



Received on 03 March 2021; received in revised form, 28 March 2021; accepted, 30 March 2021; published 31 March 2021

## BOTANICAL STUDIES ON RAW HERBAL SAMPLES OF *WOODFORDIA FRUTICOSA* (L.) KURZ- AN IMPORTANT AYURVEDIC PLANT

Pankaj Kumar<sup>1,2</sup>, Kanwaljeet Singh<sup>1</sup>, Zohra Batool<sup>1,2</sup>, Javaid Fayaz Lone<sup>1,2</sup> and Sumeet Gairola<sup>1,\*2</sup>

Plant Science Division<sup>1</sup>, CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu - 180001, Jammu and Kashmir, India

Academy of Scientific and Innovative Research (AcSIR)<sup>2</sup>, Ghaziabad - 201002, Uttar Pradesh, India.

### Keywords:

Dried raw herbal sample,  
Identification problem, Macroscopic  
and Microscopic characterization,  
Reference standards.

### Correspondence to Author:

**Sumeet Gairola**

Senior Scientist,  
Plant Science Division, CSIR-Indian  
Institute of Integrative Medicine,  
Canal Road, Jammu - 180001, Jammu  
and Kashmir, India.

**E-mail:** sumeetgairola@iiim.res.in

**ABSTRACT:** Raw herbal samples used in the herbal medicine industry need to be properly identified for use in an herbal preparation. Plant parts of *Woodfordia fruticosa* (L.) Kurz belonging to the Lythraceae family, apart from some commercial uses, is known for its medicinal value in ethno medicines and various Indian traditional medicine systems, including Ayurveda. Flowers are reported high trade value (2000-5000 MT), are used in some Ayurvedic formulations such as Atisara, Raktapitta, Trsna, Vrana, Visarpa, Arjunarishta (Parthadyarishta), and Partharishtam. The present study aimed at botanical characterization and identification of raw leaf, flower, and stem bark herbal samples of *Woodfordia fruticosa*. Macroscopic and microscopic characters were studied using stereomicroscope and compound microscope. The morpho-anatomical description was provided for flower, leaf, and stem bark samples. Anatomical study of a leaf with a crescent-shaped vascular bundle, three different types of trichomes, and bark with linearly arranged rosette crystals crossing uniseriate medullary rays longitudinally were observed as characteristic features. Powder organoleptic and microscopic characters were described for each studied herbal sample. Characters compiled in the present study can be used as reference standards for future identification of raw leaf, flower, and stem bark samples of *Woodfordia fruticosa*.

**INTRODUCTION:** *Woodfordia fruticosa* (L.) Kurz belonging to the family Lythraceae, occurs in tropical and subtropical parts throughout India, especially in the Himalayas and Gangetic plains up to an altitude of 1500 m asl; and also cultivated in gardens<sup>1,2</sup>. It is commonly known as Fire flame bush, Dhavi, Dhaatkikephool, Shiranjitea, Thawi, and several other names<sup>3</sup>.

Trade names of flower samples are Dhaiphool, Dhavadiphool, Dhataki; and are reported with a high annual trade value of 2000-5000 metric tonnes in Indian herbal market<sup>4</sup>. Commercially, flowers known to yield a red dye used to color silks<sup>3</sup>.

Leaves are reported to yield pink and red dye (due to the presence of Lawsone, 2-hydroxy naphthoquinone)<sup>5</sup>, milk enhancement in livestock<sup>6</sup> and also in perfume, leather, and textile industries<sup>7</sup>. Different plant parts of *W. fruticosa* especially flowers, stem bark, and leaves are reported with medicinal importance. Flowers known used as astringent, antipyretic, appetizer, blood purifier, used in dysentery, diarrhea, leucorrhoea, skin problems, fever, asthma, liver disorder,

	<p><b>QUICK RESPONSE CODE</b></p>
	<p><b>DOI:</b> 10.13040/IJPSR.0975-8232.IJP.8(3).129-37</p>
<p>The article can be accessed online on <a href="http://www.ijpjournal.com">www.ijpjournal.com</a></p>	
<p><b>DOI link:</b> <a href="http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.8(3).129-37">http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.8(3).129-37</a></p>	

rheumatism, menorrhagia, and inflammatory conditions<sup>8-13</sup>. Flowers are known to have antibacterial<sup>14, 15</sup>, antiviral (antiEV71)<sup>16</sup>, hepatoprotective<sup>17, 18</sup>, immunomodulatory<sup>19</sup>, antihyperglycemic<sup>20</sup>, antifertility<sup>21</sup>, antitumor activity<sup>22</sup>, cytotoxicity, anti-inflammatory, and analgesic properties<sup>23</sup>. Flowers of *W. fruticosa* are known used in Ayurvedic formulations including Arjunarishta (Parthadyarishta)<sup>24</sup>, in Ayurvedic drug 'Partharishtam',<sup>25</sup> and other Ayurvedic formulations including Atisara, Raktapitta, Trsna, Vrana, Visarpa and known with therapeutic uses of Atisara, Raktapitta, Trsna, Vrana, Visarpa<sup>2</sup>. Flowers are the key ingredient used in the alcoholic preparation of "Asavas-Arishtas"<sup>26</sup>. Several species of yeast (such as *Pichia anomola*, *Aspergillus niger*, and *Saccharomyces cerevisiae*, etc. have been reported from *W. fruticosa*<sup>27, 28</sup>. Stem bark was reported used in jaundice<sup>29</sup>, diarrhoea<sup>30</sup>. Leaves are used as disinfectant<sup>31, 32</sup>, used in fever<sup>15, 33</sup>, rheumatism<sup>34</sup>, hemoptysis<sup>35</sup>, ulcers<sup>36</sup>, and in gall bladder problems<sup>12</sup>. Leaves are known to have anti-microbial compounds<sup>37</sup>, stem bark with analgesic activity<sup>38</sup>; leaves and stem bark with antibacterial<sup>39</sup> and antidiabetic activity<sup>40</sup>.

