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Research Article

PHARMACOGNOSTICAL AND PHYTOCHEMICAL EVALUATION OF *TALINUM TRIANGULARE* (JACQ.) WILLD

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ABSTRACT

Objective: The aim of the present study was to investigate the pharmacognostical and phytochemical characters of the medicinal plant *Talinum triangulare* (Portulacaceae), commonly known as waterleaf. The leaves of the shade-loving plant possess great therapeutic value in the traditional system of medicines but have not been fully exploited.

Methods: Morphological and anatomical details of different parts of waterleaf were studied. The physico-chemical parameters, fluorescence analysis and quantitative estimation were determined for the crude drug. Preliminary phytochemical screening was carried out for different waterleaf extracts.

Results: Physico-chemical properties such as loss on drying, total ash, acid insoluble ash and water soluble ash were calculated to be 10.643%, 28.070%, 0.067% and 7.789% (w/w) respectively. Water soluble extractive value (23.420% w/w) was more than the alcohol soluble extractive (10.080% w/w) of the drug. Preliminary phytochemical investigations of waterleaf extracts revealed the presence of various phyto-constituents such as like alkaloids, flavonoids, saponins, tannins, proteins and carbohydrates. Plant metabolites such as alkaloids (0.637 ± 0.191 mg/gm dry weight), flavonoids (0.225 ± 0.041 mg/gm dry weight), phenolics (0.319 ± 0.059 mg/gm dry weight), carbohydrates (1.295 ± 0.229 mg/gm dry weight), amino acids (2.033 ± 0.120 mg/gm dry weight) and proteins (1.218 ± 0.049 mg/gm dry weight) were quantitatively estimated.

Conclusion: The evaluation of these characters will help future researchers in phytochemical as well as pharmacological analysis of this species.

Keywords: *Talinum triangulare*, Portulacaceae, Microscopy, Pharmacognosy, Phytochemicals

INTRODUCTION

Talinum triangulare (Jacq.) Willd. (Portulacaceae) is a caulescent, perennial herb growing to a height of 80-100 cm. It is popularly known as Waterleaf because of its high moisture content of almost 90.8 g per 100 gm of edible leaf [1]. The herb with fleshy green leaves, succulent stem and pink flowers [2] was first introduced into South India from Sri Lanka and is cultivated in Tamil Nadu as Ceylon Spinach for its edible leaves [3]. The plant is widely grown in most of the humid tropical countries such as West Africa, Asia and South America [4]. It thrives well under shade and in cloudy weather. Waterleaf is relatively tolerant to drought conditions as they tend to adopt a crassulacean acid metabolism (CAM) pathway, thus resulting in efficient utilization of available moisture, carbon dioxide assimilation during night and increased growth [1].

The plant has a rich content of crude protein, total lipids, essential oils, cardiacglycosides, flavonoids and polyphenols [5]. Preliminary phytochemical studies on *T. triangulare* revealed the presence of omega -3-fatty acids and high levels of essential nutrients like minerals (such as calcium, potassium and magnesium), soluble fibres (such as pectin) and vitamins (such as C, α and β tocopherols and β-carotene) which are required for growth and development [4]. The leaf extracts of waterleaf have been proved to possess remarkable antioxidant activity [6] and high kaempferol content [7]. Waterleaf is a mucilaginous vegetable with high oxalate content and is rich in saponins. Cooking or blanching removes nearly most of the soluble oxalate. Furthermore, the leaves serve as sauce, condiment, spice, softening of soups and for flavouring in foods [8].

Talinum triangulare leaves have been implicated medically in the management of cardiovascular diseases like stroke and obesity [9]. According to traditional medicine the leaves of waterleaf are used to treat polyuria [10], internal heat, measles [1], gastrointestinal disorders [11], hepatic ailments and cancer [6]. In India, diabetics and invalids use the leaves of *T. triangulare* as a substitute for *Amaranthus gangeticus* [10].

In spite of the numerous medicinal uses attributed to this plant, there is no pharmacognostical report on anatomical and other physico-chemical standards required for the quality control of crude drug. Hence, the present study was designed to investigate the detailed pharmacognostical and phytochemical aspects of *Talinum triangulare.*

MATERIALS AND METHODS

Collection and authentication of plant material

Talinum triangulare plants were collected from the herbal garden at Irula Tribal Women's Welfare Society, Chengalpattu, Chennai, India in the month of December, 2010. The plant material was identified and authenticated by Dr. D. Narasimhan, Centre for Floristic Research, Department of Plant Biology & Plant Biotechnology, Madras Christian College, Chennai. A herbarium voucher specimen (LCH 42) was preserved for future reference and has been deposited in the Loyola College Herbarium.

Morphological investigation

Healthy plants were selected for morphological evaluation. Macroscopical characters like shape, size, colour and odour were also examined.

