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Anatomical, histochemical and phytochemical screening of the vegetative parts of *Eichhornia crassipes*

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Abstract

Eichhornia crassipes, commonly known as water hyacinth, is a free-floating aquatic plant that is a member of the Pontederiaceae family. Due to its rich phytochemical composition, it can be used in a wide range of medicinal and industrial applications. Hence, the present study attempts to assess the morphological, anatomical, and phytochemical characteristics of *Eichhornia crassipes*. *E. crassipes* has kidney-shaped leaves that turn dark green and have several layers including cuticle, epidermis, palisade parenchyma, spongy parenchyma, air cavities, xylem, and phloem. The roots are feathery and dark purple with different layers including root epiblema, upper cortex, middle cortex, lower cortex, pericyclic xylem, phloem, and pith. The bulb also has different layers including epidermis, outer cortex, cells with crystal, air space, xylem, and phloem. Stomata are present on both sides of the leaf and quantitative phytochemical analysis shows the presence of various secondary metabolites with the highest quantity of alkaloids in the root and the highest quantity of tannin and flavonoid in the leaf. *E. crassipes* has unique anatomical features such as kidney-shaped leaves with a dark green color and various tissues like cuticle, epidermis, palisade parenchyma, and spongy parenchyma. The roots have a dark purple appearance with different tissue layers, while the bulb has the epidermis, outer cortex, cells with crystals, and phloem tissue. The plant's leaves have stomata on both sides and contain alkaloids in the root and tannins and flavonoids in the leaf. Further, research is recommended to examine this plant more pharmacognostically for various disorders.

Keywords: Anatomical characteristics, *Eichhornia crassipes,* Histochemical feature, Phytochemical screening

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Introduction

The perennial aquatic plant, *Eichhornia crassipes,* is known for its free-floating nature and can grow up to 0.3 m. It is commonly found in a range of freshwater environments, including large rivers, marshes, and shallow ponds (Villamagna & Murphy, 2010). One species in this family has enlarged leaves that resemble grass. The flowers are zygomorphic and actinomorphic, with a spike-shaped inflorescence with six stamens, six petals, and one style. The fruits come in capsule shape, and each capsule has a seed within. The ability of the plants to produce photosynthesis makes them autotrophic. Humans introduced water hyacinth from a tropical to a subtropical location (Aboul-Enein et al., 2011). It grows quickly and produces thick mats. The environment and human way of life may both be severely impacted by specific aquatic weeds. The water hyacinth, *E. crassipes*, continues to be the most pernicious and pervasive aquatic plant among the common ones (Elenwo & Akankali, 2016). Due to its fast expansion, ecological resilience, and detrimental effects on the environment, economic growth, and human health, water hyacinth has emerged as the most invasive weed in the world (Anuja et al., 2016).

E. crassipes is a widespread plant in the Punjab, particularly in the Gujranwala and some districts of Khyber Pakhtunkhwa. It lives in large marshy areas and spreads quickly by stolons. It forms an impenetrable growth over huge expanses of water. During the blossoming season, lilac blossoms are a stunning sight. It has developed into a nuisance weed in and around Lahore, particularly in the Gujranwala region, due to its difficulty in eradication and rapid growth. It has been documented in Brazil, Argentina, Paraguay, Venezuela, Chile, El Salvador, Panama, Costa Rica, Mexico, Portugal, Spain, Israel, Italy, Japan, India, Indonesia and Pakistan (Dersseh et al., 2019) as well as Brazil, Argentina, Paraguay, Venezuela, and Chile (Téllez et al., 2008; Wali et al., 2019). The plant poses a threat to the ecological integrity of these water sources due to its ability to thrive in various aquatic ecosystem types, such as lakes, streams, ponds, rivers, and ditches, as well as in cold and warm temperatures (Degaga, 2018). It has been a hazard to the local inhabitants as well as the aquatic biota. *E. crassipes* decreases the biodiversity of the surroundings. It effects by sunlight blocking, which in turn influences the formation of planktons and other aquatic plants and, circuitously, the production of other individuals that living in the aquatic-ecosystem (Sindhu et al., 2017).

