Identification of “Huoshan shihu” Fengdou: Comparative authentication of the Daodi herb Dendrobium huoshanense and its related species by macroscopic and microscopic features

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Abstract
“Huoshan shihu,” derived from Dendrobium huoshanense, is a well-known, valuable, and rare Daodi herb. Because of its higher price and scarce resources, its related species D. officinale and D. moniliforme are usually presented as “Huoshan shihu” for sale. Fengdou, the processed form of D. huoshanense, its identification is particularly important. To effectively identify Fengdou of D. huoshanense and protect the Daodi herb, the morphological and microscopic characteristics of the stems of three Dendrobium species were examined. The results showed that macroscopic and microscopic features helpful for identification of the three species were the total lengths and internode numbers of stems, diameter and length of each internode, number of vascular bundles, and presence or absence of silica masses. The key features useful for distinguishing between D. huoshanense and its related species, and also between their Fengdou, were the stem lengths and the trends of change in diameter in different internodes. The results of the study indicated that a combination of macroscopic and microscopic identification techniques might conveniently and effectively be applied for identification of Dendrobium species. “Longtou Fengwei” is the main feature of the Daodi herb “Huoshan shihu,” (D. huoshanense Fengdou) and reflects the wisdom behind the protection of Daodi herbs in ancient times.

KEYWORDS
“Huoshan shihu” Fengdou, Dendrobium huoshanense, macroscopic, microscopic, identification

1 | INTRODUCTION

Shihu is not only an ornamental plant with beautiful flowers, but also a precious medicinal herb that has a wide and effective application in traditional Chinese medicine. It is derived from Orchidaceae (Dendrobium) plants (Tsi, Chen, Luo, & Zhu, 1999). According to a traditional Chinese medicine theory, the main functions of this herb are to tonify the stomach and promote body fluid, nourish yin, and clear heat (Chinese Pharmacopoeia Committee, 2015). There are 74 species and two varieties of Dendrobium in China (Tsi et al., 1999), and ~50 species are used as traditional or folk medicines in different regions of China (Bao & Shun, 1999; Bao, Shun, Zhang, & Jin, 2005; Ma, Xu, Xu, & Li, 1995; Zhao,
Macroscopic and microscopic characteristics of some Dendrobium species have been reported (Bao et al., 2005; Chu et al., 2014; Ding, Xu, Wang, Shi, & Xu, 2001; He, Li, & Su, 1992; Li, Liu, Wei, & Wang, 2004; Li et al., 1986, 1989; Ma, Xu, Xu, & Wang, 1996; Namba and Lin, 1981a,b; Xu, Xu, Sha, & Luo, 1980; Xu et al., 1981). However, it is still unknown whether the macroscopic and microscopic characteristics can be used to identify them effectively when D. moniliforme and D. officinale are processed into Fengdou with different numbers of internodes.

To effectively authenticate and distinguish between D. huoshanense and its most common relatives, D. moniliforme and D. officinale, this article seeks to address 2 issues: (1) Comparison of macroscopic and microscopic characteristics of D. huoshanense, D. moniliforme, and D. officinale; and (2) Rapid identification of D. huoshanense Fengdou.

2 MATERIALS AND METHODS

2.1 Plant materials

"Shihu," derived from fresh or dried stems of Dendrobium species, was usually harvested around October. The fresh aerial stems of Dendrobium species that had no leaves and flowers were called "Xiantiao" when used as medicines. Some of the stems of the Dendrobium species had a relatively small size, thick flesh, soft texture, and were rich in slime, such as D. huoshanense, D. moniliforme, and D. officinale. Their fresh stems were heated until soft, twisted or wound into a spiral or spring form, and dried, also known as "Fengdou." In the market, there are many types of Dendrobium species that can be processed into Fengdou. D. moniliforme and D. officinale were usually mixed with D. huoshanense.