Microscopical investigation

Preparation and sectioning of specimen

Fresh and turgescent plant material such as root, stem, leaf, peduncle and flower bud were collected in the morning before exposure to sunlight. They were gently washed to remove any dust or dirt particles adhering to the plant tissues. All the specimens were fixed in FAA solution (40% formalin, glacial acetic acid and 70% ethyl alcohol in the ratio 5:5:90 v/v). The materials were left in the fluid for three days, after which they were washed in water and gradually dehydrated with tertiary butyl alcohol (TBA). Infiltration of the specimens was carried out by gradual addition of paraffin wax (melting point 58-60 ºC) (Merck, Germany) until TBA solution attained super saturation. The specimens were embedded into paraffin blocks for sectioning.

The paraffin-embedded blocks were mounted on wooden stubs and longitudinal microtome sections (10 µm) were cut using a Spencer

820 rotary microtome (American Optical Corporation, Buffalo, NY, USA). The resulting paraffin ribbons were stained with alcoholic safranin (0.5% w/v) and counter stained with fast-green (0.25%, w/v) solution. The slides, after staining with safranin, were dehydrated by employing a graded series of ethyl alcohol (30%, 50%, 70%, 90% and absolute alcohol; v/v). The specimens were stained with fast green in clove oil and xylol: alcohol (50:50), passed through 100% xylol and finally mounted in DPX (distyrene plasticizer and xylene) mountant [12].

To study the histology of stomata and venation pattern, paradermal sections (parallel to the surface of leaf) were taken. The clearing of leaves for studying stomatal number and stomatal index was carried out with 5% sodium hydroxide (w/v) along with chlorinated soda solution supplemented with slight heating. The mounting of cleared materials was performed with dilute glycerine after staining. Quantitative microscopy was carried out and values were determined as per the procedure described by Wallis [13]. Descriptive terms of the anatomical features are as stated in the standard anatomy books [14-15].

Powder microscopy

To a little quantity of finely ground plant powder taken on a microscopic slide, 1-2 drops of 0.1% phloroglucinol solution was added along with a drop of concentrated HCl. It was mounted in glycerol and observed under microscope. The characteristic features of the powder were noted.

Photomicrographs

Photomicrographs of different magnifications were taken with the help of a Nikon Eclipse E200 microscope (Nikon Corp., Japan) using a Nikon digital camera. Magnifications of the figures are indicated by scale-bars.

Preparation of dried plant material

Freshly collected *T. triangulare* aerial parts (leaf and stem) were chopped into small pieces and shade-dried at room temperature to prevent photolysis and thermal degradation. After 6-10 weeks, the dried material was ground into coarse powder in an electric blender. Fine plant powder was obtained by passing it through 40 mesh sieve. The powders were stored in an airtight glass container until further use.

Fluorescence analysis

Fluorescence analysis was carried out as per the method described by Kokoski *et al.* [16] and Chase & Pratt [17]. The powdered drug treated with various reagents and solvents were observed for the presence of fluorescence under day light and ultraviolet (UV) light.

Physico-chemical analysis

Physico-chemical constants of crude drugs were evaluated using coarsely ground plant powder. Percentage values of loss on drying, foaming index, total ash, acid insoluble ash, water soluble ash, alcohol soluble extractive and water soluble extractive values were determined according to standard methods [18-20]. The determinations were performed in triplicates and the results are expressed as mean ± SE. The percentage (w/w) values were calculated with reference to the air-dried drug.

Preparation of plant extracts

For extraction of crude bioactives, 200 g of coarsely powdered plant material was soaked in 1.2 L hexane for 3 days. The filtrate was removed and concentrated in a rotary evaporator under reduced pressure. The marc was re-extracted twice with hexane at 3 day intervals. All the extracts were pooled and the colour, consistency and percentage yield of the extract was noted. This hexane extracted marc was then sequentially extracted with chloroform, ethyl acetate and methanol using the same procedure as above. All the extracts were stored at 4 °C in glass vials for further studies.

Preliminary phytochemical investigation

The crude extracts (hexane, chloroform, ethyl acetate and methanol) which were re-dissolved in methanol and was used for the qualitative analysis of primary (proteins and carbohydrates) and secondary metabolites (alkaloids, flavonoids, tannins, saponins, steroids, terpenoids, glycosides). The screening procedures for all the primary and secondary metabolites were done according to the protocols described by Trease & Evans [21]; Sofowora [22]; Plummer [23]; Tyler *et al.* [24] and Kokate *et al.* [25].

Quantitative estimation of phytochemicals

Quantitative estimation of metabolites like total free amino acids [26], total soluble proteins [27], carbohydrates [28], flavonoids [29], alkaloids [30] and total phenolic content [31] was performed using the standard methods. The determinations were performed in triplicates and the results are expressed as mean ± SE with reference to the air-dried drug (mg/gm dry weight).