Many authors have to different extents reviewed and written articles on *E. crassipes* over the years. The leaf extracts of *E. crassipes* showed antimicrobial activity against bacteria such as *Escherichia coli, Bacillus subtilis, Bacillus cereus, Lactobacillus casei*, and *Pseudomonas aeruginosa*. It also exhibited antifungal activity against six pathogenic fungi including *Aspergillus flavus*, *A. niger*, *Alternaria alternata*, *Colletotrichum gloeosporioides*, *Candida albicans*, and *Fusarium solani* using the well diffusion method (Haggag et al., 2017). *E. crassipes* impacts on the aquatic environment as a whole were the focus of Villamagna and Murphy's thorough investigation (Villamagna & Murphy, 2010). The South African biological control initiatives against *E. crassipes* were described by Coetzee et al., 2011. In this study, we evaluate the morphological, anatomical traits and phytochemical screening of *E. crassipes.*

Materials and Methods

Plant collection

In April 2021, the fresh plants of *E. crassipes* were procured from Akbarpura. Apart from one another were the leaves, root, and bulb (Fig. 1). The pieces were cleaned using tap water utilized for microscopic and macroscopic research. To prevent fungal growth and to store for future use, certain sections were air - dried at room temperature, individually pulverized by an electric grinder, and kept in airtight bottles (Maier et al., 2010).

Macroscopic analysis

Organoleptic approach (Evans, 1997) was used to study the morphological characteristics of *E. crassipes'* leaves, bulb, and root. Shape, size, odour, colour, presence or absence of a petiole, surfaces venation, apex, lamination, base, texture, and flavor were recorded as the macroscopic characteristics of fresh leaves, bulbs, and roots.

Anatomical analysis

To explore the histology of these components, a transverse piece of a leaf, root, and bulb were put under a microscope (Chaudhary & Imran, 1997; Chaffey, 2001; Trease & Evans, 2002; Hussain et al., 2009).

Transverse segment of the plant parts

The transversal section (T. S.) of the plant organs is cut using a sharp razor. A thin section was taken and stained in order to investigate the segment under a microscope and create a permanent slide (Chaffey, 2001).

Palisade ratio

Palisades are parenchymal cells, and the average number of palisade cells were observed by following Evans and Trease (2002). Plant leaves, chloral hydrate, slides, microscope was sued for Palisade ratio. Put the little bits of leaf that are cut between both the midrib and margin in 200% chloral hydrate and bring to a boil. Chloral hydrate makes the leaf fragments transparent; take the fragment and mount it on the plate. The epidermal cell underlying the four groups of epidermal cells was focused by the microscope to reveal the palisade cells, which covered over half of the epidermal cells. Readings were obtained from various leaves in order to acquire the exact result (Evans & Trease, 2002).

Stomatal study

Stomata number refers to how many stomata there are on a leaf's surface per square millimeter of epidermis. Stomata index refers to the stomatal density per unit area occupied by epidermal cells used to calculate the percentage (Evans & Trease, 2002). For the stomatal investigation, the chosen plant leaf, forceps, microscope, slides, and distilled water were all utilized. In order to maintain the firmness of the leaf, it was submerged in water and the top and bottom layers were removed with forceps. These layers were then washed with distilled water and placed on a slide, which was observed under a microscope to analyze various characteristics, including the type of stomata present, their size, and whether they were present or absent (Chaudhary & Imran, 1997). With the following formula the stomatal index was calculated:

$$\text{Stomata index} = \frac{\text{Stomata number per unit area}}{\text{Stomata number per unit area} + \text{Epidermal cells number per unit area}} \times 100$$

Vein-Islet and vein termination number

A vein termination is the ultimate free termination of a veinlet, and the number of vein-terminations per square millimeter of area occupied by veinlet is referred to as the vein-termination number. The materials utilized for determining the number of vein terminations and vein-islets in plant leaves include chloral hydrate solution, a water bath, a test tube, a slide, and a microscope. Take a test tube, fill it with chloral hydrate, then chop some leaves into little pieces and put those pieces in the test tube. Afterwards, using a water bath, you should boil the test tube. The transparent piece of leaf is placed on a slide, which is then mounted under a microscope. The vein islets on the slide are

focused on the inside and outside edges of the square, and their numbers are tallied. Together with vein islet, vein terminations are only counted inside the square. The 10 readings were collected from the continuous square and vein-islet and were tallied for accuracy (Evans & Trease, 2002).

Powdered drug study

Wallis (Iyengar & Nayak, 1979; Wallis, 2005) methods were used for the microscopic examination and chemical reagent analysis of powdered drugs. After adding methanol to the powdered root, leaves, and bulb in a beaker, this solution was filtered using filter paper. For a clear image of the powdered extract, the leftover powder was put on a slide and a few drops of chloral hyd rate were added. The slide was positioned beneath the microscope, and a digital camera was used to take pictures.

Qualitative screening for phytochemicals

According to the technique described by Harborne (1998); Evans and Trease (2002), the phytoconstituents screening of *E. crassipes* leaf, bulbs, and root powder was performed.