Various parts of *W. fruticosa* are reported to have tannins, such as in bark (20-27% tannins), flowers (24.1% tannins), and leaves (12-20% tannins)<sup>41</sup>. Chemically, leaves are known to have flavonoids<sup>42</sup>, essential oil<sup>43</sup>, and phenolic compounds<sup>44, 45</sup>. Leaves and flowers are known to have polyphenols<sup>46</sup>, flowers have tannins, phytophenols, anthocyanins<sup>47</sup> and Woodfordina ABC (tannins)<sup>48</sup>, bark with C-glucoside and bergenin<sup>9</sup>. In the herbal drug industry, proper identification and authentication of raw herbal samples are essential to ensure the quality, safety, and efficacy of herbal medicines<sup>49-51</sup>. Several pharmacopeia monographs are known to use macro-morphological and organoleptic characters of herbal drugs in the correct identification of species<sup>52</sup>. Botanical identification methods are considered as simple, easy, time, and cost-effective methods in the correct identification of raw herbal drugs<sup>53-54</sup>.

The present study involved detailed qualitative and quantitative characterization of macroscopic and microscopic features of the leaf, stem bark, and flower samples. Botanical characters compiled in the present study can be used as reference standards

for future identification of raw herbal samples of *Woodfordia fruticosa* used in herbal medicines preparations.

**MATERIAL AND METHODS:** Plant material was collected from two different locations of the U.T. of J&K's **Table 1**. Plant material was collected for herbarium sheet preparation, for raw crude herbal samples, and for botanical studies. Herbarium sheets were prepared following standard herbarium procedures<sup>55</sup>. Duly identified herbarium sheets were submitted to internationally recognized Janaki Ammal Herbarium (RRLH) at the Indian Institute of Integrative Medicine (CSIR-IIIM), Jammu. Oven-dried raw herbal samples (of flowers, stem bark, and leaves) were submitted to the Crude Drug Repository at CSIR-IIIM Jammu. Herbarium and crude drug accession numbers have been provided in **Table 1**.

In botanical studies, macroscopic and microscopic characters of flower, stem bark, and leaves were studied using stereo-microscope (LEICA S9i) and compound microscope. For anatomical studies, transverse sections (T.S.) of leaf and stem bark samples were obtained by freehand sectioning using a razor blade. Obtained fine sections were stained according to Kumar et al.,<sup>56</sup> with some modifications. Thin T.S. were dehydrated in different series of alcohol gradients (30%, 50%, and 70% alcohol, each for 10-15 min), stained in safranin (5-7 min), decolorized in 70% alcohol (5-10 min), staining in fast green (2-3 min) and then were again decolorized in 70% alcohol for 5-10 min. The sections were dehydrated in 90% alcohol followed by absolute alcohol (each for 5-7 min), mounted in Canada balsam, and observed under a compound microscope (Leica DM 750) with an associated camera (LEICA ICC50E). All micrometric measurements were performed by LEICA LAS V 4.9.0 software. For powder study, samples were crushed to a powder, passed through a fine sieve, and studied in water-mounted slides under a compound microscope. An iodine test was performed to detect the presence of starch grains in powder samples. Organoleptic characters of leaf flower and stem bark samples were also noted.

## RESULTS:

**Botanical Description:** The plant is bushy, spreading, semi-deciduous, perennial, under shrub

or shrub, 1-3 m high, growing on rocky, dry areas in hilly areas **Fig. 1A**. Plants bear several bright red flowers in axillary clusters along the branches and twigs.

### Morphological Characters:

**Leaf and Flower:** Leaves are ovate-lanceolate to ovate, opposite or sub opposite, 8-12 × 2.4-3.5 cm, whitish and tomentose abaxially, texture leathery, margin smooth, base subcordate, apex pointed and slightly curved, petiole nearly absent **Fig. 1L**. Flowers bright red colored, axillary, present in paniculate-cymose clusters (of 3-15 flowers) **Fig. 1B, C**, dried flowers dull red **Fig. 1J**, with short pedicels (0.4-0.6 cm) **Fig. 1D**. Flower buds with 6 angular protrusions, mature flower actinomorphic (appear slightly zygomorphic) with tubular corolla (16-20 mm long, 1.6-2.7 mm thick); sepals and petals six in number, sepals triangular-shaped, small tooth-like protrusions (0.9-1.2 mm), petals are narrowly linear slightly longer than the calyx-teeth (2.5-3.5 mm) **Fig. 1F, G**. Stamens are 12 in number, 0.8-1.4 cm, epipetalous, inserted little above ovary base **Fig. 1E**. Pistil size ranged from 1.6-1.9 cm, stigma bifid **Fig. 1H**, ovary bilocular, anthers versatile **Fig. 1I**. Anthers fall off easily from the filament in dried flower samples **Fig. 1D, E**, and **2C**.

**Stem Bark:** The bark is thin (0.5 cm or more in thickness), smooth, reddish-brown colored, freshly peeled bark dark brown on the outer side and light creamy colored on the inner side. Bark surface observed with transverse and longitudinal cracks, peeling off in flakes (near the base of the stem) and in thin and fibrous strips (middle stem region) become curved on drying **Fig. 1K**. Dried bark samples are irregularly curved **Fig. 1K** with the outer surface dark brown colored and inner surface reddish-grey colored.

### Microscopic Characters:

**Flower:** Cut view of flower showed superior and bilocular ovary (0.5-0.65 cm), with several rounded to oval ovules **Fig. 2C, F**, style elongated (0.9-1.2 cm), bifid stigma **Fig. 1H**, and with versatile anthers **Fig. 1I**.

**Stem Bark:** T.S. of bark showed outer flaky, thin cork zone ( $81.08 \pm 6.45 \mu\text{m}$ ) with compactly packed cells. Cork zone followed by a broad parenchymatous secondary cortex zone ( $166.66 \pm$

$12.43 \mu\text{m}$ ) with oval to slightly transversally elongated thick-walled cells. Cortex followed by a continuous thick phloem zone with phloem cells interspersed in cortex cells. Phloem formed a major part (thickness of  $630.59 \pm 17.06 \mu\text{m}$ ) in studied cross-section of bark (of a total thickness of  $788.64 \pm 5.83 \mu\text{m}$ ). Phloem comprised of oval-shaped cells interspersed with vertical medullary rays.

Phloem cells observed with several rosette crystals arranged in a transverse parallel row-like pattern. Medullary rays were nearly uniseriate on the inner phloem and showed dilatation growth (up to 4-10 cells wide) in the outer phloem near the cortical region. The inner zone of the phloem was comprised of the phloem fiber zone, followed by the xylem region consisting of well distinct xylem fibers and vessels **Fig. 2A, D**. Quantitative microscopic characters are shown in **Table 2** and **3**.

