

# Huang qi - *Radix Astragali membranacei*: on the Botanical Identity of Involved *Astragalus* Species (Leguminosae)

K.M. Valant-Vetschera and C. Zyka  
Institute of Botany  
University of Vienna  
Rennweg 14  
A-1030 Vienna  
Austria

**Keywords:** *Astragalus mongholicus*, Leguminosae, taxonomy, traditional Chinese medicine

## Abstract

The official and main source of the Chinese drug huang qi is derived from *Astragalus membranaceus* and *A. mongholicus*, respectively. However, several other species are used either as sources or as adulterants. The present paper aims at clarifying the taxonomic and nomenclatural situation, with indication of major botanical and geographical characters of all species involved. According to a recent revision, *A. membranaceus* is synonymous to *A. mongholicus* var. *dahuricus*, which is the now valid name. Relationships of other *Astragalus* spp. relating to huang qi are briefly addressed.

## INTRODUCTION

Huang qi is a prominent drug used in Traditional Chinese Medicine (TCM), with attributed effects particularly as a tonic, diuretic and a wide range of immunopotentiating properties. The active ingredients of the plant are mainly saponins, polysaccharides and flavonoids (Ma et al., 2000a, b). In TCM, huang qi is never administered as a monodrug, but forms part of mixtures depending on the indications. Officially acknowledged sources of Huang qi are the roots of *Astragalus membranaceus* or *Astragalus mongholicus* (Bensky and Gamble, 1993).

However, several other species such as *A. floridus*, *A. chrysopterus*, *A. hoantchy*, *A. tongolensis*, *A. tribulifolius*, *A. aksuensis*, *A. ernestii*, *A. lehmannianus* and even *Hedysarum polybotrys* are on the market as huang qi (Ma et al., 2000 a,b). Some pharmacognostical studies also report on *A. mahoschanicus* (Li et al., 1996) and some further taxa associated here with *A. penduliflorus* (Chen and Zhu, 1990; Zhu and Chen, 1991).

Apart from the problematic infrageneric taxonomy, species delimitation is a general problem in this genus. In fact, some of the discriminating morphological and geographical characters are so minute that a clear taxonomic alignment is often problematic (Weninger, 1992). The need for discriminating the drug sources of huang qi was obvious and led to attempts both in classical botany (e.g. karyology: Chen and Zhu, 1990), in molecular systematics (Ma et al., 2000b) and in pharmacognosy (Higashi et al., 1958; Hsiao et al., 1964; Li et al., 1994, 1996). For revisionary work on parts of the genus see Weninger (1992) and Podlech (1982, 1993, 1996).

Taxonomic, systematic and chemosystematic data of these *Astragalus* spp. were screened in the course of a PhD study on Leguminosae used in TCM (Zyka, unpublished). The present paper focuses on the taxonomic and nomenclatural aspects of the species involved. In addition, the botanical characters of the different species will be summarized and briefly discussed.

## RESULTS

### Nomenclatural and Taxonomic Issues

All species relating to huang qi are listed in Table 1, with indication of botanical

authorities and recognized synonymy. Data are mainly based upon the work of Podlech (Thesaurus Astragalorum, 1996) and some data from the ILDIS internet-database. Especially the latter is not always reliable. Thus, checking of original literature both nomenclatural and taxonomic is strongly encouraged. According to Podlech (1982), all of the species listed belong to various sections of *Astragalus* subgen. *Astragalus*. Sect. *Cenantrum* Bunge thus includes *A. mongholicus* and its variants, further *A. floridulus*, *A. penduliflorus*, *A. tongolensis*, *A. aksuensis* and *A. ernestii*. The remaining species belong to different sections that are only distantly related.