Carbohydrate detection

The sample solution was added in small quantities to equal amounts of Fehling's A (which contains copper sulphate in distilled water) and Fehling's B (which contains potassium tartrate and sodium hydroxide in distilled water) prior to being heated. When reducing sugar is present, brick-red cuprous oxide precipitate forms (Evans & Trease, 2002).

Protein and amino acid detection

2 ml of Millon's reagent were added to the extract, respectively. During light heating, a white precipitate forms that becomes red, revealing the presence or absence of an amino acid or protein (Evans & Trease, 2002).

Phytosterols and triterpenoids detection

A few drops of sulphuric acid and chloroform were added to the extract, and the test tube was shaken. Triterpenoids and phytosterols were evident in the yellow hue, while sterol was visible in the red colour at the bottom layer (Harborne, 1998).

Saponin detection

Take 5 ml of the extract and thoroughly shake it in a test tube. The existence of saponins is evidenced by foam production (Chukwuka et al., 2011).

Anthocyanins detection

Once 2 ml of Hcl was added to the extract solution, a pink, reddish hue first appears. As a few drops of ammonia are added, the colour changes to blue, indicating the presence of anthocyanin (Harborne, 1998).

Steroidal glycosides detection

To detect the presence of steroidal glycosides, a mixture of 2ml extract, glacial acetic acid, concentrated sulphuric acid, and one drop of ferric chloride is used. The indication of the presence of steroidal glycosides is the blue-green color of the layer (Harborne, 1998).

Flavonoids detection

In the extract solution, sodium hydroxide solution has been included. Flavonoids were detected in the yellow to crimson precipitation (Kokate, 1994).

Phenol detection

A test tube containing 2ml of extract received 2ml of ferric chloride solution. The existence of phenol is indicated by the strong bluish green tint (Dahiru et al., 2006).

Tannins detection

The blue green colour presence and tannin detection were combined in the extract solution of $FeCl_3$ (Kokate, 1994).

Alkaloid detection

Adding a few drops of Wagner's reagent to 2 ml of extract solution, the mixture became reddish brown, indicating the presence of alkaloids (Khandalwal & Sethi, 2008).

Spot test for fixed oils

Extracts (leaves, root and bulb) were separately pressed between two filter papers. Permanent of oil stain on the paper is the presence of fixed oil (Gomathi et al., 2010).

Volatile oil for fixed oils

Extracts (leaf, root, and bulb) were pressed separately between two filter sheets. volatile substance in the presence of permanent stain (Benjamin & Christopher, 2009).

Quantitative determination

Tannin determination

The Van Buren and Robinson (1969) technique can be used to calculate the sample's tannin percentage. 2 grams of ethanolic extract (leaves, root, and bulb) was mixed with 75 ml of distilled water before being shaken. The mixture was filtered, and lead acetate and lead tinnate were combined in the filtrate solution. To prevent lead sulphate acidification, the residue

was dissolved in 20 cc of distilled water before being treated with diluted sulfuric acid. The weighted filter paper without residue was regarded as (W1). The mixtures were filtered to remove the tannins using this pre-weighted filter paper, which was designated as W2. The filter paper was then baked at 60°C to dry it out. To estimate the weight of tannins (X) in mg/g and the percentage of the sample's initial weight, the weight of the filter paper (W2) is calculated.:

$$\text{Tannins amount (mg/g)} = x / (\text{weight of sample})$$
$$\text{Percent (\%) of tannins} = x / (\text{weight of sample}) \times 100$$

Where

X = Tannins weight = W2-W1

Sterol determination

A solution was prepared by combining 25 ml of potassium hydroxide with 75 ml of distilled water, followed by the addition of 2 grams of ethanolic extract obtained from the root, leaves, and bulb. Upon mixing, chlorophyllins were produced due to the water-soluble nature of the salt. The resulting mixture was subjected to three rounds of separation using 75 ml of petroleum ether in a separatory funnel. The separated mixture was transferred into an empty flask (previously weighed and labeled as W1) and dried in a hot water bath. After drying, the flask containing the residue was weighed again (W2), and the amount of sterol present was calculated in mg/g and as a percentage:

$$\text{Sterol amount (mg/g)} = x / (\text{weight of sample})$$
$$\text{Percent (\%) of sterol} = x / (\text{weight of sample}) \times 100$$

Where

X = Sterol weight = W2-W1

Flavonoid determination

At room temperature, 2gm of plant material (including leaves, roots, and bulbs) were treated with 100ml of 80% aqueous methanol. The liquid was filtered through filter paper to fill a 250ml beaker. The mixture was transferred to the beaker (W1), weighed, and then dried in a water bath. The beaker with the residue was weighed again (W2) to determine the amount of flavonoids in mg/g and as a percentage:

$$\text{Flavonoid amount (mg/g)} = x / (\text{sample weight})$$
$$\text{Flavonoid Percent} = x / (\text{sample weight}) \times 100$$