Transverse section of leaf blade (from midrib region) showed typical dicot leaf anatomy with central midrib region (with a notch in the center) and wing-like extended lamina region **Fig. 2B**. The Lamina region consisted of a single-layered, cuticularised upper epidermis with rectangular-shaped cells. Lamina epidermis consisted of few oval-shaped glandular trichomes and few curved, pointed trichomes with a broad base and abruptly tapering tip **Fig. 2E**. Epidermis followed by palisade layer with compactly packed elongated cells, then by spongy parenchyma zone. The lower epidermis region consisted of several uniformly thickened curved trichomes. The Midrib region consisted of a single-layered cuticularised epidermis followed by an inner collenchymatous patch and then by a broad parenchymatous tissue zone. The vascular zone was crescent-shaped with well distinguishable xylem facing the upper epidermis, followed by a less distinct phloem zone sheathed by a well-differentiated continuous sclerenchymatous zone. Xylem vessels were present in linear rows with comparatively broader vessel lumen diameter towards the abaxial side than the adaxial side. The vascular zone was followed by a broad parenchymatous zone (8-10 cell wide) with rosette crystals in some cells, an inner 2-3 cell wide collenchymatous tissue zone, and a single-layered lower epidermis. Quantitative microscopic characters are shown in **Table 4**.



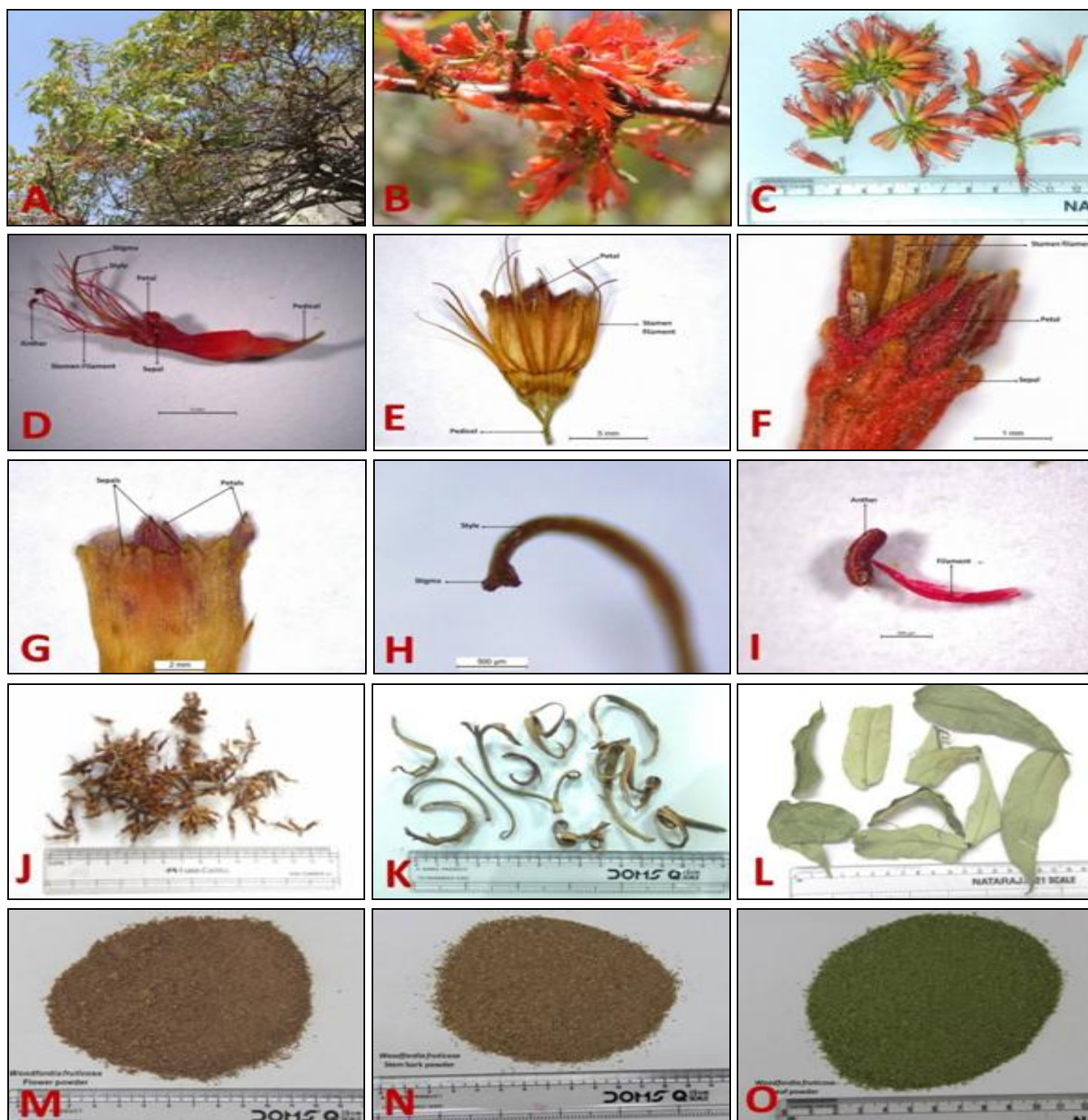


FIG. 1: MORPHOLOGICAL STUDIES ON RAW HERBAL SAMPLES OF *W. FRUTICOSA*, A). PLANT HABIT, B). FLOWERS CLUSTER ON THE PLANT, C). FRESH RAW FLOWER SAMPLES, D). SINGLE FLOWER MORPHOLOGY, E). THE FLOWER OPENED (SHOWING STAMEN ATTACHMENT TO FLOWER TUBE), F). FLOWER PART SHOWING SEPALS, PETALS, AND STAMEN FILAMENTS, G). SEPAL, PETAL MORPHOLOGY AND FLOWER TUBE, H). STIGMA MORPHOLOGY, I). ANTHOR MORPHOLOGY, J). DRIED FLOWER SAMPLES, K). DRIED STEM BARK SAMPLES, L). DRIED LEAF SAMPLES, M). FLOWER POWDER SAMPLE, N). STEM BARK POWDER SAMPLE, O). LEAF POWDER SAMPLE