Based upon a recent taxonomic and nomenclatural revision Podlech (1999), *A. membranaceus* represents only a variant of *A. mongholicus* Bunge, and its nomenclaturally correct name is thus *A. mongholicus* Bunge var. *dahuricus* (DC.) Podlech. Consequently, the name of *A. membranaceus* is now a synonym only. The variety status of *A. membranaceus* and *A. mongholicus* is based upon differences in the presence of hairy ovaries and pods in these two sympatric taxa (Podlech, 1999) and some minor indumentum characters as listed in Table 1. Nomenclature revisions like this are hard to understand for applied science, but they should facilitate communication about plant names in a correct and reproducible way.

### Botanical Characters and Systematic Relationships

In Table 1, some important characters are listed; most of them being taken from literature, combined with herbarium observations. Important characters relate to the root system and the growth form, but both are rarely reported in literature. Also, relevant herbarium material which was consulted did not reveal much of underground parts. In general, it must be assumed that all of these taxa show a strong main root system (tap root) and form a lignified base with branches of stems called a pleiocorm (Kästner and Karrer, 1995). The presence of rhizomes in *A. tribulifolius*, *A. chrysopterus* and *A. mahoschanicus* (Fu, 1993) appears rather unlikely and needs to be confirmed as a diagnostic character. Leaf morphology may be quite distinct, particularly with those taxa only distantly related to the main source *A. mongholicus*. However, variations are sometimes noted within a single specimen (Peter-Stibal, 1937/38). Flower color is a critical character as herbarium material tends to either fade or darken. Indumentum characters appear to be the most reliable distinguishing features in this genus (Podlech, 1982).

Pharmacognostic studies on most of the involved taxa indicated differences in anatomical root structures (Li et al., 1994; 1996). Their species or taxon specificity is in need of confirmation by further comparative analyses, and data will become more clear once the relevant Chinese publications are fully translated. In any case, the study of cultivated material would be the best way to check the stability of morphological and anatomical characters. Unfortunately, seed material of most of the species is difficult to obtain. International cooperation would thus be highly appreciated.

Character diversification within *A. mongholicus* is rather poor (see also Table 1). Geographical distribution, the lack of crossing barriers and polyploidy add to the complexity not only of the studied group, but of many *Astragalus* taxa in general (Hegnauer and Hegnauer, 2001). Relationships probably exist to *A. penduliflorus*, a taxon of varying concept. *A. mongholicus* is sometimes considered to form a complex of species, including the sources of huang qi (Zhu et al., 1991). By contrast, European authors consider this taxon to be restricted to alpine regions (Hegnauer and Hegnauer, 2001). Based upon results on seed proteins and karyology (Chen and Zhu, 1990), the authors proposed *A. pendulifolius* to be a single species, comprising the subspecies *penduliflorus*, *membranaceus*, and *mongholicus*. However, the Flora of China does not acknowledge *A. penduliflorus* at all for its territory (Fu, 1993), nor is this taxon mentioned in the new Flora of China checklist (see ILDIS). Further and detailed morphological and systematic studies are needed to clarify the relationships between those critical taxa, since general character diversification is indeed rather poor (Table 1).

## DISCUSSION

From the systematic and evolutionary point of view, the diversifications between taxa of sect. *Cenantrum*, relating to huang qi, are quite interesting. Molecular phylogenetic analysis revealed close affinities between the varieties of *A. mongholicus* (listed as varieties of *A. membranaceus*; Ma et al., 2000a). In the same study, *A. lehmannianus* and *A. hoantchy* claded together, but were separated from the former taxa. Studies on the distribution of isoflavonoids and polysaccharides (Ma et al., 2000b) revealed higher yields in both varieties of *A. mongholicus* var. *mongholicus*. Similarly, the contents was higher than in the adulterants *A. lehmannianus*, *A. hoantchy*, *A. aksuensis* and *A. propinquus*, respectively. Apart from these data, comparative chemical studies on the other taxa involved are rare or missing (Hegnauer and Hegnauer, 2001). Chemosystematic and molecular systematic studies are still needed to clarify the interspecific relationships within this group.