RESULTS AND DISCUSSION

Macroscopic characters

Talinum triangulare is an annual or perennial herb with strong branches usually growing up to a height of 80-100 cm in height. Roots short, thick, swollen, smooth-surfaced, pale yellow to brown colour; secondary roots thin, pale yellow in colour. Stems erect, succulent, branched, glabrous, obtuse-angular to terete, 0.5-1.0 cm in diameter, fracture short. Leaves simple, alternate, sub-sessile, slightly fleshy; stipules absent; blade obovate to spathulate, 3-10 cm x 1-3.5 cm, base long-tapering, apex rounded to notched, mucronate, entire; venation pinnate, distinct midrib. Inflorescence terminal; in cymes or raceme-like panicles, borne on a 3-angled (triangular) stalk 10-12 cm in length. Flowers bisexual, regular, hypogynous, ephemeral, 1-1.5 cm across; pedicel 1-2 cm long, recurving in fruit; sepals 2, free, broadly ovate, concave, apiculate, thinly membranous with 3 prominent veins, 0.4–0.5 cm long; petals 5, free, obovate, upto 1 cm long, magenta; stamens numerous, usually adnate to base of petals, filaments magenta, anthers yellow; ovary superior, 1-celled, green; style magenta, slender, 3 short-spreading capitate stigma, exceeding stamens; ovules many. Fruit globose to ellipsoid capsule, dull yellow, 0.4-0.7 cm in length, unilocular, 3-valved, seeds borne on a free-central placenta, elastically dehiscent. Seeds, numerous, compressed globose-reniform, 0.1 cm in length, tuberculate, shining black. The twig of the plant bearing flower and fruits and an enlarged portion of its flower are depicted in Fig 1a and b respectively. No characteristic odour or taste was noted.

Fig. 1: Showing *Talinum triangulare* plant: a – A twig showing leaf arrangement, bearing flower and fruits; b – Enlarged portion of flower (*Bar*: 1 cm)

Microscopic characters

Transverse section of root

Transverse section of root is 3 to 6 mm in diameter. The structure depicts an almost circular outline with a wide, central woody part and a thin outer bark (Fig. 2a). The outermost cork consists of 10 to 12 rows of tabular closely arranged cells. The phellogen is composed of a single row of narrow, thin-walled tangentially-elongated cells. It is followed by phelloderm consisting of large, slightly tangentially-elongated cells. Phloem is composed of sieve tubes, companion cells and phloem parenchyma (Fig. 2b). Inner to the phloem is the cambium which is formed of one or two rows of narrow, thin-walled cells.

The wood which forms the major part of the root is composed mostly of secondary elements. It is made up of vessels, parenchyma, fibres and medullary rays (Fig. 2c). The vessels are many, mostly solitary and vary in diameter 150-225 µm (Fig. 2c). Medullary rays are many, long, straight, uniseriate or biseriate. The ray cells are rectangular & vertically elongated.

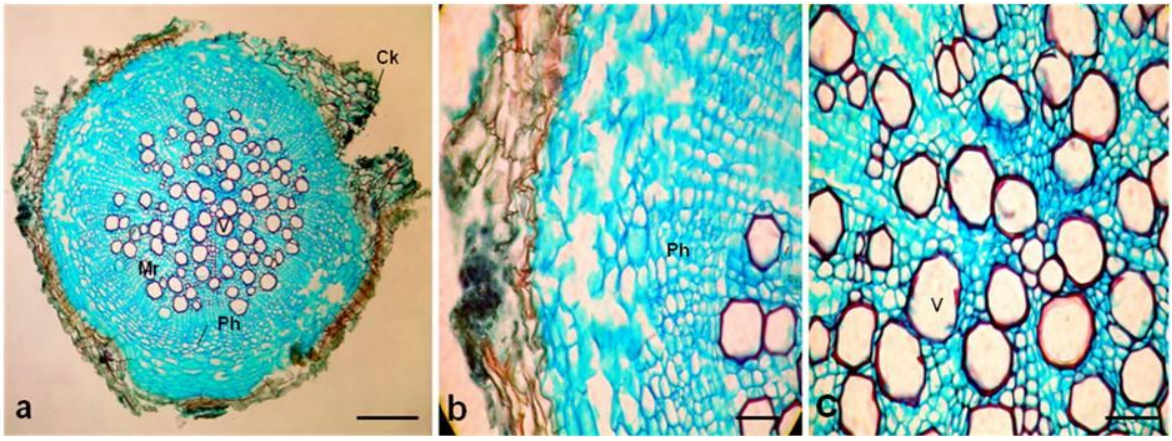

Fig. 2: Showing transverse section of root: a – Ground plan (*Bar*: 1 mm); b – A portion enlarged (*Bar*: 100 µm); c – Enlarged portion of central wood region (*Bar*: 100 µm)

[Ck – Cork; Ph – Phloem; Mr – Medullary ray; V – Vessel]

Transverse section of stem

Transverse section of stem is oval to circular in shape with a diameter 5 to 10 mm. The epidermis is made up of rectangular cells covered with thin cuticle. The cortical region is divided into 2 distinct zones, namely, an outer region of collenchyma cells (1 or 2 layers) and an inner region made up of large, tangentially-elongated thin-walled less-compact parenchyma cells. Collateral vascular bundles are eight in number, separate (Fig. 3a) individually distinct and arranged in ring-like manner, with radial xylem elements and possessing a sclerenchymatous sheath of pericyclic cap over the phloem (Fig. 3b). Vessels are solitary, thick walled and penta-hexagonal (Fig. 3c). The central pith region is wide and composed of thin walled, round to polygonal parenchyma cells. Cluster crystals of calcium oxalate or druses are scattered in the parenchyma cells of the pith and occasionally seen in the cortical region. Such druses have also been reported in *Portulaca oleracea* [32]. Most of the parenchyma cells contain mucilage. Many lysigenous cavities are seen in the cortex and pith region.