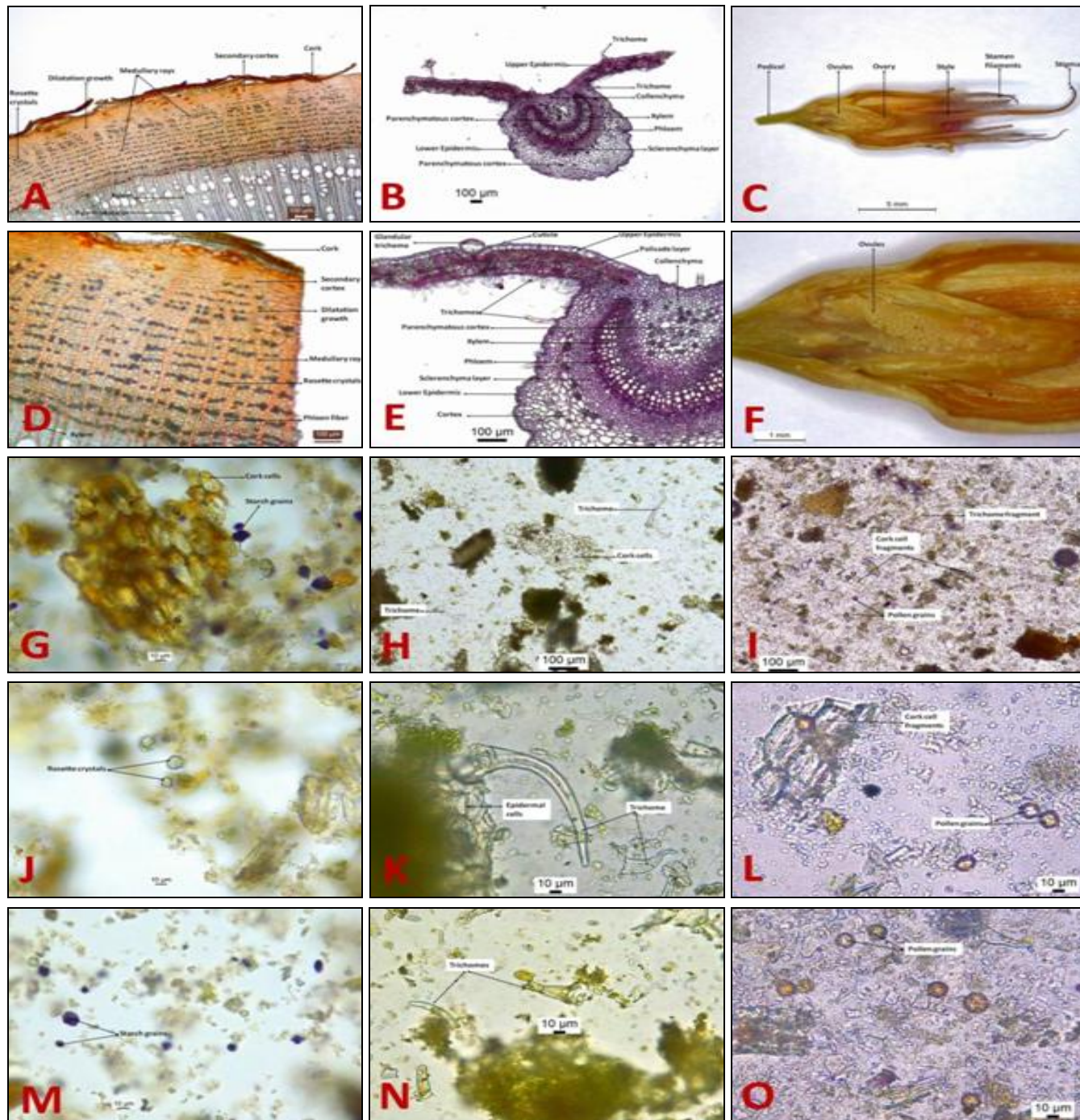
**Powder Study:** Organoleptic features including color, odor, texture, and taste of each drug sample (flower, stem bark, and leaf samples) were observed characteristic. Organoleptic characters of flower leaf and stem bark samples are provided in **Table 1**. A microscopic study of powder samples was observed with characteristic features for each

drug type. Microscopic powder study of leaf samples was observed with cork cell fragments, non-glandular trichomes, few golden yellow fragments, and few rosette crystals; flower samples with few cork cells, several rounded pollen grains (mean size of  $17.64 \pm 0.21 \times 16.88 \pm 0.27 \mu\text{m}$ ), a few unicellular trichomes, few cork cells, and few



prismatic crystals. Microscopic powder study of stem bark sample was observed with cork cell fragments, starch grains (mean size of  $12.18 \pm 0.74 \times 9.71 \pm 0.47 \mu\text{m}$ ), and rosette crystals (mean size of  $14.58 \pm 0.96 \times 12.46 \pm 0.84 \mu\text{m}$ ). Iodine test revealed abundant starch grains in stem bark

powder sample while starch was not detected in leaf and flower powder sample. The mean size and range of starch grains, rosette crystals, and pollen grains in studied powder samples are shown in **Table 3** and **4**.



**FIG. 2: MICROSCOPIC STUDIES ON RAW HERBAL SAMPLES OF *W. FRUTICOSA*, A). PLANT HABIT, B). FLOWERS CLUSTER ON THE PLANT, C). FRESH RAW FLOWER SAMPLES, D). SINGLE FLOWER MORPHOLOGY, E). THE FLOWER OPENED (SHOWING STAMEN ATTACHMENT TO FLOWER TUBE), F). FLOWER PART SHOWING SEPALS, PETALS, AND STAMEN FILAMENTS, G). SEPAL, PETAL MORPHOLOGY AND FLOWER TUBE, H). STIGMA MORPHOLOGY, I). ANTHOR MORPHOLOGY, J). DRIED FLOWER SAMPLES, K). DRIED STEM BARK SAMPLES, L). DRIED LEAF SAMPLES, M). FLOWER POWDER SAMPLE, N). STEM BARK POWDER SAMPLE, O). LEAF POWDER SAMPLE**

