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Characterisation of indigenous plants for herbal formulations preparation based on pharmacognostic and physiochemical data

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Abstract

The use of plant-based drugs has increased considerably in the modern world for their efficiency in managing diseases with lesser side effects than synthetic drugs. The current study was aimed to confirm the identity, quality and purity of some locally available potential medicinal plants such as *Alstonia scholaris* (bark), *Centella asiatica* (whole plant), *Drymaria cordata* (whole plant), *Hydrocotyle sibthorpioides* (whole plant), *Oroxylum indicum* (bark), *Senna hirsuta* (leaf), *Senna occidentalis* (leaf), *Solanum indicum* (root), *Stephania japonica* (tuber) in powdered form. The powdered plant parts were evaluated for preliminary phytochemicals, pharmacognostical studies, physical characteristics and heavy metals. Preliminary phytochemical screening of the different extracts inferred the existence of carbohydrates, phenolics, alkaloids and amino acids while triterpenoids were absent. Microscopical study of the powder revealed the diagnostic qualities such as stone cells, trichomes, stomata, calcium oxalate crystal, fibres, xylem vessel, pitted spiral vessels, etc. The colour, odour, flavour/taste and texture of the pulverized plant were overall acceptable. The physical characteristics which determine the flow rate of the powder with respect to Carr's index and Hausner's ratio were found to be good to passable except for *Hydrocotyle sibthorpioides* (whole plant), *Oroxylum indicum* (bark), which were not easily passable. The heavy metal test showed the absence of bismuth, cadmium and lead. Thus the present study may serve as a standard reference for the quality control analysis of the herbal drug either singly or in synergy.

Keywords

Medicinal plants, organoleptic, heavy metal, *Alstonia, Centella, Drymaria, Hydrocotyle, Oroxylum, Senna, Solanum, Stephania*

Introduction

Plant-based chemical moieties have attracted people since ancient times to treat various ailments because of innumerable healing properties (1, 2). This claim is supported by the World Health Organization. As per WHO, 88% of the population among the member countries are dependent on traditional and complementary medicine (3). The use of medicinal herb has been in practice in India since the days of yore due to the pool of secondary metabolites it houses (4). Ayurveda, a unique discipline for disease management using natural products in India, has been accepted globally for its exemplary output and uniqueness (5). Herb-herb combination is the basis of polyherbal formulation which provide collective effects in the treatment of diseases. A single plant may have therapeutic ability but when compared to polyherbal formulations which have the collection of several plants, it is less potential (6, 7). In traditional Chinese medicine (TCM) herbal combinations are popularly used in order to decrease toxicity and increase efficacy of a formulation. The herb-herb combinations are simpler rather than complex without losing its basic therapeutic value (8, 9). Though Ayurveda medicine is gaining popularity, the main problem that poses is its standardisation and quality control during the manufacturing process (10). Standardisation is considered to be the first and important step of drug development which helps to evaluate the quality of polyherbal drugs and avoid variation from batch to batch (11, 12). This growing interest in naturopathy attracted us to explore the floral diversity in our vicinity for their potential therapeutic uses. A total of 9 plants were selected based on the uses by traditional healers in the locality for hepatoprotection for the current study.

Materials and Methods

Plant materials

Based on the traditional use by the *Bodo* tribe, plants such as *Alstonia scholaris* (bark), *Centella asiatica* (whole plant), *Drymaria cordata* (whole plant), *Hydrocotyle sibthorpioides* (whole plant), *Oroxylum indicum* (bark), *Senna hirsuta* (leaf), *Senna occidentalis* (leaf), *Solanum indicum* (root), *Stephania japonica* (tuber) were collected from various localities of Bodoland Territorial Region and were identified initially by Plant Taxonomist Dr. Sanjib Baruah, Department of Botany, Bodoland University, Kokrajhar, Assam, India. However, the voucher specimens was deposited at Botanical Survey of India, Central National Herbarium, Howrah for final authentication and identification (CNH/Tech.II/2021/42 date 26.11.2021). The plant materials were washed, shade dried, grounded using mechanical grinder, sieved through a sieve of mesh size of 600 µm and stored in airtight glass bottles for further analysis. A brief description of the nine plants selected for the current study are as follows:

Alstonia scholaris (L.) R.Br. is locally known as Sitaona in Bodo and blackboard or devil's tree in English (13). It belongs to the family Apocynaceae, an evergreen tree native to southern China, tropical Asia and Australasia (14). Though *A. scholaris* bark is reported to be toxic at a higher dose (15), yet, it is found to be used in the treatment of myriad diseases (16). It is also reportedly used for medicinal purposes for the treatment of various diseases such as dysentery, diarrhoea, fever and other stomach aches (17), hepatoprotective (18), malaria, jaundice, gastrointestinal troubles and cancer (13).

