



Review

Bletilla striata: Medicinal uses, phytochemistry and pharmacological activities



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ABSTRACT

Ethnopharmacological relevance: *Bletilla striata* (Thunb.) Reichb. f. (Orchidaceae), also known as Hyacinth Orchid and Baiji (Simplified Chinese: 白及), not only has been widely used for the treatment of hematemesis, hemoptysis, and traumatic bleeding due to the efficacy of arresting bleeding with astringent action, but also has been applied topically to overcome ulcers, sores, swellings, and chapped skin due to the efficacy of dispersing swelling and promoting tissue regeneration. Additional medical applications include the treatment of tuberculosis, malignant ulcers, hemorrhoids, anthrax, eye diseases, and silicosis.

Aim of this review: This review aims to provide up-to-date information on the botanical characterization, medicinal uses, chemical constituents, pharmacological activities, and toxicity of *B. striata*. In addition, this paper also focuses on the possible exploitation of this plant for the treatment of different diseases, and uncovers opportunities for future research.

Materials and methods: The relevant information on *B. striata* was gathered from worldwide accepted scientific databases via an electronic search (Google Scholar, Web of Science, ScienceDirect, ACS Publications, PubMed, Wiley Online Library, SciFinder, CNKI). Information was also obtained from The Plant List, Chinese pharmacopoeia, Chinese herbal classics books, PhD and MSc dissertations, etc.

Results: A comprehensive analysis of the literature obtained through the above-mentioned sources confirmed that the ethnomedical usages of *B. striata* have been recorded in Mongolia, Korea, Japan, and China. Phytochemical investigations revealed that the major chemical constituents of *B. striata* are polysaccharides, bibenzyls, phenanthrenes, triterpenoids and its saponins, steroids and its saponins, which also have been proven to be the main bioactive substances capable of exhibiting numerous pharmacological activities including wound healing, antiulcer, hemostasis, cytotoxicity, antimicrobial, anti-inflammation, anti-oxidation, immunomodulation, anti-fibrosis, antiaging, anti-allergy, and anti-itch.

Conclusions: Preliminary investigations on pharmacological properties of *B. striata* have shown that *B. striata* is an outstanding astringent hemostatic medicinal, *B. striata* polysaccharides (BSP) as the major bioactive components not only capable of promoting wound healing, but also show good performance as a kind of promising natural biomaterial. More importantly, BSP are also reported to be excellent embolic material. However, further investigations need to be carried out to fully clarify its efficacy of dispersing swelling and promoting tissue regeneration. Moreover, this plant also needs a lot more investigations to clarify the pathways of absorption, distribution, metabolism and excretion, and to evaluate its long-term *in vivo* chronic toxicity before proceeding to the development of pharmaceutical formulation.

Abbreviations: α -SMA, alpha smooth muscle actin; ABTS, 2, 2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid); ADP, adenosine diphosphate; BSP, *Bletilla striata* polysaccharides; CFDA, China Food and Drug Administration; Con A, concanavalin A; COX-1, cyclooxygenase-1; COX-2, cyclooxygenase-2; DNFB, dinitrofluorobenzene; DPPH, 2, 2-diphenyl-1-picrylhydrazyl; ELISA, enzyme-linked immunosorbent assay; FRAP, ferric reducing antioxidant power; HMCs, human mesangial cells; HUVEC, human umbilical vein endothelial cell; IL, interleukin; iNOS, inducible nitric oxide synthase; IC₅₀, 50% inhibiting concentration; IFN- γ , interferon- γ ; IGF, insulin-like growth factor; L-DOPA, levodopa; LPS, lipopolysaccharide; MBC, minimum bactericidal concentration; MIC, minimum inhibitory concentration; NF- κ B, nuclear factor kappa-light-chain-enhancer of activated B cells; NO, nitric oxide; NOX4, NADPH oxidase 4; p22^{phox}, human neutrophil cytochrome b light chain; PCR, polymerase chain reaction; PVA, polyvinyl alcohol; Rac, a subfamily of the Rho family of GTPases; ROS, reactive oxygen species; SEM, scanning electron microscopy; TCM, traditional Chinese medicine; TEM, transmission electron microscope; TEAC, trolox equivalent antioxidant capacity; TLR2, toll-like receptor 2; TGF- β , transforming growth factor beta; Th cells, T helper cells; TNF- α , tumor necrosis factor-alpha; UVB, ultraviolet B