**TABLE 1: COLLECTION DETAILS AND POWDER STUDIES OF DIFFERENT SAMPLES OF WOODFORDIA FRUTICOSA**

Collection details of plant samples			
	GPS location	Herbarium accession number	CDR accession number
Nandini WLS (J&K)	32°50.674N, 074°56.660E (529m asl)	23811	Flower (4174), Stem
Pallan (Billawar, J&K)	32°33.320N, 75°33.751E (633m asl)	23395	(4175 bark), Leaves (4220)
Powder organoleptic characters			
	Flower	Stem bark	Leaf
Colour	Soil like brown colored (Figure 1M)	Soil colored (Figure 1N)	Light green to creamish green (Figure 1O)
Odor	Slightly characteristic odor	No characteristic odor	Characteristic odor
texture	Slight granular	Sand like granular	Smooth to slightly rough
Taste	No characteristic taste	Slightly bitter with a rough mouthfeel	Characteristic, slightly bitter

**TABLE 2: QUANTITATIVE MICROSCOPIC CHARACTERS OF THE T.S. OF STEM BARK OF WOODFORDIA FRUTICOSA**

Character	Min	Max	Mean (±S.D.)
Stem bark (µm)			
T.S. thickness	746.49	818.49	788.64±5.83
Cork thickness	55.36	115.62	81.08±6.45
Cortex thickness	123.66	250.96	166.66±12.43
Phloem thickness	514.12	683.96	630.59±17.06
Intermedullary ray width	19.93	80.08	48.81±6.34

**TABLE 3: QUANTITATIVE MICROSCOPIC CHARACTERS OF STEM BARK OF WOODFORDIA FRUTICOSA**

	Min	Max	Mean (±S.D.)	Min	Max	Mean (±S.D.)
Stem bark cell size (µm)	Length			Breadth		
Cork	11.69	21.45	17.50±1.06	6.76	16.80	12.16±0.89
Cortex	21.07	43.13	30.08±2.07	9.03	16.36	13.20±0.69
Phloem parenchyma	12.33	22.47	16.07±1.00	10.14	13.65	11.99±0.43
Stem bark medullary ray	474.01	709.03	626.25±30.25	13.30	24.19	17.48±1.08
Starch grains	9.69	16.65	12.18±0.74	7.91	11.91	9.71±0.47
Rosette crystals	9.97	19.13	14.58±0.96	7.29	15.24	12.46±0.84

**TABLE 4: QUANTITATIVE MICROSCOPIC CHARACTERS OF FLOWER AND LEAF OF WOODFORDIA FRUTICOSA**

	Min	Max	Mean (±S.D.)	Min	Max	Mean (±S.D.)
Flower characters						
Pollen grains	Equatorial axis			Polar axis		
	16.56	18.57	17.64±0.21	15.63	18.07	16.88±0.27
Leaf characters						
	Length			Breadth		
Upper epidermis (midrib region)	5.85	9.09	7.17±0.32	3.24	6.42	5.08±0.39
Upper epidermis (lamina region)	14.22	23.85	18.66±1.05	12.47	24.5	17.37±1.36
Lower epidermis (midrib region)	5.29	9.87	7.12±0.45	4.86	7.93	6.77±0.30
Adaxial cortical cell size	11.69	24.1	18.48±1.16	8.36	17.31	13.10±0.91
Abaxial cortical cell size	16.26	45.36	26.97±3.21	12.34	34.20	19.99±2.81
Trichome (Curved)	25.10	94.24	50.32±6.88	8.86	18.65	11.66±1.13
Trichome (Straight)	42.42	181.72	79.94±16.22	17.93	43.88	29.65±2.22
Palisade thickness	59.10	73.45	65.28±1.60			
Xylem length	65.75	114.09	93.11±5.13			
Xylem vessel diameter	10.24	29.56	19.20±1.90			

**DISCUSSION:** Identification of entirely unknown raw herbal samples without a reference standard is considered problematic<sup>57</sup>. Detailed macroscopic and microscopic characterization, including qualitative and quantitative features, can be more useful in the identification of raw herbal samples<sup>54, 58</sup>. Macroscopic and microscopic characterization

has been performed in different types of herbal samples such as whole plant<sup>59</sup>, heartwood<sup>60</sup>, leaves<sup>61</sup>, root<sup>62</sup>, rhizome<sup>63</sup>, stem bark<sup>64</sup>, flowers<sup>26</sup>, etc. Botanical-based identification methods vary for different plant samples<sup>65</sup>. Anatomical characters have been used for the identification of raw leaf and bark drug samples in several species



<sup>66-68</sup>. Kotina et al., <sup>68</sup>, observed characters such as trichomes, sclereids, secretory canals, druse crystals, brown contents in parenchyma cells as diagnostic microscopic features in the identification and differentiation of raw leaf and bark herbal material from adulterant samples.

For identification of stem bark, macroscopic characters (such as shape, size, surface color, texture, etc.), microscopic features (of rhytidome, cork, cortex, ray dilation, sclereids in phelloderm, secondary phloem, phloem fibers, starch grains, the shape of crystals, stone cells, tannins, etc.) and powder features were known helpful in species characterization <sup>69-72</sup>.

In the present study, botanical identification studies with macroscopic, microscopic, and powder characterization were performed on the leaf, stem bark, and flower samples. Studies performed included descriptions of qualitative and quantitative macroscopic and microscopic botanical characters. Botanical studies with anatomical characterization have been done in some previous studies on leaf samples <sup>73</sup> and flower samples <sup>26, 74, 75</sup>. Leaf anatomical characters observed in the present study also corresponded with anatomical features studied by Birajdar et al., <sup>73</sup> In the microscopic study of flower powder of *W. fruticosa*, Baravalia et al., <sup>75</sup>, observed unicellular trichomes, rosette, and calcium oxalate crystals. However, in the present study, rosette crystals were not observed in flower powder microscopic study. Microscopic studies for stem bark samples were described for the first time in the present study. In the present study, the anatomical study of leaf samples revealed some characteristic features, including a notch in the central region of the midrib, crescent-shaped vascular bundle, varied types of trichomes (oval-shaped glandular trichomes; curved and straight non-glandular trichomes). Transverse section of stem bark was observed with uniseriate longitudinal medullary rays (with dilation growth near cortical region) and phloem parenchyma cells with rosette crystals in a transverse arrangement.

Powder study of stem bark was observed with few cork cell fragments, abundant oval to elongated starch grains, and rosette crystals. Starch grains were not detected in leaf and flower powder samples.