Centella asiatica (L.) Urb. is also known as Indian Pennywort and Asiatic pennywort (English), and Manimuni geder (Bodo). It is an herbaceous plant native to Southeast Asian countries such as India, China, Indonesia, and Malaysia as well as a few African countries and belonging to family Apiaceae (19). *Centella asiatica* has been used as a vegetable and as a medicinal herb (19, 20). Some of the medicinal properties of *C. asiatica* are its use in the management of the liver disorder (21), and having anti-cancerous, antibacterial, anti-fungal, anti-inflammatory, neuroprotective, antioxidant, wound healing, anti-depressant activities (21), cognitive function (22), anti-diabetic (23), central nervous system, skin and gastrointestinal disorders (24).

Drymaria cordata (L.) Willd. ex Schult, locally named as Jabsri in Bodo and commonly known as chickweed in English, belongs to the family Caryophyllaceae, extensively distributed in Northeast India and originated from tropical America (25). It is mostly considered a weed of gardens but possesses many medicinal properties and find its application in the treatment of snake bites (26), many kinds of diarrhoea (26, 27), skin problems (28), constipation and throat pain (29); moreover, it has been reported to have some properties such as antibacterial property (30), antitussive activities and to manage acute cold attacks, coughs, sinusitis (31). Analgesic and antipyretic properties of *D. cordata* are well established (32).

Hydrocotyle sibthorpioides Lam. belongs to the family Umbelliferae, a perennial herb widely distributed in parts of Asia (33) and Africa (34). It is known as Lawn pennywort in English and Manimuni pisa in Bodo. The people of India and China traditionally use it for the treatment of various illnesses and disorders (34). *H. sibthorpioides* is also widely used in managing fever, rheumatalgia, coughing, liver problems, dysentery, sore throat, psoriasis, oedema, herpes zoster infection, hepatitis-B infection, soothing pain, dysmenorrhoea and carbunculosis (34). It also possesses anti-inflammatory (35) and anti-chikungunya virus activities (36).

Table 1. List of plants with information on parts used, vernacular names and GPS coordinates of the collection site

Botanical Name	Parts Used	Vernacular names		GPS Coordinates	
		Bodo Name	Assamese Name	Latitude	Longitude
Alstonia scholaris (L.) R.Br.	Bark	Sitaona	Chatiyana, Sotiyana, Chatim	26.470425°N	90.296998°E
Centella asiatica (L.) Urb.	Whole plant	Manimuni geder	Bor manimuni	26.4706114°N	90.2969722°E
Drymaria cordata (L.) Willd. ex Schult	Whole plant	Japsri	Thunthuni, Laijabori, Lai Jabori	26.534360°N	90.015519°E
Hydrocotyle sibthorpioides Lam.	Whole plant	Manimuni pisa	Soru manimuni	26.4697987°N	90.2968682°E
Oroxylum indicum (L.) Kurz	Bark	Karokandai	Dingdinga, Toguna, Bhatghila	26.463155°N	90.297376°E
Senna hirsuta (L.)	Leaf	Sumu bipang	N/A	26.797191°N	90.540234°E
Senna occidentalis (L.) Link	Leaf	Gangrim bipang	Hat-thenga, Jonjoni-goch, Kusum	26.47872°N	90.3053733°E
Solanum indicum (L.) Kurz	Root	Kuntainara	Deuri tita,Tit bhek, Bhot bengena	26.79414°N	90.5303609°E
Stephania japonica (Thunb.) Miers	Tuber	Dibaolu	Galdua, Tubuki Lota, Tubuka-lot	26.790827°N	90.5300655°E

Oroxylum indicum (L.) Kurz is a deciduous tree, categorised in the family Bignoniaceae. It is popular as Karokandai in Bodo, and commonly known as Midnight horror and the Indian trumpet tree. It is native to India and countries in the Himalayan foothills like Bhutan, parts of China, Indo-China and the Malesia region. It is used in the management of gastritis, hypertension, liver problem, fever, purgative, headache, epilepsy, muscular pain, general health problems (37, 38) and hepatoprotective (39).