To conclude, *A. mongholicus* var. *mongholicus* (sub *A. membranaceus* (Fisch.) var. *mongholicus* (Bunge) P.K. Hsiao) should be used as the primary source for huang qi since it apparently accumulates the highest amounts of active principles (Ma et al., 2000a). When used for cultivation, high yielding strains should be selected, and culture conditions optimized.

## ACKNOWLEDGEMENTS

The authors are greatly indebted to Dr. Guo Yanping (currently at the Institute of Botany, WU) for providing Chinese translation of publications.

## Literature Cited

- Bensky, D. and Gamble, A. 1993. Chinese Herbal Medicine: Materia Medica. Eastland Press, Seattle.
- Chen, Ch.-J. and Zhu, X.-Y. 1990. Karyotype of *Astragalus penduliflorus* Lam. complex and its cytotaxonomic significance. *Cathaya* 2:139-150.
- Flora of China checklist. 2002. Accessed 3<sup>rd</sup> Nov at: <http://mobot.mobot.org/W3T/Search/foc.html>
- Fu, K. 1993. *Flora of China* 42(1). Science Press, Beijing.
- Hegnauer, R. and Hegnauer, M. 2001. *Chemotaxonomie der Pflanzen* vol. XIIb-2. Birkhäuser, Basel.
- Higashi, J., Mizobuchi, K. and Nagosh, K. 1958. Pharmacognostical studies of huang-ch'i II. *Journ. Jap. Bot.* 33:153-160.
- Hsiao, P.K., Feng, Y.S., Cheng, Ch.Y. and Lou, T.Ch. 1964. Botanical and pharmacognostical studies of the Chinese drug huang-ch'i. I. *Acta Pharm. Sinica* 11:114-128.
- Ildis-Database. 2002. Accessed 3<sup>rd</sup> Nov at: <http://www.ildis.org/LegumeWeb/>
- Kästner, A. and Karrer, K. 1995. Übersicht der Wuchsformtypen als Grundlage für deren Erfassung in der "Flora von Österreich". *Fl. Austr. Novit.* 3:1-51.
- Li, M., Qin, X.Q. and Feng, Y.X. 1994. Morphological and microscopical identification of the genus *Astragalus* on mainly used commercial huang qi. *Acta Pharm. Sinica* 29:862-871.
- Li, M., Feng, Y.X., Gao, G.Y. and Chen, S.B. 1996. Morphological and microscopical identification of genus *Astragalus* of local used commercial huang qi and its adulterants. *Acta Pharm. Sinica* 31:145-150.
- Ma, X.Q., Duan, J.A., Zhu, D.Y., Dong, T.T.X. and Tsim, K.W.K. 2000a. Species identification of *Radix Astragalus* (Huangqi) by DNA sequence of its 5S-rRNA spacer domain. *Phytochemistry* 54:363-368.
- Ma, X.Q., Duan, J.A., Zhu, D.Y., Dong, T.T.X. and Tsim, K.W.K. 2000b. Chemical comparison of *Astragalus Radix* (Huangqi) from different regions of China. *Nat. Medicines* 54:213-218.
- Podlech, D. 1982. Neue Aspekte zur Evolution und Gliederung der Gattung *Astragalus* L. *Mitt. Bot. Staatssamml. München* 18:359-278.