Where

X = Flavonoid weight = W2-W1

Alkaloids determination

The Harborne, 1998 technique is used for quantitative analysis of alkaloid. After adding 100ml of 10% acetic acid to 2 g of ethanolic extract (leaves, roots, and bulbs), a few drops of ammonium hydroxide are added to the mixture. The mixture is then covered for four hours. A beaker was used to filter the mixture. Weighting the mixture into the empty beaker (W1), converting it into a beaker (W1), and then beaker drying with the filtrate before weighing it for a second time (W2) to determine the amount of alkaloid in mg/g and calculating the percentage (%):

$$\text{Alkaloid amount (mg/g)} = x / (\text{sample weight})$$
$$\text{Alkaloid (\%)} = x / (\text{sample weight}) \times 100$$

Where

X = Alkaloid weight = W2-W1

Results

Macroscopy of *E. crassipe* (Leaf, root, and bulb)

The free-floating perennial aquatic plant, *E. crassipes,* reaches a height of 0.3 meters. The kidney-shaped and oval form of an *E. crassipes* leaf are its macroscopical characteristics (Fig. 1). The glossy, 10 to 20 cm in diameter, and immediately connected to the petiole leaf has a dark green top side and a light green under side (Table 1). The powder has a soft, smooth texture and a flavor that is satisfactory. It has a dark green hue. Drugs' macroscopical evaluations take into account their flavor, shape, colour, odour, and texture to assist standardize and authenticate their raw forms. The morphological traits constitute the first pharmacognostic constraint for the proper identification of the plant. The root of *E. crassipes* has a fibrous appearance under a microscope. The fibrous roots were growing from one large tap root that was present. The exterior side of the root had a dark purple tint, while the inner side was pale (Table 1). The root's powder had a rough, fibrous appearance that resembled a thread. The bulb of *E. crassipes* was found to have a spongy-like structure, be green in colour, and have a white interior with a distinctive smooth texture, odour, and a diameter of around 5 cm (Table 1).

Table 1 Macroscopial characteristics of leaf, root and bulb *E. crassipes*

S. No.	Characteristics	Observation
Leaf		
1	Color of upper layer	Shady green
2	Color of lower layer	Bright green
3	Taste	Appropriate
4	Surface	Flat
5	Form	kidney-like and ovate
6	Size	Diameter 10-20 cm
Root		
1	Color of outer side	Shady purple
2	Color of inner side	White
3	Surface	Rough

4	Form	Fibrous
Bulb		
1	Color of outer side	Green
2	Color of inner side	White
3	Surface	Flat
4	Size	Diameter 5 cm
5	Form	Soft (spongy)
6	Scent	Typical

Fig. 1 (a) Collection area, (b) leaves, (c) root and (d) bulb of *E. crassipes*

Microscopy of root, leaf and bulb of *E. crassipes*

Transverse section of leaf

The epidermal-cell, cuticle, palisade parenchyma, spongy parenchymal cells, air cavities, phloem, and xylem regions make up the T.S of an *E. crassipes* leaf. Upper epidermis had a cuticle, and the epidermal cells were made up of wavy-walled cells. The spongy parenchyma had a round shape and contained significant air pockets, while the palisade parenchyma in the form of a cylinder. The xylem, which was located in the center and was large in size, was succeeded by smaller phloem cells (Fig. 2).

Transverse section of root and bulb

Transverse section (T. S). of *E. crassipes* root revealed that the root was comprised of pith, pericycle, phloem, xylem, upper cortex, middle cortex, and lower cortex. A single layer of epiblema was present, which might be followed by two to three layers of higher cortex. The lower cortex, which has four layers, is located after the middle cortex and is split between air cavities and aerenchyma, which had a cylindrical form. The pericycle's inner side, which is made up of phloem and xylem, and its central pith were both present. The pericycle's single layer was also present (Fig. 2). In accordance with T. S. of *E. crassipes'* bulb, the bulb is made up of xylem, phloem, crystal-filled cells, air space, and epidermis, which is followed by outer cortex (Fig. 3).