Senna hirsuta (L.) H.S.Irwin & Barneby is a type of woody annual shrub belonging to the family Fabaceae and is locally named sumu bipang (Bodo). It is native to Africa and extensively used as a medicinal herb for various ailments because of its therapeutic properties (40). This species is reported to cure bone fractures of humans and live stocks (41). It is efficient in the treatment of rheumatism (42), hypertension (42), indigestion (43), skin disease (43), fevers (42), biliousness (42), ringworm (42), dropsy (42) and eczema (42), anti-diabetic (44), antimicrobial and hepatoprotective properties (45).

Senna occidentalis (L.) Link, belonging to the family Fabaceae is distributed all through the tropical and subtropical region of the world (46). It is known as gangrim bipang in Bodo and septic weed, coffee weed and stinking weed in English. *S. occidentalis* is a common additive or substitute to coffee (47). It is reported to possess scavenging properties, larvicidal and mosquitocidal activities (48-50), antioxidant and antimicrobial (51), anti-inflammatory, immunosupressive, antianxiety, anti-depressant, analgesic, anti-diabetic and antipyretic activities (50, 52).

Solanum indicum (L.) Kurz, (Solanaceae) is commonly known as Indian nightshade and Kuntainara in Bodo. This species is commonly found throughout tropical and subtropical India. It is used in the treatment of stomach problems, anorexia, abdominal pain, worm infestation, fever, inflammation, pain, sleeping and urinary disorders (53), lung disorders (bronchitis and asthma), blood, and sexual disorders, heart problems and pruritis (54).

Stephania japonica (Thunb.) Miers, belongs to the family Menispermaceae and is popularly known as Snake vine and tape vine (English) and Dibaolu (Bodo). It is a slender twining shrub native to Asia and Australia and found abundantly in Northeast India. It is validated for use in the management of asthma, malaria, cancer, diarrhoea, dysentery, urinary disease, stomach ache, tuberculosis, hepatitis, itches, dyspepsia, fevers (55, 56), antihyperglycemic and antihyperlipidemic property (57), moderate antioxidant and potent analgesic activity (58).

Preparation of extracts

The powdered plant materials were individually extracted in a Soxhlet apparatus using double distilled water (1:10 *w/v* ratio of the sample and solvent). The extraction was carried out for 6 hrs at boiling temperature and finally evaporated under pressure at 50 °C. The extract was stored at 4 °C for experimental analysis.

Organoleptic parameters

In organoleptic evaluation, sensory impressions were used to examine and characterize the qualities of crude, such as appearance (colour and texture), odour and taste (59). The results of this experiment are based on the response of sensory organs used.

Microscopic study

For the Microscopical study, the powdered plant materials were mounted in water and safranin on clean slides and observed under the microscope for various characteristics in fragmented form using a binocular microscope (LaboMed vision 2000).

Determination of physical characteristics of powder

Bulk density

Bulk density is interpreted as powder aerated and allowed to settle gently. It is the ratio between the given value of mass and untapped volume. The powdered sample (15 g) was transferred into a 100 ml cylinder. The initial volume was noted, and the ratio of the occupied weight of volume was computed by the following standard formula (60, 61).

$$\text{Bulk density} = W/V_0$$

Where, W = powder mass V_0 = untapped volume.

Tapped density

Tapped density was calculated by pouring 15 g of powdered sample into a measuring cylinder and tapped manually for approximately 500 times. The volume before and after tapping was noted (60, 61). The tapped density was calculated by the following standard formula (60).

$$\text{Tapped density} = W/V_f$$

Where, W = mass of the powder V_f = tapped volume.