Twenty-one samples derived from D. huoshanense, D. moniliforme, and D. officinale were collected from different production areas in the Anhui province in China. Specimens were authenticated by Professor Hua-Sheng Peng of Anhui University of Chinese Medicine. Detailed information of the samples is presented in Table 1. To evaluate the consistency of morphological and anatomical characteristics, more than 10 plants were examined for each sample and at least three sections per plant piece were prepared.

2.2 Identification method of Xiantiao

Fengdou is prepared from fresh stems. Therefore, to identify Fengdou, the characteristics of the fresh stem should be compared first. The changes in the macroscopic and microscopic characteristics were associated with the internode number in the stem of Shihu; therefore, internodes of all three Dendrobium species were numbered. The most basic section of the stem near the root was numbered 1, and then the number increased towards the stem apex.

2.2.1 Macroscopic characteristics of the three Dendrobium stems

The lengths of the fresh stems, and the diameter and length of each internode, were measured with 1–150 mm dial calipers (Shanghai Measuring and Cutting Instrument, Shanghai, China). The middle
portion of the internode was used to measure the diameter. Microsoft Excel 2013 software was used for data analysis to obtain a line chart.

2.2.2 | Microscopic characteristics of three Dendrobium stems

Number of vascular bundles: The middle part of each internode was cut and 20- to 30-μm thick slices were prepared using a freezing microtome (Leica CM 1850 UV, Germany) or vibration microtome (Leica VT 1200 S, Germany). The transverse sections were observed by a fluorescent microscope (Leica DM 6000 B, Germany) and the numbers of vascular bundles were counted.

Transverse section structure of stem: Based on a preliminary comprehensive observation and comparison, the basal, medial, and upper portions of the fresh stems were selected for the present study. For every sample, a short stem of 0.3–0.5 cm in thickness was fixed using a FAA solution (70% ethanol: formaldehyde: acetic acid 590:5:5) for at least 24 hr. The sections were dehydrated using a gradient series of ethanol and then embedded in paraffin. A rotary microtome (Leica RM2265, Germany) was used to produce sections (10–15 μm thick) for permanent preparation. Subsequently, each section was stained with safranin and Fast Green and observed using a fluorescent microscope (Leica DM6000 B, Germany). Images of microscopic characteristics were recorded by a digital camera (Leica, DFC310FX) attached to the microscope (Leica DM6000 B, Germany) and utilizing LAS (Leica Applications Suite V4.1) software. Some digital images were processed using Adobe Photoshop PS6 software.

2.3 | Identification method of Fengdou

The Fengdou was placed in warm water until soft and then straightened. The diameters, lengths, and numbers of vascular bundles of different stem internodes were measured. Preparation methods were the same as for the fresh stems mentioned above.

3 | RESULTS

3.1 | Macroscopic identification of Xiantiao

In taxonomy, D. huoshanense, D. moniliforme, and D. officinale are mainly distinguished on the basis of the features of their flowers (Figure 1). But flowers cannot be used to identify the three Dendrobium species after processed into Xiantiao.

We found significant differences between the mature stems of the three Dendrobium species. Of the three species the stem of D. officinale
was thick, *D. moniliforme* was thin and long, and *D. huoshanense* was the short. The number of nodes and internode lengths of their stems were also significantly different (Figure 2). However, the short growth period or the short height plants of *D. officinale* or *D. moniliforme* are often presented as *D. huoshanense* in the market. The age of Shihu can be determined by their biological characteristics (Li, Ye, & Jiang, 2015; Liu, Wu, & Liang, 2001; Tang, Yang, Duan, & Li, 2007), but we can only see the characteristics of stem internodes when distinguishing Shihu goods in the market, no distinct growing times can be obtained. Accordingly, we examined internode lengths and stem diameters of the three *Dendrobium* species.