- Podlech, D. 1993. Revision von *Astragalus* L. Sektion Eremophysa Bunge und Eremophysopsis Gontsch. (Leguminosae). Sendtnera 1:45-64.
- Podlech, D. 1996. Thesaurus Astragalorum. Accessed 3<sup>rd</sup> Nov 2002 at: <http://www.botanik.biologie.uni-muenchen.de/botsyst/thesau1.html>
- Podlech, D. 1999. New *Astragali* and *Oxytropis* from North Africa and Asia, including some new combinations and remarks on some species. Sendtnera 6:135-174.
- Peter-Stibal, E. 1937/38. Revision der chinesischen *Astragalus*- und *Oxytropis*- Arten. cta Hort. Gotoburg. 12:21-85.
- Weninger, J. 1992. Revision von *Astragalus* L. sect. Chlorostachys Bunge, sect. Phyllobium Bunge und sect. Skythropos Simpson (Leguminosae). Mitt. Botan. Staatssamml. München 30:1-196.
- Zhu, X.-Y., and Chen, Ch.-J. 1991. Taxonomic significance of peptides from seed proteins of *Astragalus penduliflorus* complex (Fabaceae) and related taxa. Cathaya 3:65-71.

## Tables

Table 1. Characters, distribution and synonymy of *Astragalus* spp. aligned to Huang-qi.

Name/Synonyms	Descriptive characters	Geographic distribution
<p><i>A. mongholicus</i> Bunge var. <i>dahuricus</i> (DC.) Podlech  <b>Syn.:</b> <i>Astragalus membranaceus</i> (Fisch.) Bunge; <i>A. propinquus</i> Schischkin incl. <i>A. membranaceus</i> Bge. f. <i>propinquus</i> (Schischk.) Kitag.; <i>A. penduliflorus</i> Bunge, non Lam.; <i>A. penduliflorus</i> Lam. var. <i>membranaceus</i> Glehn (ined.); <i>Phaca abbreviata</i> Ledeb; <i>Phaca alpina</i> L. var. <i>dahurica</i> DC.; <i>Phaca alpina</i> <math>\beta</math> <i>dahurica</i> Fisch.; <i>Phaca membranacea</i> Fisch.; <i>Phaca alpina</i> Led.</p>	<p>Strong main root, thick, often with branches; greyish  Stems 50-100 cm, erect, with thin stripes, white tomentose  Leaves 5-10 cm, petiole obsolete; Leaflets 13-27, elliptic or oblong-obovate, apex obtuse or obcordate; white indumentum at lower surface  Stipules free, ovate, lanceolate or linear lanceolate (triangular-ovate) subacute  Inflorescence somehow dense, 10-20 flowered, oblong-ovoid to ovoid  Bracts linear-lanceolate, white membranous, sparsely covered with black hairs; Pedicels with black hairs; Calyx campanulate, glabrous, hairs practically confined to teeth  Corolla yellow/light yellow</p>	<p>China, Mongolia, Japan, Northern Manchuria, Korea, USSR: E-Siberia, Dau, Far East, Dzungaria, Altai mountains</p>
<p><i>A. mongholicus</i> Bunge var. <i>mongholicus</i>  <b>Syn.:</b> <i>A. membranaceus</i> (Fisch.) Bunge var. <i>mongholicus</i> (Bunge) P.K.Hsiao; <i>Phaca macrostachys</i> Turcz.</p>	<p>Differences from var. <i>dahuricus</i>: plant shorter, leaflets smaller  Calyx: outer surface with white or black indumentum</p>	<p>China, Mongolia, USSR: E-Siberia, Dzungaria</p>
<p><i>A. floridulus</i> Podl.  <b>Syn.:</b> <i>A. floridus</i> Bunge (invalid name)</p>	<p>Strong main root; thick, strong, stretching. Bark light brown (Fu, 1993)  Stems erect, 15-30 cm, moderately stout  Leaves 38-76 mm; Leaflets 25-31, linear-oblong, subacute, glaucous  Stipules: lanceolate or deltoid, free  Inflorescence round or oblong, 12-30 flowered  Peduncles and calyx densely black-silky; Calyx campanulate; Bracts linear, minute; Corolla bright yellow</p>	<p>Endemic to China: Provinces of Gansu, Qinghai, Sichuan, Xizang (Tibet), Yunnan</p>

Table 1. (Continued) Characters, distribution and synonymy of *Astragalus* spp. aligned to Huang-qi.