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1. Introduction

Bletilla striata (Thunb.) Reichb. f. (Orchidaceae) known as Hyacinth Orchid, Hyacinth Bletilla, Urn Orchid, Chinese Ground Orchid, Common Bletilla Tuber, Japanorchidee (German), Mikadoblomma (Swedish), Mikadoblomst (Danish), Shiran (Japanese), Jaran (Korean), and Baiji/白及 (Chinese), is not only an ornamental garden or a pot plant in Europe and United States, but an important astringent hemostatic medicinal plant native to East Asia (Bown, 1995; Wiart, 2012). *B. striata* which is mainly distributed through southern and eastern China near the Yangtze River, Japan, Korea, south to Vietnam, Thailand and Myanmar grows wild in sandy soils amongst grassy patches on cool mountain slopes (Flora of China Editorial Committee, 2009; Yeung, 1985). Due to excessive exploitation and destruction of natural habitats, the wild natural resources of *B. striata* reduced sharply. More than ten years ago, *B. striata* was listed as one of the key protected wild medicinal plants (<http://rep.iplant.cn/>). In order to solve the problem of *B. striata* resources, the artificial cultivation of *B. striata* and its related species has been developed in the majority of regions in China (Li and Wang, 2006). More importantly, research on strengthening the selection and breeding of excellent varieties of *B. striata* also has been launched (Zhang et al., 2012). *B. striata* has been used as an astringent hemostatic medicinal for thousands of years, its pseudobulbs resembling spreading corms (Fig. 1) are generally regarded as the medicinal part. Traditional Chinese Medicine (TCM) holds that it is capable of restraining leakage of blood and stopping bleeding, and dispersing swelling and promoting tissue regeneration, and thus it could be effectively applied in the treatment of hematemesis, hemoptysis, traumatic bleeding, chapped kin, and ulcerative carbuncle (Chinese Herbalism Editorial Board, 1999; Wu, 2005). Additional medical applications of *B. striata* include treatment of the tuberculosis, malignant ulcers, hemorrhoids, anthrax, eye diseases, and silicosis (Hossain, 2011). Besides, *B. striata* as vascular embolizing agent for treating primary hepatic carcinoma has been reported to be more effective than conventional gelfoam (Zheng et al., 1998). Moreover, *B. striata* particles as embolic material also have been shown to achieve better efficacy in alleviating hypersplenism than gelfoam (Liu et al., 2011). Currently, China Food and Drug Administration (CFDA) has approved four patent drugs including Bai Ji Pill, Bai Ji Capsule, Bai Ji Syrup, and Bai Ji Granule, which all only contain *B. striata* as the medicinal ingredient (<http://www.sda.gov.cn/WS01/CL0001/>). Remarkably, the typical dose of Bletillae Rhizoma (*i.e.*, dried tubers of *B. striata*) depends on conditions being treated. Officially, Chinese Pharmacopoeia recommends its dosage between 6 and 15 g or at an appropriate amount for external application, and meanwhile states that its dosage should be between 3 and 6 g when taken internally as powder. In addition, Bletillae Rhizoma is incompatible with Aconiti Radix, Aconiti Kusnezoffii Radix, and Aconiti Lateralis Radix Praeparata (China Pharmacopoeia Commission, 2015). Furthermore, non-medical uses of *B. striata* include rubbing its mucilaginous roots in inkstones with vermilion for writing (Lawler, 1984), and another use is as an insecticide (Perry and Metzger, 1990). In Japanese folk medicine, the

tubers are used for the same purposes as salep (Lawler, 1984). At present, several cosmetics and daily necessities containing *B. striata* are commercially available (Zhang et al., 2012). And as early as 1955, *B. striata* mucilage as tablet binder was regarded to be an outstanding substitute for arabia gum or gum tragacanth in the pharmaceutical industry (Koo et al., 1955).

Studies focusing on secondary metabolites have resulted in the isolation of bibenzyls, dihydrophenanthrenes, biphenanthrenes, phenanthrenes, triterpenoids and its saponin, steroids and its saponins, cyanidin glycosides and anthocyanins, phenanthraquinones, anthraquinones, lignans, organic acids, and glucosyloxybenzyl 2-isobutylmalates. In addition, *B. striata* is also rich sources of polysaccharides, which have been recently used as a variety of biomedical materials for wound healing, or as vehicles for drug delivery (Dong et al., 2009; Lin et al., 2012; Liu et al., 2014; Liu and Huang, 2010; Wu et al., 2010; Zhan et al., 2014). Reviewing the available literatures, no review concerning *B. striata* is available. In this review, we intend to provide a comprehensive insight into the botanical characterization, medicinal uses, chemical constituents, pharmacological effects, and toxicity of *B. striata* to provide knowledge to researchers for better utilization of this plant.

2. Botanical characterization

B. striata is 18–60 cm tall. The rhizome is compressed, subglobose or irregularly shaped and 1–3 cm in diameter. The stem is 3–25 cm, stout, and has 4–6 leaves. The leaves are widely spaced. The peduncle is 14–34 cm long, slender, and usually with a single sheathing bract. The rachis is flexuous or pendulous, 2–7 cm long, and has 3–10 flowers. The flowers are erect, purplish red, and showy. The sepals are purplish red or pink, narrowly oblong. The lateral sepals are oblique and acute at the apex. The petals are slightly larger than sepals, purplish red or pink, and acute at the apex. The lip is white, tinged with purplish red veins, obovate-elliptical, and 3-lobed above middle. The mid-lobe is square, crisped, and truncated at the apex. The column is subterete, slender, dilated toward the apex, and winged. The rostellum is large (Flora of China Editorial Committee, 2009; Wiart, 2012).

3. Medicinal uses

B. striata as inferior herbal item was firstly recorded in Shennong's Classic of Materia Medica (Simplified Chinese: 神农本草经). It is bitter, sweet and puckery in flavour, slightly cool and astringent in nature, and it acts on the lung, liver and stomach meridians (China Pharmacopoeia Commission, 2015; Wu, 2005). Generally, *B. striata* is collected in summer and autumn with the fibrous roots removed, the cleaned pseudobulbs are used as the medicinal part, which are soaked in boiling water or placed in steam and subsequently dried in the sun before cut, sliced or ground into a fine powder (China Pharmacopoeia Commission, 2015). Benefiting from the actions of restraining leakage of blood and stopping bleeding, *B. striata* has been widely used to treat hematemesis, hemoptysis, and traumatic bleeding (Calaway et al., 1997). Due to the actions of reducing swelling and promoting genera-



Fig. 1. (a) Hand painted whole-plant, (b) flowers, and (c) pseudobulbs with fibrous roots of *B. striata*.

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