### 3.1.1 The lengths and the numbers of internodes of the three *Dendrobium* plant stems

There were significant differences in the lengths and the numbers of internodes of the three *Dendrobium* plant stems. *D. moniliforme* stems were the longest among the three, with an average length of 204.3 mm (range, 90.5–324.7 mm) and contained 7–15 internodes. For *D. officinale* the average length of the stems was 118.3 mm (range, 45.6–250.3 mm) and contained 7–16 internodes. *D. huoshanense* stems were the shortest among the three, with an average length of 54.3 mm (range, 19.3–122.0 mm) and typically contained four to seven internodes (range: 3–9 internodes in some plants).

### 3.1.2 The lengths of the internodes of the three *Dendrobium* plant stems

The consecutive internode lengths of *D. huoshanense* stems showed a trend of first increasing and then decreasing, while *D. officinale* and *D. moniliforme* showed a trend of two consecutive decreases after increasing. There was a difference in the ranges of the internode lengths. The internode lengths of the stems were in the range of 1.5–22.6 mm (average 9.6 mm) for *D. huoshanense*, 1.9–21.8 mm (average 11.3 mm) for *D. officinale*, and 3.0–35.3 mm (average 18.9 mm) for *D. moniliforme*. In addition, for *D. huoshanense*, the third internode (second or fourth
internodes in some plants) was the longest in the stems, usually 6.8–22.6 mm in length (average 12.6 mm). For *D. officinale*, the third internode (second internodes in some plants) was the longest in the stems, usually 8.9–21.8 mm in length (average 14.4 mm). For *D. moniliforme*, the second internode was the longest in the stems, usually 15.4–35.3 mm in length (average 25.6 mm) (Figure 3).

On the basis of the above results, we can conclude that the length of each internode for the *D. moniliforme* stem was the longest and could be easily distinguished from the other two. The length of each internode of the *D. officinale* stem was relatively longer than that of *D. huoshanense* when the internode number of *D. officinale* was >10. There was no significant difference between the internode lengths of the *D. huoshanense* and the *D. officinale* stems when the node number was <10, which made it difficult to distinguish between them.

### 3.1.3 The diameters of the internodes of the three *Dendrobium* plant stems

In the three *Dendrobium* species, the diameters of consecutive internodes first increased and then decreased with increasing pitch numbers, with the exception of *D. huoshanense* (Figure 4).

For *D. huoshanense*, the diameters of its stem internodes were ~0.7–2.8 mm in diameter. For *D. officinale*, the internodes were ~1.0–8.8 mm and the thickest internode was not stable, but usually the second or third internode was with a diameter of 2.8–8.8 mm. For *D. moniliforme*, the stem internodes were ~1.1–4.8 mm and the second internode was the thickest, usually 2.5–4.8 mm in diameter (Figure 4).

Based on these results, the diameter of each internode of the *D. officinale* stem was the largest among the three and can be easily distinguished from the other two species. The internode of the *D. moniliforme* stem was slightly thin. Changes in internode diameter were the largest for the *D. huoshanense* stem, which can be used to distinguish it from the other *Dendrobium* species easily (Figure 4).

### 3.2 Microscopic identification of transverse sections of Xiantiao

#### 3.2.1 The changing regularity of vascular bundle numbers of the stem in three *Dendrobium* species

The numbers of vascular bundles in the stems of *D. officinale* first increased and then decreased in consecutive internodes. The number of vascular bundles in the stems of *D. huoshanense* and *D. moniliforme* showed a trend of gradual reduction (Figures 5 and 6) with consecutive internodes.

For *D. huoshanense*, the numbers of vascular bundles at every internode of its stem were different. The numbers of vascular bundles in the stem base were the largest, ~26–47, with an average of 34 bundles, while those in the stem apex were the least, ~9–24, with an average of 14 bundles. The numbers of vascular bundles in the *D. officinale* stem internodes were ~15–98, in which the lower part had the largest number of vascular bundles, ~64–98. For *D. moniliforme*, the numbers of vascular bundles in its stem internodes were ~7–66, which was similar to those of *D. huoshanense*. The largest number of vascular bundles was also in the stem base, ~32–66, with an average of 42 bundles (Figure 5).