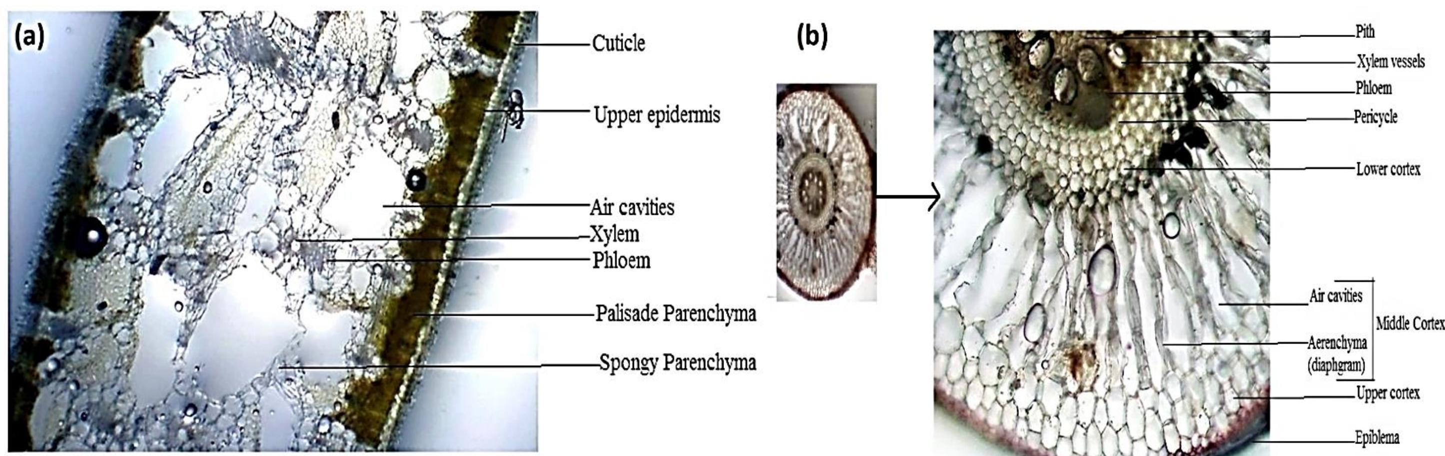

Fig. 2 Transverse section of leaf (a) and root (b) of *E. crassipes*

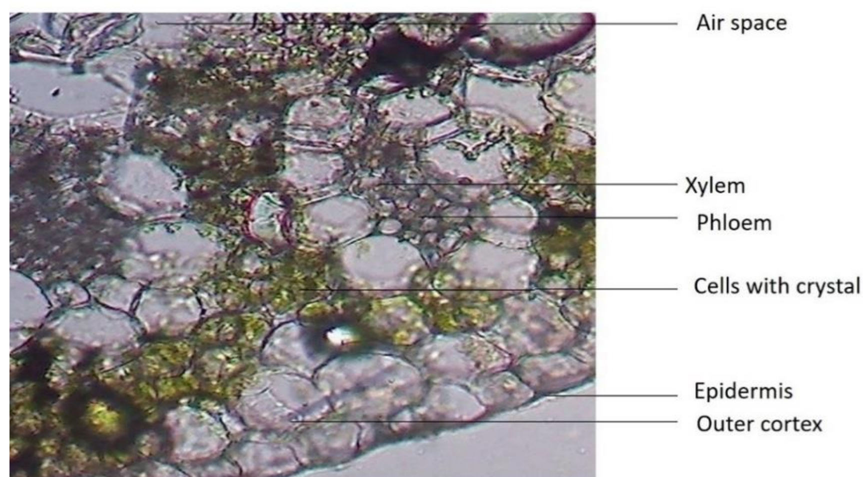

Fig. 3 Transverse section of bulb of *E. crassipes*

Vein- Islet, vein termination and stomatal studies

The vein islet number of *E. crassipes* was 13.54± 1.12 and 14.31± 1.94 vein termination (Table 2). The leaf of *E. crassipes* is known as amphistomatic as it has stomata on both the upper and lower surfaces. (Fig. 4). The stomatal number was 223± 5.61, and stomatal index was 11.21± 2.51 (Table 2).

