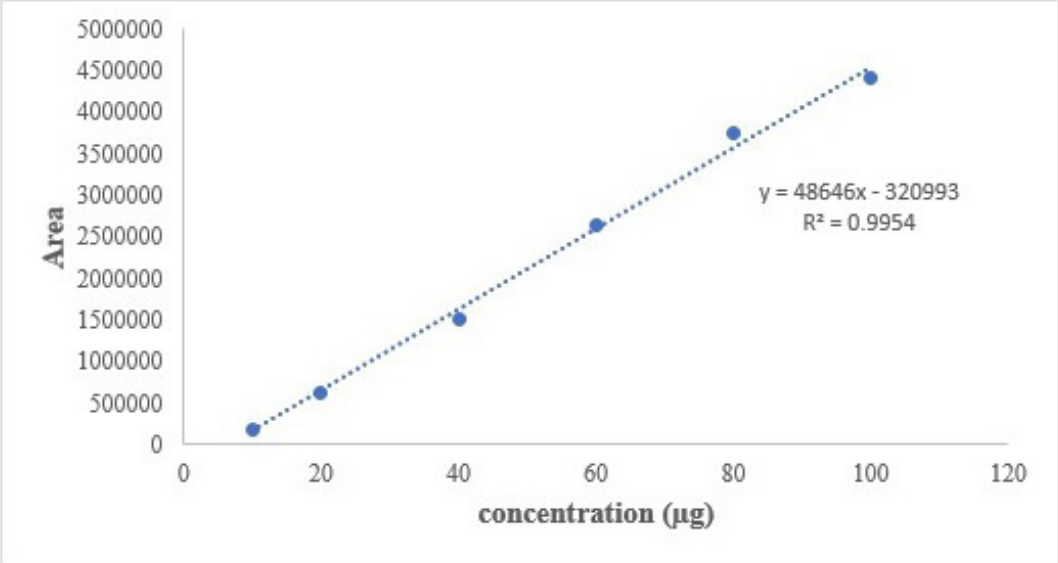

Figure 1C: Calibration curve for the standard Quercetin acid through HPLC analysis.

nephroprotective, and antiurolithiatic potential (Chewchinda *et al.*, 2019; Mandal *et al.*, 2018). These findings clearly demonstrate species-specific variation in phenolic composition and validate the traditional therapeutic prominence of *Bergenia ligulata* in urolithiasis management.

Thus, the overall findings reveal that *Bergenia ligulata* is the richest source of Gallic acid and Bergenin, while *Aerva lanata* is the major source of Quercetin. *Bergenia ciliata* contains all three compounds but in relatively lower amounts. These results not only validate the phytochemical diversity among the studied plants but also provide scientific evidence for their traditional therapeutic applications, particularly in the management of kidney stones and related disorders

CONCLUSION

The present study comparatively evaluated the phytochemical composition and antiurolithiatic potential of *Bergenia ligulata, Bergenia ciliata*, and *Aerva lanata*, three medicinal plants traditionally recognized as Pashanbheda. These plants considered as a multifaceted medicinal plants with potent bioactivities. Methanolic extracts of the plants were analyzed for antioxidant activity using the DPPH assay, along with total phenolic and flavonoid content to assess their antioxidant strength. Qualitative and quantitative profiling of phytoconstituents through HPLC further supported these findings. Based on the collective results of antioxidant assays and phytochemical evaluation, *Bergenia ligulata* exhibited the highest levels of bioactive compounds and demonstrated the greatest antiurolithiatic potential among the three species. These findings substantiate its traditional use as

an effective Pashanbheda and highlight its promise as a potent natural therapeutic candidate for managing urolithiasis. Further in-depth pharmacological and mechanistic studies are warranted to validate its clinical applicability.

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ABBREVIATIONS

HPLC: High-Performance Liquid Chromatography; **TPC:** Total Phenol Content; **TFC:** Total Flavonoid Content; **GAE/g:** Gallic Acid Equivalent per gram; **Na_2CO_3:** Sodium carbonate; **DMSO:** Dimethyl sulfoxide; **UV-visible spectrophotometer:** Ultraviolet-visible spectrophotometer.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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AUTHORS' CONTRIBUTION

This work was carried out in collaboration among all authors. Archna Sahay and Preeti Chunarkar Patil prepared the initial manuscript draft. Vaishnavi Jadhav, Saba Shaikh and Riya Nair conducted the research work. Sanskriti Patil, Gouri Chorghe, Akshay Malusare, Aboli Shelake performed literature search and prepared the manuscript. Shamim Shaikh reviewed the manuscript and performed the final checks. All authors have read and approved the final version of the manuscript.

SUMMARY

The study adopts an integrated analytical approach combining DPPH radical scavenging assay, quantification of total phenolic and flavonoid contents, and HPLC-based phytochemical profiling to comparatively evaluate the antiurolithiatic potential of selected medicinal plants. This multi-parameter assessment enables a correlation between antioxidant activity and bioactive phytochemical composition. Among the three species investigated, *Bergenia ligulata* exhibited the highest antioxidant activity and the richest phenolic profile, confirming it as the most potent antiurolithiatic species and scientifically validating its traditional use.

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