Carr's index

This is the tendency of the powder to be compressed depending upon the apparent bulk and tapped density (59, 60). The standard formula for calculating Carr's index was adopted as per standard methodology (46) and is expressed in percentage as.

$$\text{Carr's index} = (\text{Tapped density} - \text{Bulk density})/\text{Tapped density} \times 100$$

Hausner's ratio

Hausner's ratio determines the flow properties of the powder. It is the ratio of tapped density to the bulk density of powder (60, 61).

$$\text{Hausner's ratio} = \text{Tapped density}/\text{Bulk density}$$

Angle of repose

The angle of repose is defined as the maximum angle probable between the powder pile and the horizontal plane. The powder was allowed to pass through a funnel (mouth diameter 100 mm and stem diameter 10 mm) which is fixed on the tripod stand at the height of 2.9 cm. Graph paper was placed below the tripod on the table, and the height and radius of the pile were measured (59, 60). The formula (60) used for the calculation is

$$\text{Angle of repose} = \tan^{-1} h/r$$

Where, h=height of the pile, r = radius of the pile.

Qualitative phytochemical investigation

The plant samples were phytochemically evaluated for the presence or absence of carbohydrates (Benedict's test, Molisch's test, and Fehling's test), alkaloids (Dragendorff's test), phenolics (Lead acetate test and $FeCl_3$ test), amino acids (Millon's test), and triterpenoids (Salkowski's test) according to the standard procedure (62, 63).

Qualitative estimation of heavy metals

The standard procedure (64) was followed to qualitatively determine the occurrence of heavy metals like cadmium, lead and bismuth in different plant parts. It is evaluated to know the safe use of plants. .

Results and Discussion

Preliminary phytochemical screening

All the 9 plant extracts showed the presence of alkaloids and carbohydrates (Table 2). However, alkaloid was reported to be absent in the preliminary phytochemical screening of *S. occidentalis* (65). Phenols were present in *D. cordata*, *H. sibthorpioides*, *S. japonica, S. occidentalis*. While Amino acids were absent in *S. japonica*, *O. indicum, A. scholaris*, *D. cordata, C. asiatica* and *H. sibthorpioides*. Triterpenoids were not found in any of the plant extracts. Recently, the presence of secondary metabolites has also been reported in *C. asiatica and O. indicum* (66, 67) respectively. It is a known fact that the possible medicinal properties of plants are because of the presence of secondary metabolites such as alkaloids, phenols, amino acids, carbohydrates, triterpenoids and many more (68). Thus, screening of secondary metabolites is the vital step in developing a drug from the potential medicinal plants, though the phytochemical constituents vary qualitatively and quantitatively with seasons and different kind of species and even depending on storage (69).

Table 2. Preliminary phytochemical screening of various plant parts under study

Tests performed	*S. japonica*	*O. indicum*	*A. scholaris*	*D. cordata*	*S. occidentalis*	*S. indicum*	*C. asiatica*	*H. sibthorpioides*	*S. hirsuta*
Benedict's test (Carbohydrate)	Green	Brick red	Brick red	Brick red	Green	Green	Orange	Orange	Green
Molisch's test (Carbohydrate)	Violet ring	Violet ring	Violet ring	Violet ring	Violet ring	Violet ring	Violet ring	Violet ring	Violet ring
Fehling's test (Carbohydrate)	+	++	+++	+++	++	+	+++	+++	+
Dragendorff's test (Alkaloids)	++	++	++	++	++	+	++	++	++
Lead acetate test (Phenolic test)	White ppt	White ppt	White ppt	White ppt	White ppt	White ppt	White ppt	White ppt	White ppt
$FeCl_3$ test (Phenolic test)	Blue	Green	Green	Violet	Blue	Green	Green	Violet	Green
Millon's test (amino acid test)	ND	ND	ND	ND	Red ppt	Red ppt	ND	ND	Red ppt
Salkowski's test (Triterpenoids test)	ND	ND	ND	ND	ND	ND	ND	ND	ND

+= Low, ++= Moderate; +++= High, Brick Red=High, Orange=Moderate, Green (Benedict's test)=Traceable; White ppt= presence of phenols, Red ppt= presence of Amino acids, Green ($FeCl_3$)= Catechol, Violet and Blue= Phenols, ND= Not detected