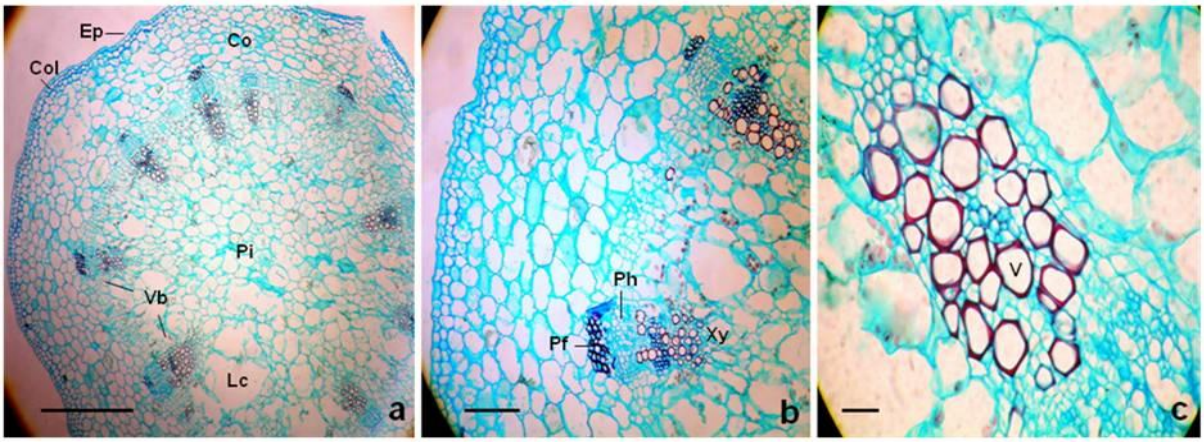

Fig. 3: Showing transverse section of stem: a – Ground plan (*Bar*: 1 mm); b – A portion enlarged (*Bar*: 1 mm); c – Enlarged portion of vascular bundle (*Bar*: 100 µm)

[Co – Cortex; Col – Collenchyma; Ep – Epidermis; Lc – Lysigenous cavity; Pf- Pericyclic fibres; Ph – Phloem; Pi - Pith; V – Vessel; Vb – Vascular bundle; Xy - Xylem]

Transverse section of leaf

Lamina

The leaf is dorsiventral in structure. A fairly mature leaf is about 1 to 1.2 mm thick. The epidermis is single layered and covered with a distinct, thick layer of cuticle. The epidermis includes solitary cells with the presence of bladder like protrusions from the surface, forming a transition to the hairs, and apparently serving for water storage. Hairs are in the form of papillae. Below the adaxial epidermis, a single layer of closely packed columnar palisade cells are seen. The palisade tissue is not continuous at major veins. The spongy mesophyll is represented by 2 or 3 layers of loosely arranged cells of varying shapes and sizes (Fig. 4a,b). Mesophyll is traversed by a number of small veins having similar arrangements of different tissues as in the midrib. Vascular bundles in the veins are not accompanied by sclerenchyma.

Midrib

Transverse section of midrib shows a shallow groove on the adaxial side and convexity on the abaxial side (Fig. 4c). An arc shaped vascular bundle is situated in the centre. The ground tissue is parenchymatous and a few cells contain druses or cluster crystals of calcium oxalate. Crystals of calcium oxalate has been reported in *Portulaca* sp. [32]. Mucilage is present in the parenchyma cells.

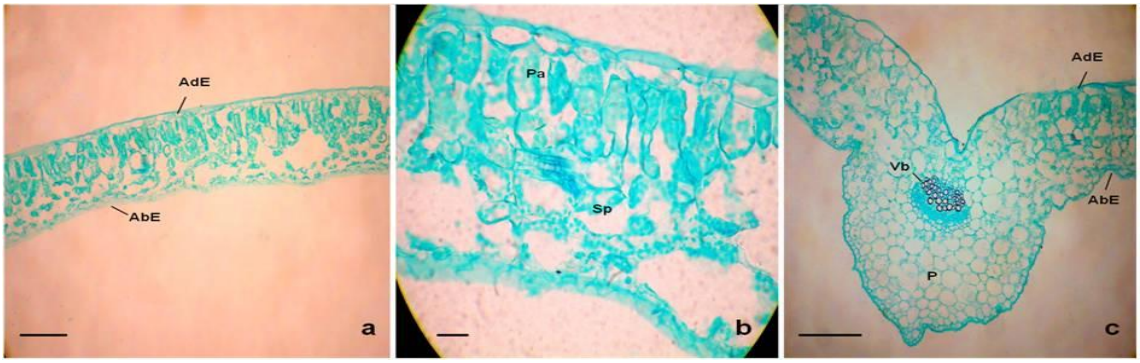

Fig. 4: Showing transverse section of leaf: a – TS of lamina (*Bar*: 500 µm); b – Lamina portion enlarged (*Bar*: 100 µm); c – TS of midrib (*Bar*: 1 mm)