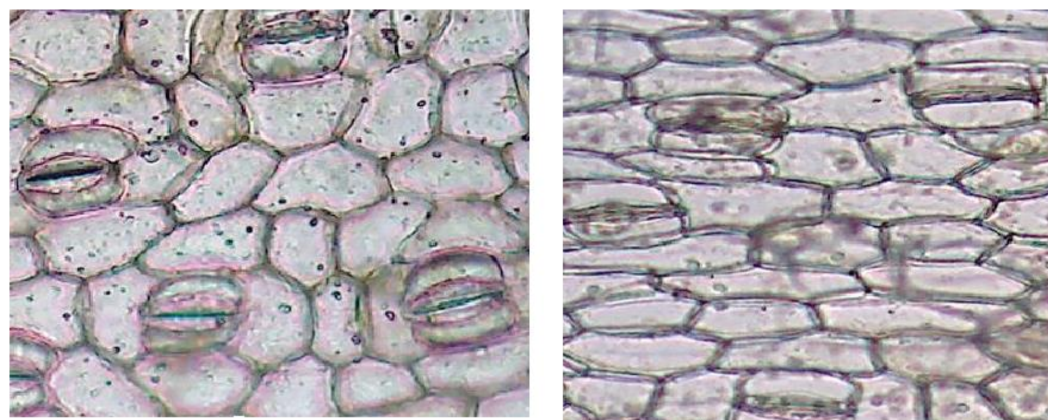

Fig. 4 Upper and lower epidermis stomata

Palisade ratio and powdered drug

The *E. crassipes* palisade ratio was 7- 12 (average of 10.91± 0.34). These cells are also employed in the detection of drug adulterants. The study of the powdered medication from an *E. crassipes* leaf revealed a variety of pieces, including lower epidermal cells, epidermis with stomata, palisade parenchyma cells, and epidermis with parenchyma (Fig. 5).

Table 2 Leaf constant values

S. No.	Parameter	Range	Average
1	Ratio of palisade	07.0- 12.0	10.91 ± 00.34
2	Number of vein islet	09.0- 15.0	13.54 ± 01.12
3	Number of vein-termination	10.0- 17.0	14.31 ± 01.94
4	Number of stomatal	200.0-250.0	22.30 ± 05.61
5	Stomatal index	08.16- 14.31	11.21 ± 02.51

The study of the powdered medicine from the root of *E. crassipes* revealed a variety of fragments, including cortical cells, non-glandular trichrome, spiral tracheids, and calcium oxalate cork rosette aggregates (Fig. 6). The powdered drug examination of the *E. crassipes* bulb revealed a variety of fragments, including cork cells, epidermal cells, phloem tissue, fractured calcium oxalate prisms, and raphides of calcium oxalate.