Organoleptic parameters

The powdered samples were physically evaluated using sensory organs for their colour, taste, texture and odour and are presented in Table 3. The colour was in the shades of brown for all, except for *O. indicum* powder which was dandelion (shade of yellow). The intensity of taste ranged from strong to slight bitter in *S. japonica*, *A. scholaris*, *S. indicum*, *O. indicum* and *S. hirsuta.* Astringent taste was detected in *D. cordata* and *S. occidentalis* while *C. asiatica* and *H. sibthorpioides* had a pungent taste. The organoleptic analysis resulted in different odours such as characteristics, woody, grassy, barnyard and sweet in nature, as mentioned for various powdered plant parts (Table 3). In terms of texture, all the powders were of moderate to fine quality except for *D. cordata* (whole plant), which was soft spongy. Organoleptic data, when deviating from the standard observation, suggest adulteration or bad quality of powder (70). Organoleptic analysis revealed that the plant was free from foreign materials and had acceptable sensory characteristics.

Powder microscopy

A microscopic study of powders revealed the occurrence of many features, as illustrated in Fig. 1, 2 and 3. The tuber of *S. japonica* showed the presence of acicular crystal, epidermal cell, fibre and xylem vessel. The powdered stem bark of *O. indicum* displayed acicular crystal, fibres, stone cell, tracheid and trichome. Calcium oxalate crystal, stone cell and fibre were observed in the stem bark powder of *A. scholaris*. The whole plant powder of *D. cordata* showed the presence of fibre, parenchyma cell, sclerenchyma cell and stone cell. The powdered form of leaf of *S. occidentalis* exhibited the presence of stomata, fibre, parenchyma cell and trichome. The roots powder of *S. indicum* revealed the presence of trichome, parenchyma cell, fibre and annular vessel. Fibre, trichome and stomata were observed in the whole plant powder of *C. asiatica*. The whole plant powder of *H. sibthorpioides* showed the presence of fibre, stomata, trichome and hair. *S. hirsuta* powdered leaf revealed the presence of trichome, pitted vessel and stomata. Similar to organoleptic analysis, microscopical evaluation helps us to ascertain the presence or absence of any foreign matters or adulterants (5). The supporting tissue,

Table 3. Organoleptic properties of powdered plants part under study

Plant Species	Characteristics			
	Colour	**Taste**	**Odour**	**Texture**
S. japonica	Brown (584520)	Bitter	Soil type	Fine powder
O. indicum	Dandelion (fbc969)	Slight bitter	Pungent	Moderately fine powder
A. scholaris	Chaimpagne brown (fad6a5)	Strong bitter	Woody	Moderately fine powder
D. cordata	Chamomile brown (dac395)	Astringent	Grassy	Soft spongy
S. occidentalis	Wood brown (Ci9a6b)	Slight astringent	Barnyard	Fine powder
S. indicum	Wheat brown (f5deb3)	Bitter	Woody	Moderately fine powder
C. asiatica	Bird seed brown (e2c28e)	Pungent	Sweet	Moderately fine powder
H. sibthorpioides	Khaki brown (c3b091)	Pungent	Sweet	Moderately fine powder
S. hirsuta	Brown bear (7f6244)	Slight bitter	Grassy	Fine powder