In summary, we concluded that there were differences in the changes of vascular bundle numbers in three *Dendrobium* species. The number of vascular bundles in each internode of *D. officinale* was
significantly higher, which made it distinct from the other two species. However, *D. huoshanense* and *D. moniliforme* were indistinguishable by the numbers of vascular bundles when the node number was less than 10 (Figure 5). Therefore, in this study, microscopy was used to provide supplemental differential points to distinguish between these three *Dendrobium* species.

### 3.2.2 | Microscopic characteristics of transverse sections of the three *Dendrobium* species

The present study demonstrated that the internal microstructure characteristics of the stem were stable from the top to the base for the three species (Figure 6).

The transverse section of the stem of *D. huoshanense* was circular. A layer of residual pericladium might be observed occasionally outside the epidermis, which was composed of parenchyma cells and vascular bundles. The epidermis comprised a layer of flattened cells, whose lateral walls were slightly lignified and covered with a very thin yellow or orange cuticle. The closed collateral vascular bundles were scattered in parenchyma, 9–47. Bundle sheath, consisting of one to two layers of fiber cells, was usually either single cap-shaped or double cap-shaped and distributed around the vascular bundles. The diameters of the outer fibers were smaller than that of the medial fibers. Parenchyma cells usually had a similar size, but were smaller near the vascular bundles. The slimy cells containing raphides were mainly near the epidermis and occasionally near the vascular bundles. Starch grains were observed in the parenchyma cells (Figure 6).

The general microscopic characteristics of *D. officinale* were similar to those of *D. huoshanense* but different in the following features. The epidermis comprised a layer of flattened or polygonal cells, with obvious thickening of the cell wall. The hypodermis consisted of one to three layers and the lateral walls were slightly lignified. The bundle sheath was double or single cap-shaped, consisting of one to three

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**FIGURE 6** Transverse sections of the stems of three *Dendrobium* species. (XT, Xian Tiao; Bar = 2 cm) [Color figure can be viewed at wileyonlinelibrary.com]
layers of fiber cells. The silica masses were mainly observed in the small parenchyma cells outside the vascular bundles (Figure 6).

The general microscopic characteristics of *D. moniliforme* were similar to those of *D. huoshanense*, but there were some differences. The epidermis comprised a layer of flattened or polygonal cells. The cell walls were slightly thickened. The hypodermis consisted of one to two layers and their cell walls were slightly lignified. The bundle sheath was mainly double cap-shaped, consisting of one to five layers of fiber cells. A single cap-shaped fiber bundle appeared occasionally. The silica masses were mainly observed in the small parenchymal cells outside the vascular bundles (Figure 6).

### 3.3 Macroscopic and microscopic identification of Fengdou

Fengdou of *D. huoshanense* and its related species are very similar in external morphological characteristics. They are all coiled into tight or loose spring-like or spiral shapes, with a golden-yellow or yellowish-green surface (Figure 7).

Fengdou of *D. huoshanense* are usually twisted into two to four rings and occasionally have five rings. The root head is at one end, with several residual fibrous roots, and is shaped as a dragon’s head, commonly known as the Longtou. The stem apex is at the other end and is shaped like the tail of the Phoenix, commonly known as the Fengwei. Thus, Huo-shan-feng-dou is usually called the “Longtou Fengwei” (Figure 7-A1). When soaked to soften and then straightened, a complete and relatively short stem was found in the Fengdou of *D. huoshanense* (Figure 7-A2).

Fengdou of *D. officinale* are usually twisted into three to six rings (Figure 7-B1). The root head or stem apex is at one end and the other end consists of an oblique or flat truncated cross section. Occasionally, Fengdou in which both ends are oblique or flat with truncated cross sections can also be observed. When soaked to soften and then straightened, usually five to seven internodes with incomplete stems were found (Figure 7-B2).

The Fengdou of *D. moniliforme* are usually twisted into two to three rings and occasionally have four rings (Figure 7-C1). Both ends are oblique or flat with truncated cross sections. Occasionally, the root head or stem apex is at one end and the other end is an oblique or flat with truncated cross section. When soaked to soften and then straightened, only two to three internodes can be found (Figure 7-C2).