<p><i>A. penduliflorus</i> Lam. <b>Syn.:</b> <i>Phaca alpina</i> L.</p>	<p>Strong main root, lignified pleiocorm (Hegi....); stems 30-50 cm, many and branched, upright or ascending Leaves 5-10 cm; Leaflets 4-15; elliptic to oblong-lanceolate Stipules: free, lanceolate, acuminate Inflorescence short, 6-14 flowered; Bracts lanceolate, dark-haired like calyx; Corolla yellow</p>	<p>Not in Flora of China checklist, not in Flora of China</p>
<p><i>A. tongolensis</i> Ulbr. <b>Syn.:</b> <i>A. potaninii</i> Kom.; <i>A. veitchianus</i> N.D.Simpson</p>	<p>Root lignified (sub <i>A. potaninii</i>); Stems 30-70 cm, stout, upright or ascending Leaves 10-15 cm; Leaflets 5-7, sessile or short-petioled, broad elliptic to ovate-lanceolate (varying often on the same plant) Stipules large, ovate or lanceolate Inflorescence lax, 10-20 flowered Bracts linear or linear-lanceolate, white or mixed with black hairs on margin; Calyx campanulate, black-haired at upper third; Corolla yellowish-white</p>	<p>Endemic to China: Provinces of Gansu, Qinghai, Sichuan, Xizang (Tibet), Yunnan</p>
<p><i>A. aksuensis</i> Bunge <b>Syn.:</b> <i>Phaca bracteosa</i> Kar. et Kir. non <i>A. bracteosus</i> Boiss</p>	<p>Root cylindrical, subtuberosa (sub <i>Phaca bracteosa</i>); pleiocorm (herbarium); Stems 50-90 cm Leaves 8-12 cm ; Leaflets 2-4, oblong-ovate, subacute to subobtuse, minutely mucronulate Stipules herbaceous, free, ovate or broadly lanceolate Inflorescence lax, many-flowered, flowers nodding; Bracts oblong-ovate to lanceolate, greenish glabrous; Calyx short cylindrical; Corolla yellow</p>	<p>USSR: Tien-shan, Pamir-Altai, Dzungaria (endemic); China: Province of Xinjiang</p>
<p><i>A. ernestii</i> Comber <b>Syn.:</b> <i>A. wilsonii</i> A.D. Simpson non Greene</p>	<p>Main root thick, strong, stretching, 1-2 cm <math>\emptyset</math>, root bark light brown (Fu, 1993); pleiocorm suspected Stems over 30 cm Leaves to 9 cm, short petioles; Leaflets: 4-7, ovate-oblong, obtuse at apex Stipules free, large, broad ovate, acute Young inflorescences dense, later lax, ca. 16-flowered; Bracts obovate, obtuse; Pedicells with black hairs; Calyx campanulate; Corolla yellowish</p>	<p>Endemic to China: Provinces of Sichuan, Xizang (Tibet), Yunnan</p>

Table 1. (Continued) Characters, distribution and synonymy of *Astragalus* spp. aligned to Huang-qi.