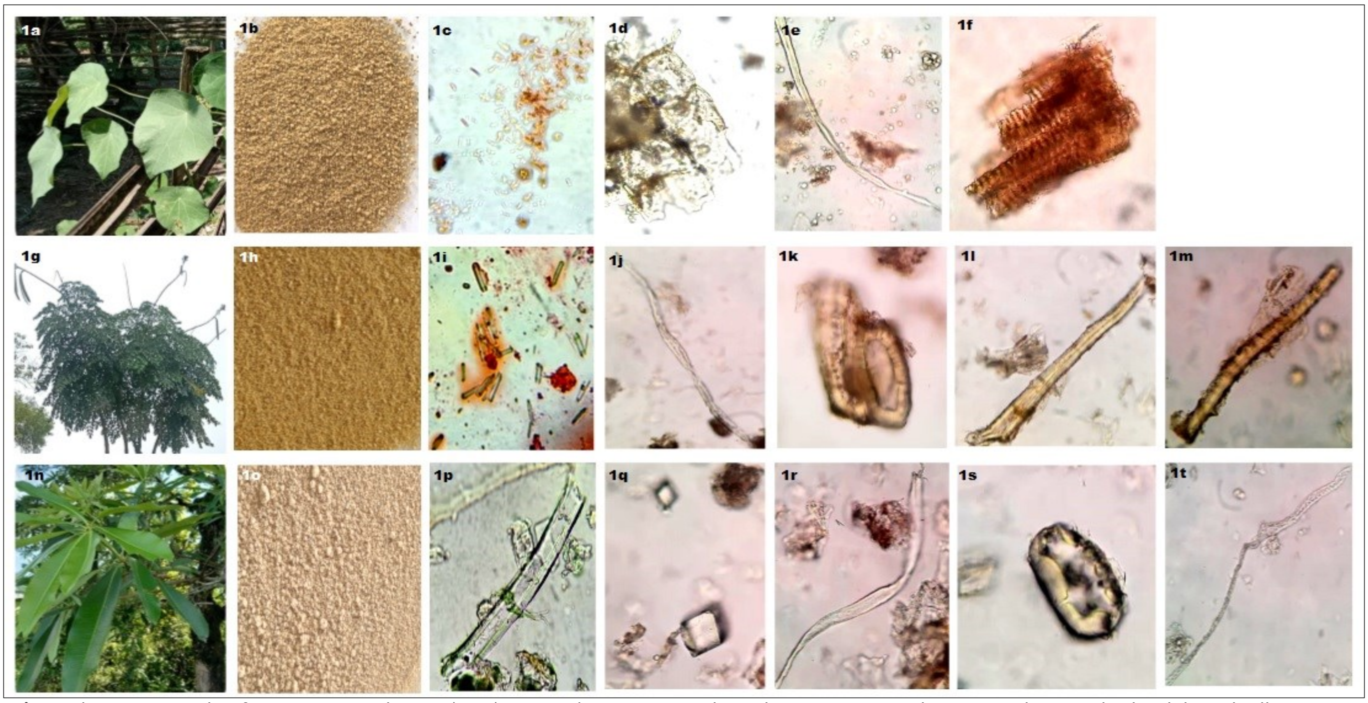

Fig. 1. Photomicrographs of microscopic evaluation (400x). 1a. *Stephania japonica* plant, 1b. *S. japonica* powder, 1c. Acicular crystal, 1d. Eplidermal cell, 1e. Fibre, 1f. Xylem vessel, 1g. *Oroxylum indicum* tree, 1h. *O. indicum* bark powder, 1i. Acicular vessel, 1j, Fibre, 1k. Stone cell, 1l. Tracheid, 1m. Trichome, 1n. *Alstonia scholaris* tree, 1o. *A. scholaris* bark powder, 1p. Fibre, 1q. Calcium oxalate crystal, 1r. Fibre, 1s. Stone cell, 1t. Tracheid