**CONCLUSION:** The present study involved detailed morphological, anatomical, and powder studies with qualitative and quantitative characterization for the raw leaf, flower, and stem bark samples of *W. fruticosa*. Some characteristic features of the leaf (crescent-shaped vascular bundles with rosette crystals in cortex cells), flower (macroscopic, microscopic features), and stem bark samples (characteristic arrangement of rosette crystals in phloem cells to uniseriate medullary rays) have been summarised in the present study. Botanical characters described in the present study can be used as a rapid reference identification standard for future identification of raw samples of *W. fruticosa* in fresh as well as dried form.

**ACKNOWLEDGEMENT:** The authors thank Director IIM Jammu for providing the necessary facilities to carry out the work. The authors are thankful to the Council of Scientific and Industrial Research (CSIR), Government of India, for financial assistance under the Phytopharmaceutical Mission (HCP-0010). PK acknowledges the financial support provided by CSIR in the form of JRF/SRF fellowships.

**CONFLICTS OF INTEREST:** No

## REFERENCES:

1. Kirtikar KR and Basu BD: Indian Medicinal Plants. Part 1-3, L.M. Basu, Allahabad, India. 1935.
2. API: The Ayurvedic Pharmacopoeia of India. Part-I, Vols, I to V. Government of India. Ministry of Health and Family Welfare, Department of AYUSH, India. 2001.
3. Kumar D, Sharma M, Sorout A, Saroha K and Verma S: *Woodfordia fruticosa* Kurz.: a review on its botany, chemistry and biological activities. Journal of Pharmacognosy and Phytochemistry 2016; 5(3): 293-98.
4. NMPB: Traded Medicinal Plant Database. <http://envis.frlht.org/traded-medicinal-plants-database.php> (accessed 28<sup>th</sup> July 2020). 2020.
5. Singh R and Srivastava S: A critical review on extraction of natural dyes from leaves. International Journal of Home Science 2017; 3(2): 100-103.
6. Salave AP and Reddy PG: Documentation of traditional knowledge on fodder uses by the native Inhabitants in Beed District (M.S.) India. Life Sci Leaflet 2012; 9: 24-34.
7. Gaur RD: Traditional dye yielding plants of Uttarakhand, India. Natural Product Radiance 2008; 7: 154-65.
8. Finose A and Devaki K: Phytochemical and Chromatographic studies in the flowers of *Woodfordia fruticosa* (L) Kurz. Asian J of Plant Sci and Research 2011; 1(3): 81-85.
9. Khare CP: Indian medicinal plants: An illustrated dictionary, Springer 2007.
10. Tambekar DH and Khante BS: Antibacterial properties of traditionally used medicinal plants for enteric infections by *Adivasi's* (bhumka) in Melghat forest (Amravati district).