*D. officinale* and *D. moniliforme* stems are three to four times longer than that of *D. huoshanense*. When processed into Fengdou, only a part of the stem is taken so the Fengdous do not consist of a complete stem. The may be from the base or middle or top of the stem. Thus, only the macroscopic characters can be used to distinguish between the Fengdou of the three *Dendrobium* species.

### 4 DISCUSSION

#### 4.1 Macroscopic and microscopic identification may distinguish between the three *Dendrobium* species

Identification of all species of the genus *Dendrobium* is based mainly on the flowers (Tsi et al., 1999). However, the flowering period is very short in the *Dendrobium* species, which makes it difficult to identify these species, especially when only the stem is used for medicinal purposes. Modern molecular technology research showed that most *Dendrobium* plants might be identified by DNA barcoding (Feng et al., 2014, 2015; Wang et al., 2009; Xiang et al., 2013). However, since they form a composite group together, it is difficult to use DNA barcoding to differentiate between *D. huoshanense* and its related species (Xiang et al., 2013). As the mainstream commodity of Shihu, Fengdou requires a higher temperature during processing, which causes some damage to its DNA and limits the application of DNA barcoding technology. This is the first study that combined macroscopic and
microscopic identification to distinguish Xian Tiao and Fengdou from the fresh and dry stems of three Shihu herbs *D. huoshanense*, *D. moniliforme*, and *D. officinale*. This study first demonstrated that the vascular bundles in stems of *Dendrobium* have changed at different internodes. The most reliable macroscopic and microscopic characters for identification are listed in Table 2 and Figures 3–6. As a traditional authentication method, macroscopic identification is also suitable for identification of *D. huoshanense* and its close related species. The results showed that *D. huoshanense* characters were significantly different compared to those of *D. moniliforme* and *D. officinale*. *D. huoshanense* can be clearly distinguished from *D. moniliforme* and *D. officinale* based on stem length, number of stem internodes, and the length and diameter of each internode. The key points of identification of *D. huoshanense* and its related species were the stem lengths and changes in diameter at each internode. The “Supplement to Compendium of Materia Medica” described it as “the stem changes like a grasshopper’s thigh” or “stems like a stack of rice” (Zhao, 1983), which is not a feature characteristic of *D. moniliforme*, *D. officinale*, and other *Dendrobium* plants. This study scientifically validates this ancient view.

Although these three *Dendrobium* species can be distinguished on the basis of macroscopic features, it still seems difficult to clearly distinguish between *D. huoshanense* and its related species when the stems of *D. moniliforme* and *D. officinale* are relatively short. In this study, microscopy was used to provide supplemental differential points to authenticate these three species. In previous studies, the numbers of vascular bundles in the stems were regarded as a basis for the identification of *Dendrobium* species (Bao et al., 2005; Chu et al., 2014; Ding et al., 2001; He et al., 1992; Li et al., 1986, 1989, 2004; Ma et al., 1996; Xu et al., 1980, 1981). The results of this study showed that the numbers of vascular bundles of three *Dendrobium* species’ stems presented certain trends in changes of node positions. Regarding changes in the numbers of vascular bundles, *D. officinale* showed a trend of an initial increase followed by a decrease, while *D. huoshanense* and *D. moniliforme* showed trends of gradual reduction with consecutive internodes. As for the numbers of vascular bundles, *D. officinale* had significantly higher numbers, *D. moniliforme* had relatively few numbers, and *D. huoshanense* had the fewest. *D. huoshanense*, *D. moniliforme*, and *D. officinale* could be clearly distinguished. In addition, there were also some differences in the thickening mode of the epidermal cell walls, the presence or absence of a sub-epidermal cell, the numbers and types of fibers, the presence or absence of silica masses, and position of raphides.