<p><i>A. chrysopterus</i> Bunge  <b>Syn.:</b> <i>Astragalus chrysopterus</i> Bunge var. <i>wutaicus</i></p>	<p>Main root, pleiocorm (Hsiao et al., 1964); Rhizome thick, strong, 2 cm <math>\phi</math>, bark yellowish-brown (Fu, 1993)  Stems 30-70 cm  Leaves 4-8.5 cm; Leaflets 12-19, broad ovate or oblong, apex obtuse or obcordate, mucronulate; base attenuate  Stipules free  Many lax inflorescences  Bracts small, lanceolate, white-tomentose at lower surface; Calyx campanulate; Corolla yellow</p>	<p>Endemic to China: Provinces of Gansu, Hebei, Ningxia, Qinghai, Shaanxi, Shanxi, Sichuan</p>
<p><i>A. hoantchy</i> Franch.  <b>Syn.:</b> <i>A. hedinii</i> Ulbr.</p>	<p>Suffruticose (sub <i>A. hedinii</i>); Stems up to 100 cm, stout, upright  Leaves 10-24 cm; Leaflets: 7-12, elliptic-rounded to broad obovate, terminal leaflets caduceous  Stipules membranaceous, white, often free, broad triangular acuminate, petiole nearly foliaceous at base  Inflorescence compact, later lax, 7-17-flowered; Bracts deciduous, narrow oblong to elliptic, acute; Calyx campanulate-tubulous, thin, membranaceous, with several black hairs; Corolla rose to purple, violet when dry</p>	<p>China: Provinces of Gansu, Nei Mongol, Ningxia</p>
<p><i>A. tribulifolius</i> Bunge  <b>Syn.:</b> <i>A. tribulifolius</i> var. <i>pauciflorus</i> Marq.; <i>A. tanguticus</i> Batalin; <i>A. petri-primi</i> Rassul. &amp; Strizh.; <i>Tragacantha tribulifolia</i> (Bunge) O. Kuntze</p>	<p>Strong main root, side roots near the basis, stems probably lignified at base (pleiocorm; Weninger 1992) ; Rhizome long, woody (Fu, 1993)  Stems 6-35 cm, creeping to ascending or upright (Weninger 1992)  Leaves 1-5 cm, short petioles; Leaflets: 3-10, short petioled, obovate, oblong-obovate, linear-lanceolate-elliptic, rarely triangular-cuneate  Stipules: basal broad triangular or triangular-ovate, often semiamplexicaule, median triangular to linear, acute  Inflorescences 2-7 per stem, lax; Bracts yellowish-white to light brown, persistent, linear, acute; Calyx campanulate, dark brown at basis, 1-11 flowered; Corolla violet, purple or dark blue-violet</p>	<p>India: Kashmir; Nepal; China: Provinces of Xizang (Tibet), Gansu, Sichuan; USSR: Tadjikistan</p>

Table 1. (Continued) Characters, distribution and synonymy of *Astragalus* spp. aligned to Huang-qi.

<p><i>A. lehmannianus</i> Bunge  <b>Syn.:</b> <i>A. sphaerophysa</i> Kar. &amp; Kir. var. <i>lehmannianus</i> (Bunge) O. Kuntze</p>	<p>Strong main root, side roots near the basis, stems probably lignified at base (pleiocorm)  Stems 30-65 cm, stout, erect  Leaves 15-27 cm, petiole indistinct, up to 2 cm; Leaflets 6-11, orbicular, rarely broadly cuneate at base, rather thick  Stipules cauline, free, partly adnate at base to petiole, triangular, acute or acuminate  Inflorescence firm, many flowered; Bracts linear, subulate-acuminate;  Calyx tubulose to ventricose, densely velutinous; Corolla yellow.</p>	<p>China: Province of Xinjiang;  USSR: Caucasus, Aral Lake (endemic)</p>
<p><i>A. mahoschanicus</i> Hand.-Mazz.</p>	<p>Root thick, strong, stretching, bark grey-white. Rhizome shortening with branches (Fu, 1993)  Stems over 20 cm long, thin, often branched  Leaves 5,5-7,5 cm; Leaflets 6-7, elliptic or oblong-ovate, obtuse or short acuminate, subrotund at base  Stipules free, almost triangular, acuminate  Inflorescence dense, 15-20 flowered; Peduncles densely black and white-haired; Bracts lanceolate; Calyx campanulate, densely black haired  Corolla when dry yellowish, maybe purple</p>	<p>China: Provinces of Sichuan, Gansu</p>

(Data partly taken from: Fu, 1993; Goncharov, 1965; Higashi et al., 1958; Hsiao et al., 1964; Ildis-Database; Peter-Stibal, 1937/38; Podlech, 1993; Weninger, 1992)