- International Journal of Pharmaceutical Sciences and Research 2010; 1(9): 120-28.
11. Bhushan B and Kumar M: Ethnobotanically Important Medicinal Plants of Tehsil Billawar, District Kathua, J&K, India. *J of Pharm and Phytochemistry* 2013; 2(4): 14-21.
  12. Gairola S, Sharma J and Bedi YS: A cross-cultural analysis of Jammu, Kashmir and Ladakh (India) medicinal plant use. *J of Ethnopharmacology* 2014; 155: 925-86.
  13. Bhatia H, Sharma YP, Manhas RK and Kumar K: Ethnomedicinal plants used by the villagers of district Udhampur, J&K, India. *J of Ethnophar* 2014; 151: 1005-8.
  14. Parekh J and Chanda S: *In-vitro* antibacterial activity of the crude methanol extract of *Woodfordia fruticosa* kurz flower (Lythraceae). *Brazilian Journal of Microbiology* 2007; 38: 204-07.
  15. Kumaraswamy MV, Kavitha HU and Satish S: Antibacterial Potential of Extracts of *Woodfordia fruticosa* Kurz on Human Pathogens. *World Journal of Medical Sciences* 2008; 3(2): 93-96.
  16. Choi HJ, Song JH, Park KS and Baek SH: *In-vitro* anti-enterovirus 71 activity of gallic acid from *Woodfordia fruticosa* flowers. *Lett in App Microbiol* 2010; 50: 438-40.
  17. Chandan BK, Saxena AK, Shukla S, Sharma N, Gupta DK and Singh K: Hepatoprotective activity of *Woodfordia fruticosa* kurz flowers against Carbon tetrachloride induced hepatotoxicity. *Journal of Ethnopharmacology* 2008; 119: 218-24.
  18. Baravalia Y, Chanda S and Kaneria M: Hepatoprotective effect of *Woodfordia fruticosa* Kurz flowers. *Asian Pacific Journal of Tropical Medicine* 2011; 4: 673-79.
  19. Shah AS and Javekar AR: *In-vitro* and *In-vivo* immunostimulatory activity of *Woodfordia fruticosa* flowers on non specific immunity. *Pharmaceutical Biology* 2010; 48: 1053-58.
  20. Verma N, Amresh G, Sahu PK, Rao V and Singh AP: Antihyperglycemic activity of *Woodfordia fruticosa* Kurz flowers extracts in glucose metabolism and lipid peroxidation in streptozotocin induced diabetic rats. *Indian Journal of Experimental Biology* 2012; 50: 351-58.
  21. Kushlani H, Tatke P and Singh KK: Antifertility activity of dried flowers of *Woodfordia fruticosa* Kurz. *Indian Journal of Pharmaceutical Sciences* 2006; 68: 512-29.
  22. Yoshida T, Chou T, Nitta A, Miyamoto K, Koshiura R and Okuda T: Woodfordin C, a macro-ring hydrolysable tannin dimer with antitumor activity, and accompanying dimmers from *Woodfordia fruticosa* flowers. *Chemical and Pharmaceutical Bulletin* 1990; 38(5): 1211-17.
  23. Baravalia Y, Kumar YV and Chanda S: Brine shrimp cytotoxicity, anti inflammatory and analgesic properties of *Woodfordia fruticosa* kurz flowers. *Iranian Journal of Pharmaceutical Research* 2012; 11: 854-61.
  24. Singh H, Mishra SK and Pande M: Standardization of Arjunarishta formulation by TLC method. *International J of Pharma Sci Review and Research* 2010; 2(1): 25-28.
  25. Sadhanandham S, Narayanan G, Rao MRK, Prabhu K, Jones S, Ravi A and Dinakar S: GC-MS Analysis and Antioxidant studies of an Ayurvedic drug, Partharishtham. *International Journal of Pharmaceutical Sciences Review and Research* 2015; 34(2): 273-81.
  26. Admani M, Kumar KNS and Mallya SV: Pharmacognostic characterisation of flowers *Woodfordia fruticosa* Kurz. (Dhataki Pushpa) used as fermentation initiators. *Journal of Ayurvedic and Herbal Medicine* 2015; 1(1): 09-12.
  27. Vohra A and Satyanarayana T: A cost-effective cane molasses medium for enhanced cell-bound Phytase production by *Pichia anomala*. *Journal of Applied Microbiology* 2004; 97: 471-76.
  28. Manwar J, Mahadik K, Paradkar A, Sathiyarayanan L, Vohra M and Patil S: Isolation, biochemical and genetic characterizations of alcohol-producing yeasts from the flowers of *Woodfordia fruticosa*. *Journal of Young Pharmacists* 2013; 5(4): 191-94.
  29. Sharma J, Gairola S, Gaur RD and Painuli RM: The treatment of jaundice with medicinal plants in indigenous communities of the Sub-Himalayan region of Uttarakhand, India. *Journal of Ethnopharmacology* 2012; 143: 262-91.
  30. Das PK, Goswami S, Chinniah A, Panda N, Banerjee S, Sahu NP and Achari B: *Woodfordia fruticosa*: Traditional uses and recent findings. *J of Ethno* 2007; 110: 189-99.
  31. Khan AM, Qureshi RA, Gillani SA and Ullah F: Antimicrobial activity of selected medicinal plants of Margalla Hills, Islamabad, Pakistan. *Journal of Medicinal Plants Research* 2011; 5: 4665-70.
  32. Xavier F, Arun VR and Rose F: Ethnopharmacological studies on the medicinal plants used by tribal inhabitants of Meenagadi region in Wayanadu district of Kerala, South India. *International Journal of Medicinal Plants Research* 2012; 1: 58-62.
  33. Kaur R and Kaur H: The Antimicrobial activity of essential oil and plant extracts of *Woodfordia fruticosa*. *Archives of Applied Sciences Research* 2010; 2: 302-9.
  34. Jeyaprakash K, Ayyanar M, Geetha KN and Sekar T: Traditional uses of medicinal plants among the tribal people in Theni District (Western Ghats), Southern India. *Asian Pacific J of Tropical Biomedicine* 2011; 1: 20-5.
  35. Dubey D and Padhy RN: Surveillance of multidrug resistance of two gram-positive pathogenic bacteria in a teaching hospital and *in-vitro* efficacy of 30 ethnomedicinal plants used by an aborigine of India. *Asian Pacific Journal of Tropical Disease* 2012; 2: 273-81.
  36. Bharati KA and Sharma BL: Some Ethnoveterinary plant records for Sikkim Himalaya. *Indian Journal of Traditional Knowledge* 2010; 9: 344-6.
  37. Dubey D, Patnaik R, Ghosh G and Padhy RN: *In-vitro* antibacterial activity, GC-MS analysis of *Woodfordia fruticosa* Kurz. leaf extract and host toxicity testing with *in-vitro* cultured lymphocytes from human umbilical cord blood. *Osong Public Health and Research Perspectives* 2014; 5(5): 298-12.
  38. Rose BN and Prasad NK: Analgesic activity of extracts of *Woodfordia fruticosa* stems bark in animal models. *Indian Journal of Biological and Pharma Res* 2013; 4: 175-80.
  39. Chougale AD, Padul MV, Arfeen S and KakadSI: Antibacterial activity directed fractionation of *Woodfordia fruticosa* kurz. leaves. *J Medi Plants* 2009; 8(31): 75-81.
  40. Beck NR and Namdeo KP: Anti diabetic activity of aqueous extracts of leaves and stem barks of *Woodfordia fruticosa* in animal model. *World Journal of Pharmaceutical Sciences* 2015; 3(3): 468-74.
  41. Rastogi RP and Mehrotra BN: *Compendium of Indian Medicinal Plants*. Vol-1, Central Drug Research Institute, Lucknow 1999.
  42. Khan AM, Qureshi RA, Ullah F, Khan ZS and Khan J: Flavonoids distribution in selected medicinal plants of Margalla Hills and surroundings. *Pakistan Journal of Botany* 2012; 44: 1241-5.
  43. Hemraj, Gupta A, Thakur A and Upmanyu N: Hydro distillation of *Stephania glabra* tubers and *Woodfordia fruticosa* leaves. *Asian Journal of Pharmaceutical and Clinical Research* 2012; 5: 105-7.
  44. Bhatt LR, Lim JA, Lim CH and Baek SH: Antimicrobial and antiradical activity of Nepalese medicinal plants. *Korean J of Oriental Physio and Patho* 2007; 21: 1564-8.