As Fengdou is made from Xian Tiao, the macroscopic and microscopic characteristics of Xian Tiao are applicable to Fengdou. When Fengdou are straightened after soaking the diameters, lengths, and numbers of vascular bundles of different stem internodes are the same as that of Xian Tiao. Consequently, using these macroscopic and microscopic identification methods we can also distinguish between the Fengdou of *D. huoshanense*, *D. officinale*, and *D. moniliforme* very well. The results indicated that macroscopic and microscopy techniques are simple, convenient, economical, and may be unambiguously applied for authentication of the three *Dendrobium* species.

### 4.2 Processing of Fengdou may destroy the cuticle and membranous pericladium

The structures of the *Dendrobium* stem from the outermost layer to the core are membranous pericladium, compact cuticle, epidermis, hypodermis cells, ground tissue, and vasculature (Stem, 2014). These characteristics may allow *Dendrobium* plants to better adapt to subtropical and tropical forest environments. The outer structure of the stem may also allow long-term preservation of Shihu without drying. Even after harvesting, Shihu can germinate and blossom as long as the humidity is stable, since the fresh stems are difficult to dry. However, this process consumes the nutrients in the stem. Therefore, in order to allow the stem of *Dendrobium* to dry quickly, the membranous pericladium, cuticle, and epidermal cells must be destroyed. The ancient Chinese invented the processing method of Fengdou long before. During processing, a high temperature, constant rubbing, and twisting may be beneficial for removing the remaining pericladium and destroying the cuticle. This is convenient for the evaporation of water and to allow the *Dendrobium* stem to dry faster.

### 4.3 “Longtou Fengwei” is the main feature of *D. huoshanense* Fengdou

*Dendrobium* has more than 1,100 species in the world. In China, there are 74 species and 2 varieties (Tsi et al., 1999). Fengdou is the main commodity form of *Dendrobii Caulis*. According to a survey, more than 30 *Dendrobium* species can be processed into Fengdou (Bai, Yan, Bao,
Wang, & Wu, 2007; Bao, Shun, Ye, & Gu, 1999; Ding, Wang, Xu, Xu, & Zhou, 2002; Li et al., 2011; Wu, Shun, Bao, & Ji, 2007). Most of them are highly adhesive, small in size, and have little fiber such as D. huoshanense, D. moniliforme, and D. officinale. The processing of Fengdou limits the texture and morphology of the raw materials so that its character can be used for distinguishing Shihu. However, when these different species of Dendrobium are processed into Fengdou, their appearances and shapes are very similar, thus increasing the difficulty of identification.

D. huoshanense has a very short stem that is found in 50 types of Dendrobium medicinal plants (Bao and Shun, 1999; Bao et al., 2005; Ma et al., 1995; Tsi et al., 1999; Zhao, 2014). As a Daodi medicinal material of Shihu, D. huoshanense is processed into “Longtou Fengwei” using its whole stem together with some roots because of its small size and high viscosity. Other species with tall stems in genus Dendrobium cannot be processed into Fengdou like D. officinalis, and D. officinale cannot be processed into Fengdou like Longtou Fengwei, nor even Longtou Fengwei, “Longtou Fengwei,” not even the close D. moniliforme and D. officinale. To maximize their aesthetics, the stems of D. moniliforme and D. officinale must be cut and processed into several Fengdou without having Longtou and Fengwei simultaneously. However, we cannot ignore situations in which herbalists use dwarf or short D. moniliforme and D. officinale plants for processing into “Longtou Fengwei” in order to present them as D. huoshanense in the market. In this case, we should combine macroscopic and microscopic characteristics for comprehensive judgment of authenticity.

Therefore, the complete stem morphology is preserved even when D. huoshanense is processed into Fengdou and the characteristic changes in the features of its stem internodes are retained. “Longtou Fengwei” can effectively be used to distinguish between Fengdou of Daodi medicinal material D. huoshanense and other Dendrobium species. This processing technology also reflects ancient awareness of protecting Daodi medicinal material.

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REFERENCES