[AbE – Abaxial epidermis; AdE – Adaxial epidermis; P – Parenchyma; Pa – Palisade tissue; Sp – Spongy tissue; Vb – Vascular bundle]

Epidermis in surface view

The adaxial (upper) epidermal cells are polygonal larger in size with slightly wavy walls. The abaxial (lower) epidermal cells are smaller in size, with wavy walls. Both the epidermis are perforated by paracytic (rubiaceous) stomata accompanied by two subsidiary cells parallel to the pore. Stomata are more in abaxial surface (Fig. 5 c,d) when compared to the adaxial surface (Fig. 5 a,b). In surface view, lamina shows venation (Fig. 6a) and distribution of druses or cluster crystals of calcium oxalate (Fig. 6 b,c). The leaf constants, i.e., stomatal index, palisade ratio and vein islet number is presented in Table 1.

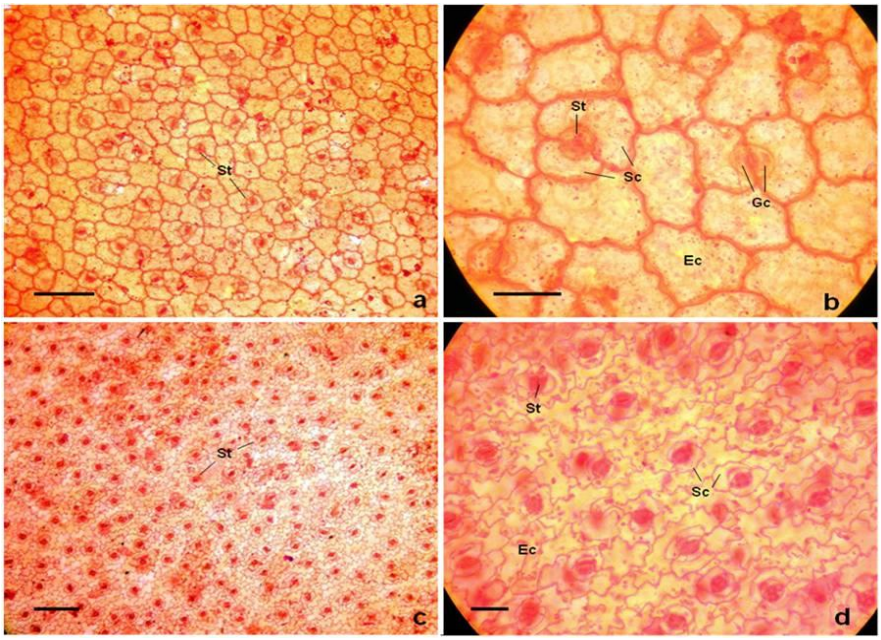

Fig. 5: Showing epidermis in surface view: a & b – Adaxial foliar epidermis (*Bar*: 500 µm & 100 µm); c & d – Abaxial foliar epidermis (*Bar*: 500 µm & 100 µm)

[Ec – Epidermal cell; Gc – Guard cell; Sc – Subsidiary cell; St – Stomata]

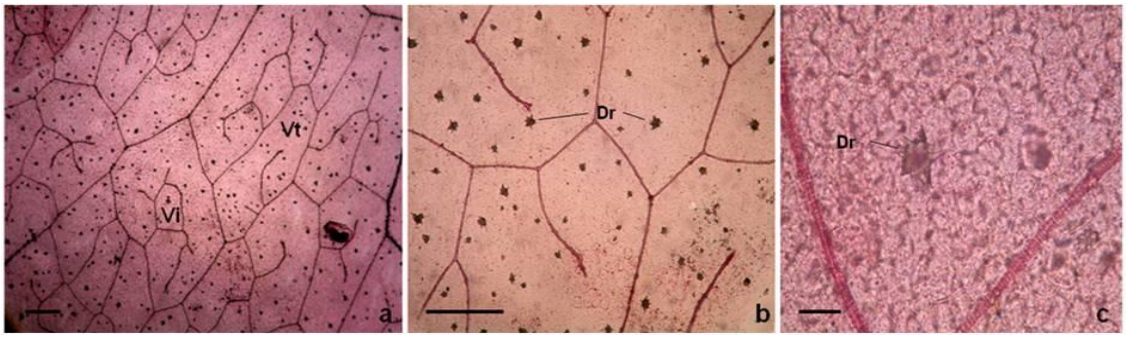

Fig. 6: Showing epidermis in surface view: a – Surface view of lamina showing venation pattern (*Bar*: 1 mm); b – Surface view of lamina showing distribution of druses (*Bar*: 500 µm); c – Enlarged portion showing druse/calcium oxalate crystal (*Bar*: 100 µm)