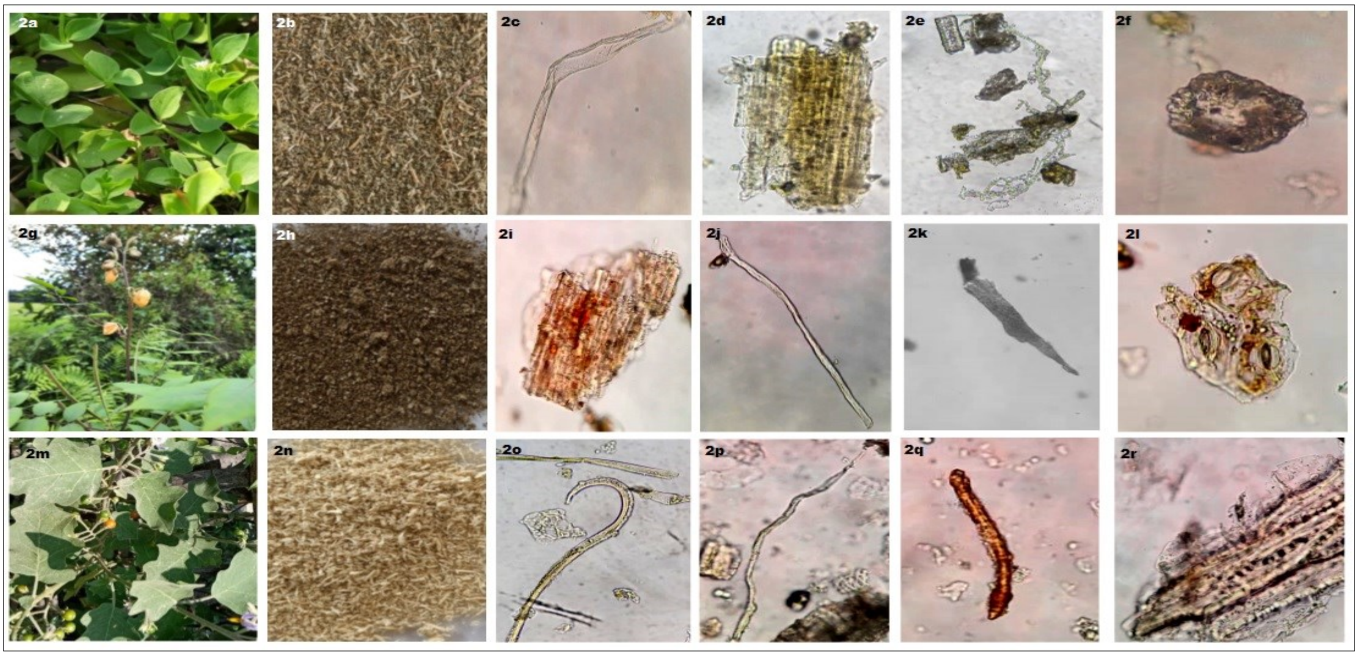

Fig. 2. Photomicrographs of microscopic evaluation (400x). 2a. *Drymaria cordata* plant, 2b. *D. cordata* whole plant powder, 2c. Fibre, 2d. Parenchyma cell, 2e. Sclerenchyma cell, 2f. Stone cell, 2g. *Senna occidentalis* plant, 2h. *S. occidentalis* leaf powder, 2i. Parenchyma cell, 2j. Fibre, 2k. Trichome, 2l. Stomata, 2m. *Solanum indicum* plant, 2n. *S. indicum* powder, 2o. Annular vessel, 2p. Fibre, 2q. Trichome, 2r. Xylem vessel.

Fig. 3. Photomicrographs of microscopic evaluation (400x). 3a. *Centella asiatica* plant, 3b. *C. asiatica* whole plant powder, 3c. Fibre, 3d. Stomata, 3e. Fibre, 3f. Trichome, 3g. *Hydrocotyle sibthorpioides* plant, 3h. *H. sibthorpioides* whole plant powder, 3i. Fibre, 3j. Stomata, 3k. Trichome, 3l. Hair, 3m. *Senna hirsuta* plant, 3n. *S. hirsuta* leaf powder, 3o. Trichome, 3p. Pitted vessel, 3q. Stomata.

i.e. fibre provides mechanical support (71), was seen in all the plant samples except *S. hirsuta*. The trichomes or hairs are mainly responsible for providing protection against pathogens in addition to regulating temperature by reducing evaporation (72) whereas, stomata is associated with gaseous exchange (5).

Reports are on (73) the microscopic evaluation of powdered stem bark of *O. indicum* and found the acicular crystal, fibres, stone cell, along with other characteristics. However, the presence of tracheid and trichome were reported for the first time. Reports are on (74) the presence of trichome and stomata in *C. asiatica* fresh leaves similar to our study in powdered form.

Flow ability

The flow property of the prepared powders was evaluated using simple procedures such as bulk density, tapped density, angle of repose, Hausner's ratio and Carr's index. The angle of repose of *A. scholaris* and *D. cordata* was found to be in the range of 34.30±0.50 and 34.62±0.31 respectively, which signifies the good flow of granules; the value of Carr's index was observed in the range of 23.68±0.070 and 19.05±0.025 indicating poor and fair compressibility of granules. Hausner's ratio was found to be in the range of 1.31±0.005 and 1.24±0.010, indicating passable and fair flow properties as shown in Table 4. The angle of repose and Hausner's ratio of *S. hirsuta* was found to be fair flow with 38.09±0.50 and 1.29±0.010 respectively and the compressibility was found to be slightly poor. The flow and compressibility properties of other plants were moderate. However, there was no data available for comparison in the case of the plants under study. Previously, there has been no test conducted to compare the flow properties and compressibility of these nine plant species. The insight of flow properties of powder enables pharmaceutical industries to operate smoothly by taking consideration during the processes such as filling, packaging, mixing and transportation (76).