45. Bajracharya AM, Yami KD, Prasai T, Basnyat SR and Lekhak B: Screening of some medicinal plants used in Nepalese traditional medicine against enteric bacteria. *Sci World* 2008; 6: 107-10.
46. Nair AGR, Kotiyal JP, Ramesh P and Subramanian SS: Polyphenols of the flowers and leaves of *Woodfordia fruticosa*. *Indian Journal of Pharmacy* 1976; 38: 110-11.
47. Yoshida T, Chou T, Nitta A and Okuda T: Tannins and related polyphenols of lythraceous plants III hydrolysable tannins oligomers with macro cyclic structures and accompanying tannins from *Woodfordia fruticosa* Kurz. *Chemical and Pharmaceutical Bulletin* 1992; 40: 2023-30.
48. Yoshida T, Chou T, Nitta A and Okuda T: *Woodfordia* ABC. dimeric hydrolysable tannins from *Woodfordia fruticosa* flowers. *Heterocycles* 1989; 29: 2267-71.
49. Zhao ZZ, Hu YN, Liang ZT, Yuen JPS, Jiang ZH and Leung KSY: Authentication is fundamental for standardization of Chinese medicines. *Planta Medica* 2006; 72: 865-74.
50. Shinde VM, Dhalwal K, Potdar M and Mahadik KR: Application of quality control principles to herbal drugs. *International Journal of phytomedicine* 2009; 4-8.
51. Sahoo N, Manchikanti P and Dey S: Herbal drugs: standards and regulation. *Fitoterapia* 2010; 81(6): 462-71.
52. Upton R, David B, Gafner S and Glasl S: Botanical ingredient identification and quality assessment: strengths and limitations of analytical techniques. *Phytochemistry Review* 2019; 19: 1157-77.
53. Li J, Yi T, Lai HS, Xue D, Jiang H, Peng HC and Zhang H: Application of microscopy in authentication of traditional Tibetan medicinal plant *Halenia elliptica*. *Microscopy Research Technique* 2008; 71(1): 11-19.
54. Akbar S, Hanif U, Ali J and Ishtiaq S: Pharmacognostic studies of stem, roots and leaves of *Malva parviflora* L. *Asian Pacific J of Tropical Biomed* 2014; 4(5): 410-15.
55. Rao RR and Sharma BD: A manual for herbarium collections. *Botanical Survey of India* 1990.
56. Kumar P, Singh K and Gairola S: Botanical standardization of raw herbal drug *Pashanabhedha* [*Bergenia ciliata* (Haw.) Sternb.] used in Indian Systems of Medicine. *Plant Archives* 2020; 20(2): 8645-52.
57. Ghorbani A, Saeedi Y and Boer HJ: Unidentifiable by morphology: DNA barcoding of plant material in local markets in Iran. *PLoS ONE* 2017; 12.
58. Hassan LM, Galal TM, Farahat EA and El-Midany MM: The biology of *Calotropis procera* (Aiton) W.T., *Trees* 2015; 29: 311-20.
59. Wang Y, Wen Y and Gao J: Anatomy and microscopic characteristics of *Picris japonica*. *Revista Brasileira de Farmacognosia* 2018; 28: 640-46.
60. Sundharamoorthy S, Govindarajan N, Chinnappillai A and Raju I: Macro-Microscopic Atlas on Heartwood of *Santalum album* L. (Sandalwood). *Pharmacognosy Journal* 2018; 10(4): 730-33.
61. Kumar KNS: Macro-microscopic examination of leaves of *Cinnamomum malabratrum* (Burm. f.) Blume sold as Tamalapatra. *AYU* 2013; 34(2): 193-99.
62. Manohan R, Palanuvej C and Ruangrunsi N: Pharmacognostic specifications of five root species in Ben-Cha-Moon-Yai remedy: Thai traditional medicine remedy. *Pharmacognosy Journal* 2013; 5: 46-55.
63. Kala C, Ali SS and Chaudhary S: Comparative pharmacognostical evaluation of *Costus speciosus* (wild ginger) and *Zingiber officinale* (ginger) rhizome. *International Journal of Current Pharmaceutical Research* 2016; 8(4): 19-23.
64. Sharma N, Singh S and Singh SK: Pharmacognostical standardization and preliminary phytochemical investigations on *Acacia auriculiformis* A. Cunn. Ex. Benth stem bark. *J of Medi Plants Stud* 2017; 5(1): 398-02.
65. Evans WC: *Trease and Evans pharmacognosy*. 16th edition, 2009; 541-50.
66. Coelho VPM, Leite JPV, Nunes LG and Ventrella MC: Anatomy, histochemistry and phytochemical profile of leaf and stem bark of *Bathysa cuspidate* (Rubiaceae). *Australian Journal of Botany* 2012; 60: 49-60.
67. Barkatullah, Ibrar M, Jelani G and Ahmad I: Leaf, stem bark and fruit anatomy of *Zanthoxylum armatum* DC. (Rutaceae). *Pak Journal of Botany* 2014; 46(4): 1343-49.
68. Kotina EL, Van Wyk BE, Tilney PM, Anatomy of the leaf and bark of *Warburgiasalutaris* (Canellaceae), an important medicinal plant from South Africa. *South African Journal of Botany* 2014; 94: 177-81.
69. Eltahir AS and AbuReish BI: Comparative morphological and anatomical studies of the barks of three *Albizzia* species. *Journal of Chemical and Pharmaceutical Research* 2010; 2(3): 260-68.
70. Sreedhar S, Kumar UP and Shree ABR: Pharmacognostic Analysis of Stem Bark of *Combretum albidum* G. Don; An Unexplored Medicinal Plant. *Pharmacognosy Journal* 2012; 4(28): 13-18.
71. Mota GS, Sartori CJ, Miranda I, Quilho T, Mori FA and Pereira H: Bark anatomy, chemical composition and ethanol-water extract composition of *Anadenanthera peregrina* and *Anadenanthera colubrina*. *Plos One* 2017; 12(12): 1-14.
72. Somavilla NS, Fagg CW and Brandao MGL: Morpho-anatomy of native species used as substitute of quina (*Cinchona* spp.) in Brazilian traditional medicine: *Esenbeckia febrifuga*. *Revista Brasileira de Farmacognosia* 2018; 28: 223-27.
73. Birajdar VV, Mhase AG, Gurav AM and Murthy SN: Preliminary pharmacognostic and phytochemical standardization of Dhataki [*Woodfordia fruticosa* (L.) Kurz.] leaves. *Ayu* 2014; 35(3): 309-15.
74. Shome U, Mehrotra S and Sharma HP: Pharmacognostic studies on the flower of *Woodfordia fruticosa* Kurz. *Proceedings of the Indian Academy of Sciences (Plant Sciences)* 1981; 90(4): 335-51.
75. Baravalia Y, Nagani K and Chanda S: Evaluation of pharmacognostic and physicochemical parameters of *Woodfordia fruticosa* Kurz. flowers. *Pharmacognosy Journal* 2011; 2(18): 13-18.

**How to cite this article:**

Kumar P, Singh K, Batool Z, Lone JF and Gairola S: Botanical studies on raw herbal samples of *Woodfordia fruticosa* (L.) kurz- an important ayurvedic plant. *Int J Pharmacognosy* 2020; 8(3): 129-37. doi link: [http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.8\(3\).129-37](http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.8(3).129-37).

This Journal licensed under a Creative Commons Attribution-Non-commercial-Share Alike 3.0 Unported License.

This article can be downloaded to **ANDROID OS** based mobile. Scan QR Code using Code/Bar Scanner from your mobile. (Scanners are available on Google Playstore)