[Dr– Druses; Vi- Vein islets; Vt– Vein termination]

Table 1: Quantitative microscopical parameters of the leaf of *Talinum triangulare*

S. No.	Leaf constants	Values obtained
1.	Stomatal index for adaxial epidermis	18 – 22 / mm^2
2.	Stomatal index in abaxial epidermis	33 – 35 / mm^2
3.	Palisade ratio	4 – 6
4.	Vein islet number	2 – 3 / mm^2

Transverse section of peduncle

Transverse section of peduncle is triangular in shape. Epidermis is single layered and covered by a layer of cuticle. Hypodermis is composed of 1 or 2 layers of collenchyma cells. Vascular bundles are four in number, the larger one towards the adaxial surface and three separate smaller bundles in the centre. The ground tissue is parenchymatous. Lysigenous cavities are seen in the ground tissue. Some parenchyma cells contain druses or calcium oxalate crystals. Some of the medullary or pith parenchyma cells are lignified (Fig. 7a).

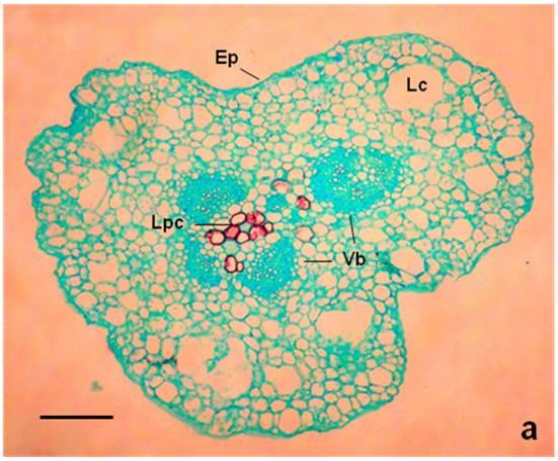

Fig. 7: Showing transverse section of peduncle: a – Ground plan (*Bar*: 1 mm)

[Ep – Epidermis; Lc – Lysigenous cavity; Lpc – Lignified parenchyma cells; Vb – Vascular bundle]

Longitudinal section of flower bud

Longitudinal section (L.S.) of flower bud shows the floral architecture with sepals, petals, numerous stamens and the superior ovary (Fig. 8a). L.S. of sepal and petal shows a single layered epidermis and loosely arranged parenchymatous ground tissue traversed by a row of vascular strand. Basal portion of flower bud is composed of parenchymatous thalamal tissue in which lignification of some parenchyma cells are noticed (Fig. 8b). The ovary is unilocular with numerous ovules on central column. The style arising from the surface of the ovary flanked by anthers holding the microspores are also seen (Fig. 8c).

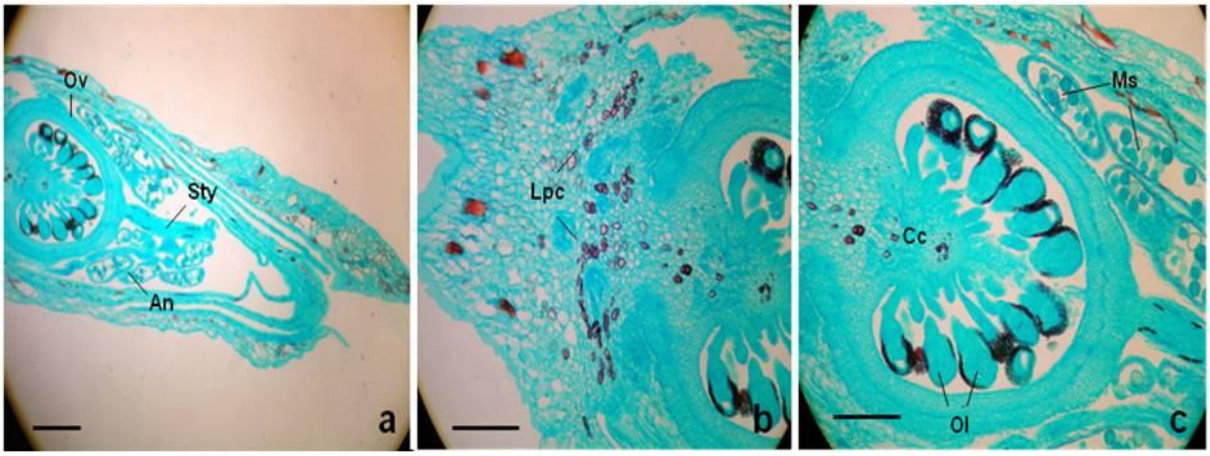

Fig. 8: Showing longitudinal section of flower bud: a – LS showing floral architecture (*Bar*: 1 mm); b – LS showing lignifications of some parenchyma cells (*Bar*: 300 µm); c – LS showing unilocular ovary with numerous ovules on a central column (*Bar*: 300 µm)

[An – Anther; Cc – Central column; Lpc – Lignified parenchyma cells; Ms – Microspores; Ol – Ovules; Ov – Ovary, Sty – Style]

Powder microscopy

The powder is green in colour with no characteristic odour and taste. When viewed under the microscope, it revealed the presence of vessels, fibres, parenchyma cells, palisade cells, fragments of leaf with paracytic stomata, mucilage cells and druses (Fig. 9).