Table 4. Physical characteristics of the powder of different plant parts

Plat Species	Angle of repose	Bulk density (g/mL)	Tapped density (g/mL)	Hausner's ratio	Carr's index
Alstonia scholaris	34.30±0.50	0.39±0.035	0.52±0.010	1.31±0.005	23.68±0.070
Centella asiatica	37.35±0.15	0.25±0.015	0.29±0.020	1.18±0.005	15.00±0.050
Drymaria cordata	34.62±0.31	0.24±0.005	0.29±0.010	1.24±0.010	19.05±0.025
Hydrocotyle sibthorpioides	35.27±0.29	0.28±0.020	0.38±0.005	1.36±0.010	26.42±0.100
Oroxylum indicum	35.94±0.47	0.22±0.010	0.30±0.005	1.34±0.005	25.37±0.050
Senna hirsuta	38.09±0.50	0.15±0.005	0.19±0.010	1.29±0.010	22.33±0.050
Senna occidentalis	36.28±0.14	0.19±0.020	0.25±0.005	1.31±0.010	23.75±0.025
Solanum indicum	35.94±0.47	0.25±0.005	0.30±0.005	1.22±0.010	18.03±0.100
Stephania japonica	35.27±0.39	0.45±0.010	0.60±0.005	1.32±0.005	24.24±0.100

Angle of repose= 30–40 Passable (79); Hausner's ratio= 1.12–1.18 (Good), 1.19–1.25 Fair, 1.26–1.34 (Passable) and 1.35–1.45 (Poor) (80)
Carr's index= 12–16 (Good), 18–31 (Fair to Passable) (79).

Heavy metal test

Heavy metal contaminations with herbal medicines beyond the safety level affect our health (77). Heavy metal is known for bioaccumulation in humans because of its non-degradable property (78). In the present study, there was no contamination of cadmium, bismuth and lead (Table 5) in any of the plants, which indicates that the prepared powders are safe to use in the formulation of drugs.

Table 5. Determination of heavy metals in plant parts

Sample solution	Procedure	Heavy metals					
		Cadmium (Cd)	Cadmium (Cd)	Bismuth (Bi)	Bismuth (Bi)	Lead (Pb)	Lead (Pb)
		Sample solution + NH_4OH	Sample solution + Potassium Ferrocyanide	Sample solution + NH_4OH	Sample solution + H_2S	Sample solution + Dil HCl	Sample solution + KI
Stephania japonica	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Oroxylum indicum	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Alstonia scholaris	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Drymaria cordata	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Senna occidentalis	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Solanum indicum	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Centella asiatica	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Hydrocotyle sibthorpioides	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent
Senna hirsuta	Observation	No white ppt.	No white ppt.	No white ppt.	No dark brown ppt.	No white ppt.	No yellow ppt.
	Inference	Absent	Absent	Absent	Absent	Absent	Absent

of capsule or tablet. Most of the plants included in this study are evaluated for the first time for the above parameters. Though, the evaluation procedures used here are simple and inexpensive but this knowledge of standardisation could help the society whenever traditional medicine is used as a source of cure. It rightly can be state that the plants here are clearly potential candidate for medicinal uses. Thus, the present study may serve as a standard reference for the quality control analysis of the herbal drug either singly or in synergy.

Conclusion

Mother Nature has blessed us with medicinal plants that are known fact, and now responsibilities are vested upon researcher to promote healthy life in the society by validation of the traditional knowledge. Pharmacognosy mainly unveils the therapeutic potential of plants in the management of diseases. Standardisation of herbal drugs draws attention of researchers due to its vast sources with high variables. These reasons motivated us to characterize nine indigenous medicinal plants on the basis of phytochemicals (qualitative), organoleptic, microscopy, flow characteristics and heavy metals parameters. The presence of various phytochemical constituents in the different plants parts under study reveals that they have therapeutic potentials. The authentication of the plant species can be achieved by the organoleptic and micro-morphological features, whereas the flow properties is essential in pharmaceutical industry to obtain finished products in the form

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Authors contributions

AKG conceptualized and designed the study. BM, SB and MK carried out the research work and acquired the data. All the authors analyzed the data and wrote the first draft of the manuscript. Finally all the authors edited the manuscript and approved the final version for submission.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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