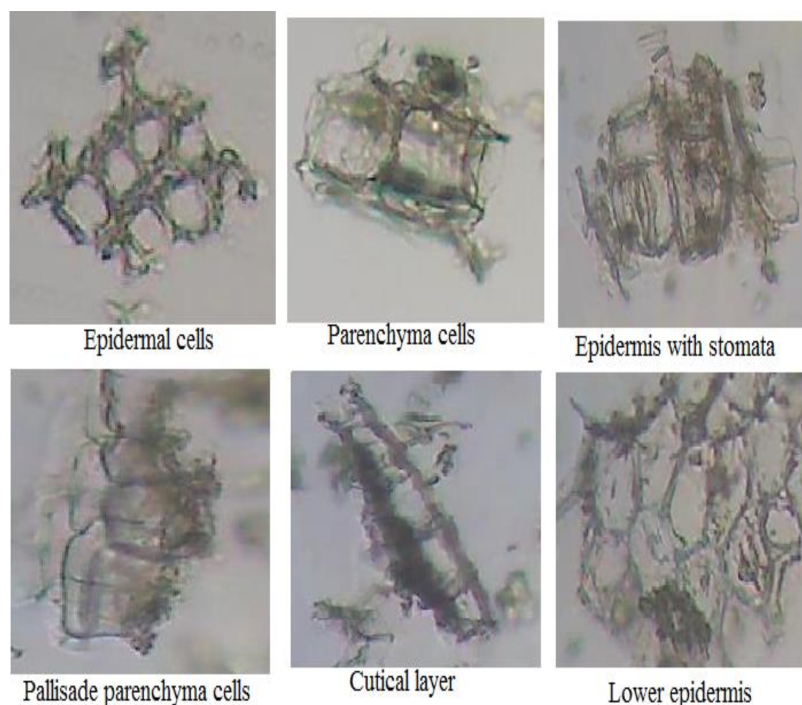

Fig. 5 Powdered form of the drug derived from the leaf of *E. crassipes*

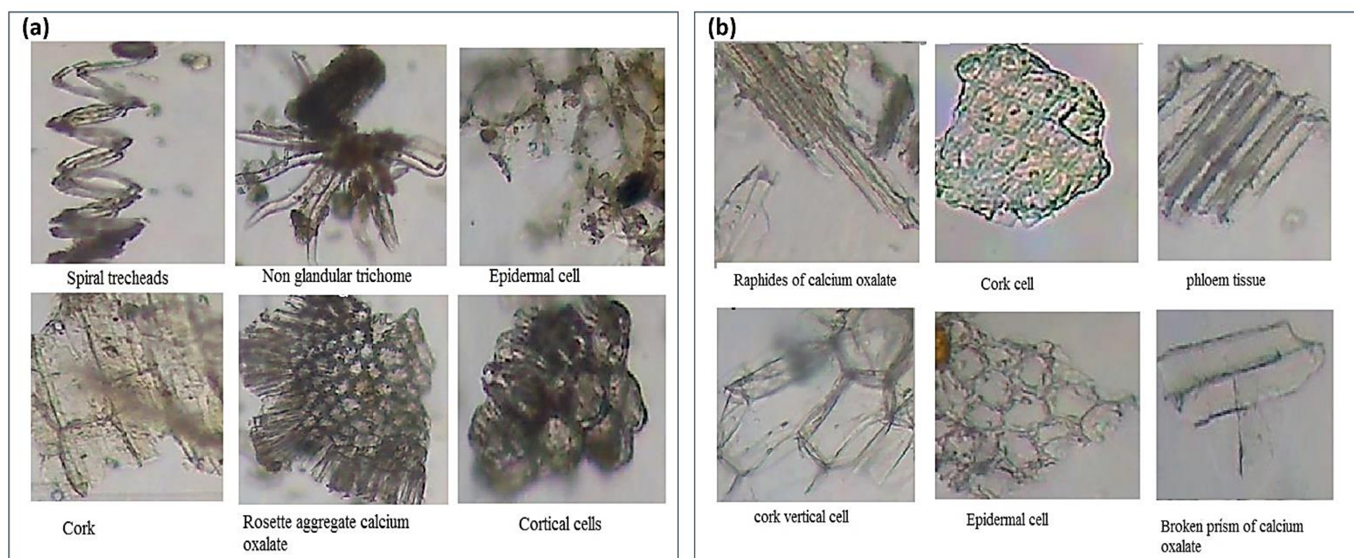

Fig. 6 A analyzing the powdered form of the root (a) and bulb (b) of *E. crassipes*

Phytochemical screening

Qualitative screening

The various plant portions of *E. crassipes* were treated with various chemical reagents to recognize the phyto-constituents. In Table 3, the chemical constituent's presence and absence are displayed. The various plant components revealed the presence of phenol, alkaloids, glycosides, flavonoids, tannins, phytosterol, triterpenes, anthraquinones, and fixed oil, as well as the absence of proteins, anthocyanins, saponins, and volatile oils (Table 3). For the accurate assessment of the chemical substance that is utilized for medicinal properties, phytochemical screening is highly important since secondary metabolites from plants are present and have a variety of medicinal characteristics.

Table 3 Phytochemical screening of *E. crassipes* root, bulb and leaf

S. No.	Constituents	Test name	Root	Bulb	Leaf
1	Carbohydrates	Fehling's	+	+	+
2	Protein	Ninhydrine	-	-	-
3	Alkaloids	Wagner's	+	+	+
4	Phytosterol and Triterpenoids	Salko-wskii's	+	+	+
5	Phenol	Ferric-chloride	+	+	+
6	Flavonoids	Alkali-reagent	+	+	+
7	Tannins	Ferric-chloride	+	+	+
8	Saponins	Frothing	-	-	-
9	Anthraquinone	Hcl	+	+	+
10	Glycosides	Killaer - kilani	+	+	+
11	Anthocyanins	Hydrochloric - acid	-	-	-
12	Fixed - oil	Spot - test	+	+	+
13	Volatile - oil	Spot - test	-	-	-

Quantitative screening

Table 4 displays the results of the quantitative screening of various parts of the *E. crassipes* plant extract. Chemical reagents were used to determine the chemical constituents in the root, leaf, and bulb. The root had the highest percentage of alkaloids (15.95%), while the leaf had the lowest (1.3%). Sterols were found in the highest quantity in the bulb (10.6%) and the lowest in the root (2.95%). Tannins were present in the highest amount in the bulb (16%) and the lowest in the root (12%). The leaf had the highest amount of

flavonoids (20%), while the root had the lowest (5%) (Table 4).

Table 4 Root, bulb, and leaf of *E. crassipes* were subjected to quantitative phytochemical screening

S. No.	Vegetative part	Solvent	Quantity (%)
1	Root	Flavonoid.	05.00%
		Alkaloid.	15.95%
		Tannins.	12.00%
		Sterol.	02.95%
2	Bulb	Flavonoid	15.00%
		Alkaloid	09.90%
		Tannins	16.00%
		Sterol	10.60%
3	Leaf	Flavonoid	20.00%
		Alkaloid	01.30%
		Tannins	15.00%
		Sterol	04.80%