Fluorescence analysis

The fluorescence characteristic of the powdered drug with different chemical reagents was studied by observing under day light and UV Light (long UV) and the data is tabulated in Table 2. Fluorescence is an important phenomenon exhibited by various chemical

constituents present in plant material. Some constituents show fluorescence in the visible range during normal day light. The ultra violet light produces fluorescence in many natural products which do not visibly fluoresce in day light. If the substances are not fluorescent by themselves, they may often be converted into fluorescent derivatives by applying different reagents. Therefore, some crude drugs are often assessed qualitatively and this is an important parameter of pharmacognostical evaluation [33].

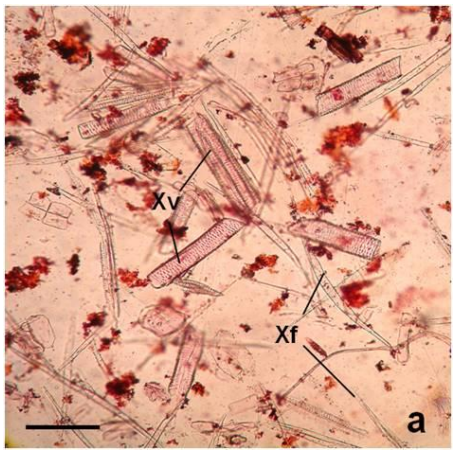

Fig. 9: Powder microscopy: a – Powder showing xylem vessel and fibres (*Bar*: 100 µm)

[Xv – Xylem vessels; Xf – Xylem fibres]

Table 2: Fluorescence analysis of crude drug of *T. triangulare*

Chemical treatments/ solvents used	Visible	UV light (Long – UV)
Powder as such	Greenish brown	Green
Powder + water	Yellowish brown	Greenish yellow
Powder + 1M sodium hydroxide	Orange brown	Brownish black
Powder + 1N hydrochloric acid	Dirty yellow	Green
Powder + 1N sulphuric acid	Brown	Brownish black
Powder + dilute ammonia	Orange brown	Brown
Powder + hexane	Greenish yellow	Green
Powder + chloroform	Yellowish green	Dark green
Powder + ethyl acetate	Yellowish green	Green
Powder + acetone	Olive green	Green
Powder + glacial acetic acid	Green	Dark green
Powder + methanol	Green	Dark green
Powder + 5 % ferric chloride	Orange brown	Brown

Physico-chemical analysis

Results of the quantitative determination of various physicochemical parameters are tabulated in Table 3. The values obtained for *T. triangulare* for loss on drying at 105 °C was 10.643 ± 0.014 % (w/w). When the moisture content is less, it prevents bacterial and fungal growth [34]. The total ash value was determined to be 28.070 ± 0.078 %, while acid insoluble ash and water soluble ash was found to be 0.067 ± 0.001 % and 7.789 ± 0.002 % (w/w) respectively. Ash value represents the inorganic salts that are naturally occurring in the drug. Total ash is the residue remaining after incineration. The value of total ash was high which could indicate high content of carbonates, phosphates and silicates. The acid insoluble ash is a part of the total ash which is insoluble in dilute hydrochloric acid [18-19]. The total ash is important in the evaluation of purity of drugs, especially the presence or absence of foreign organic matter such as metallic salts and/or silica. This value of a plant material indicates the amount of minerals and other earthy materials attached to the crude drug. Water soluble extractive value (23.420 ± 0.127 %) was found to be higher than the alcohol soluble extractive (10.080 ± 0.092 %) of the drug. Extractive values are primarily useful for the determination of exhausted or adulterated drugs [35]. The foaming index to detect the presence of saponins was <100. Among the Portulacaceae family, physico-chemical parameters were studied for *Portulaca oleracea* [32] and *Portulaca quadrifida* [36].

Table 3: Physico-chemical properties of *T. triangulare*

S. No.	Parameters	Values obtained (% w/w) [a]
1.	Loss on drying at 105 °C	10.643 ± 0.014
2.	Ash values	
	Total ash	28.070 ± 0.078
	Acid insoluble ash	0.067 ± 0.001
	Water soluble ash	7.789 ± 0.002
3.	Extractive values	
	Alcohol soluble extractive	10.080 ± 0.092
	Water soluble extractive	23.420 ± 0.127
4.	Foaming index	< 100

[a] : represents mean percentage value ± Standard error of three replicates

The colour, nature and the total yield of each extract obtained from different solvents are presented in Table 4. The variation in extractable matter in various solvents such as hexane, chloroform, ethyl acetate and methanol (Table 4) is suggestive of the fact that the formation of the bioactive principles is influenced by a number of intrinsic and extrinsic factors. High alcohol soluble extractive values reveal the presence of polar substances like phenols, tannins and glycosides, as also reported by Sharma *et al.* [37].

Table 4: Colour, nature and percentage yield of extracts of *T. triangulare*

Extract	Colour	Nature	Yield (% w/w)
Hexane	Yellowish green	Solid	2.013
Chloroform	Dark green	Solid	1.921
Ethyl acetate	Dark green	Semi-solid; sticky	2.860
Methanol	Green	Semi-solid	2.972

Qualitative screening of phytochemicals

The preliminary phytochemical screening with the different qualitative chemical tests revealed the presence of various secondary metabolites (Table 5). Ethyl acetate and ethanol extract showed positive results for alkaloids, flavonoids, tannins, saponins, proteins, starch and amino acids. Steroids, terpenoids and alkaloids were prominently seen in hexane and chloroform extracts. These secondary plant metabolites are known to possess various pharmacological effects and might be responsible for the actions exerted by the plant [38]. Similar to the current study, the presence of alkaloids, carbohydrates, tannins, phenolics, flavonoids, saponins, proteins, amino acids and steroids were reported in methanolic extract of *Portulaca oleracea* [32].

Table 5: Preliminary phytochemical screening of different extracts of *T. triangulare*

Phyto-constituent	Test/ Reagents used	Hexane extract	Chloroform extract	Ethyl acetate extract	Methanol extract
Alkaloids	Dragendorff's reagent	+	–	+	+
	Wagner's reagent	–	–	–	–
	Meyer's reagent	+	–	+	+
Flavonoids	10 % $FeCl_3$	–	+	+	+
	NH_3 – HCl	–	–	+	+
	1 % $AlCl_3$	–	–	+	+
Saponins	Foam test	+	+	+	+
Tannins	5 % $FeCl_3$	–	–	+	+
	Iodine	–	–	–	+
	H_2SO_4 – HCl	–	–	+	+
	$K_2Cr_2O_7$	–	–	–	+
	10 % lead acetate	–	–	–	+
Phlobatannins	1 % HCl	–	–	–	–
Steroids	Liebermann Buchard test	+	+	+	–
Terpenoids	Salkowski test	+	+	+	+
Anthraquinones	Borntrager's test	–	–	–	–
Cardiac glycosides	Keller- Killiani test	–	–	+	–
Starch	KOH	–	–	+	+
Proteins	Biuret test	–	–	+	+
Amino acids	Ninhydrin test	–	–	+	+
Resins	1 % HCl	–	–	–	–

+ : Presence; – : Absence

Quantitative estimation

Amino acids, proteins, carbohydrates, flavonoids, phenolics and alkaloids were quantitatively determined and are graphically represented in Fig. 10. Total amino acids were calculated to be 2.033 ± 0.120 mg/gm dry weight, while the total soluble proteins were estimated as 1.218 ± 0.049 mg/gm dry weight. Total soluble sugars and the amount of alkaloids were found to be 1.295 ± 0.229 and 0.637 ± 0.191 mg/gm dry weight, respectively. Total phenolic content (0.319 ± 0.059 mg/gm dry weight / pyrocatechol equivalents) and flavonoids (0.225 ± 0.041 mg/gm dry weight) were found to be in very less quantities. Primary metabolites (amino acids, proteins, carbohydrates) are directly involved in the normal growth, development and reproduction [39]. Whereas secondary metabolites (alkaloids, flavonoids, phenolics) perform specific functions such as pollinator-attractors and in defence against external stimuli such as UV radiation and microbial infections [40]. Thus, the curative properties of such medicinal plants are perhaps due to the presence of the various secondary metabolites [41].

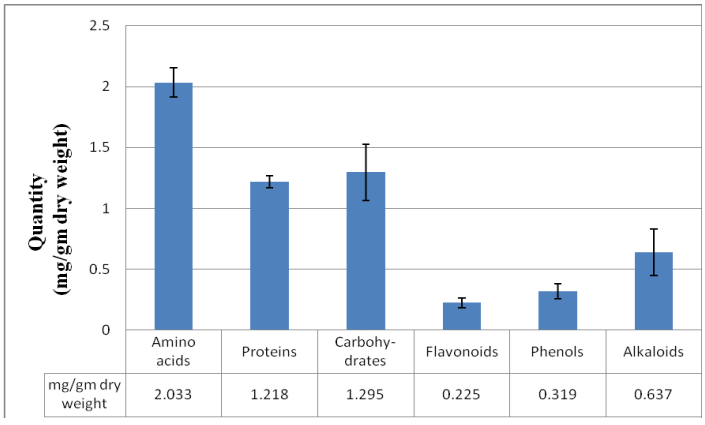

Fig. 10: Quantitative estimation of phytochemicals in *T. triangulare*

CONCLUSION

Since there are no reports on pharmacognostical studies of *Talinum triangulare* the present work was designed at laying down standards, which could be useful to determine the authenticity of this traditionally valued plant. Anatomical and morphological parameters discussed here provide useful information in regard to the correct evaluation and authentication of the plant. Physico-chemical analysis and phytochemical screening add to its quality control and quality assurance, and serves as a standard monograph for identification and substantiation of the crude drug.

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