Discussion

Valuable information about the morphological and anatomical characteristics of *E. crassipes'* leaf, root, and bulb can be obtained through both macroscopic and microscopic evaluations (Zhao, 2010). The plant's leaf is notable for its kidney-shaped and oval shape, as well as its glossy, dark green color with a light green underside. The root has a fibrous appearance while the bulb has a spongy-like structure, distinguishing them from each other (Girigaon & Kulkarni, 2012). These macroscopic features are crucial for accurate plant identification, standardization, and authentication in pharmacognostic research (Kadam et al., 2012). The leaf's cross section analyses, it is apparent that there are multiple layers of tissue including the epidermal cells, palisade parenchyma, spongy parenchyma, air cavities, xylem, and phloem. The spongy parenchyma enables gas exchange due to its significant air spaces, while the palisade parenchyma plays a critical role in photosynthesis *e.g*., (Salimpour et al., 2009). The root cross section also exhibits a fibrous structure with distinct tissue layers such as the upper, middle, and lower cortex, pericycle, xylem, phloem, and central pith. The presence of air cavities and aerenchyma in the lower cortex is crucial for buoyancy and gas exchange, which is essential for an aquatic plant like *E. crassipes*. Lastly, the bulb cross section reveals the arrangement of xylem, phloem, crystal-filled cells, and epidermis, indicating its function in nutrient storage and support (Gontova & Zatylnikova, 2013).

Leaf analysis considers vein islet number and vein termination as crucial quantitative parameters (Saeed et al., 2010). Efficient vascular supply and distribution within the leaf is indicated by *E. crassipes* with an average of 13.54± 1.12 vein islet number and 14.31± 1.94 vein termination. The study of stomata reveals that *E. crassipes* is amp-hi-stomatic, with stomatal percentage on the lower and upper sides of the leaves. The plant's survival in aquatic environments is contributed by these stomatal characteristics, which play a vital role in gas exchange and transpiration e.g., Taylor et al., (2008). The average stomatal number and stomatal index were determined to be 22.3± 5.61 and 11.21± 2.51, respectively. The examination of *E. crassipes* leaf, root, and bulb in powdered drug form can aid in verifying and ensuring the quality of herbal medicines by highlighting distinct cellular components (Handral et al., 2010). Through qualitative phytochemical screening, various secondary metabolites such as alkaloids, flavonoids, tannins, and phytosterols have been identified in different plant parts (Pachkore et al., 2012). Quantitative phytochemical analysis has revealed that the root contains the highest amount of alkaloids (15.95%), while the leaf has the highest concentration of flavonoids (20%) and tannins (15%). The bulb, on the other hand, shows the maximum quantity of phytosterols (10.60%). These phytochemical constituents contribute to the medicinal and pharmacological properties of *E. crassipes*, making it a promising candidate for further pharmacognostic investigations and therapeutic applications (Bharti & Vasudeva, 2013).

A thorough comprehension of the physical and chemical attributes of *E. crassipes* has been attained through the combination of macroscopic, microscopic, and phytochemical data. This knowledge is essential for accurately identifying, ensuring quality, and possibly utilizing this aquatic plant for medicinal purposes (Kagithoju et al., 2013). It is suggested that further investigation be conducted to uncover the therapeutic possibilities and create pharmaceutical products utilizing the identified phytochemical components. Furthermore, conducting more comprehensive pharmacognostic analyses can aid in the sustainable utilization and control of *E. crassipes* as a valuable natural resource.

Conclusion

E. crassipes is a 0.3m tall aquatic plant, belonging to family of Pontederiaceae. It has a kidney-shaped leaf that is dark green in color and glossy, has a spongy bulb and a feathery, dark-purple root. Epidermal, parenchymal, stomatal, cuticular, and lower epidermal cells were all visible in the analysis of leaf powder medication. Spiral trecheads, non-glandular trichomes, parenchyma cells, and cortical cells were visible in the analysis of the root. Studying the powdered drug from the bulb of *E. crassipes* revealed the presence of epidermal and cork cells, xylem and phloem tissue, calcium and broken calcium oxalate prisms, and a vertical view of cork cells. Stomata can be found on both the upper and lower sides of the *E. crassipes* leaf, making it amphistomatic. The stomatal number and index was 223± 5.61 and 11.21± 2.51, respectively. The vein islet number was 13.54± 1.12 and the vein termination was 14.31± 1.94, while the palisade ratio was 10.91± 0.34. The presence of various secondary metabolites was revealed by qualitative-phytochemical screening of the root, leaf and bulb of the *E. crassipes*. Alkaloids were most abundant (15.95%) in the root

of *E. crassipes*, while flavonoids (20%) and tannins (16%) were observed in significant quantities in bulb and leaf. The current research will be beneficial for characterizing *E. crassipes* from a pharmacological and pharmacognostic standpoint. Additional research is required to examine this plant more pharmacognostically for the treatment of various diseases.

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