Astragalus Root

Astragalus membranaceus &
Astragalus membranaceus var.
mongholicus

Analytical, Quality Control,
and Therapeutic Monograph

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**Nomenclature**

**Botanical Nomenclature**

*Astragalus membranaceus* (Fisch.) Bge., *Astragalus membranaceus* (Fisch.) Bge. var. *mongholicus* (Bge.) Hsiao.

**Botanical Family**

*Fabaceae*

**Definition**

*Astragalus* consists of the dried roots of *Astragalus membranaceus* (Fisch.) Bge. or *Astragalus membranaceus* (Fisch.) Bge. var. *mongholicus* (Bge.) Hsiao conforming to the methods of identification provided.

**Common Names**

- **United States:** Astragalus.
- **China:** Huang qi, bei qi (Mandarin); beg kei, buck qi (Cantonese).
- **Japan:** Ogi.
- **Korea:** Hwanggi.

![Image of Astragalus membranaceus](image.jpg)

**Figure 1 Astragalus membranaceus.**


**History**

The use of astragalus is thought to date back to the *Divine Husbandman’s Classic of the Materia Medica* [Shen-nong Ben-cao Jing] which was ascribed to Shen-nong, a legendary figure in Chinese culture who is considered the founder of agriculture and Chinese civilization itself. The true origin of this work is largely lost in antiquity and is thought to represent the works of a collection of writers. The first work attributed to Shen-nong dates back to the first century AD while the codification of this work began with the writings of T’ao Hung-ching (AD 452-536). In this work astragalus was classified among the “superior” herbs [shang pin] which were among the most highly respected medicinals for their tonifying activity. This was in contrast to the lower class of herbs which were used for the treatment of disease. According to the writings of T’ao Hung-ching, the upper class of herbs are “rulers...they control the maintenance of life and correspond to heaven. They do not have a markedly medicinal effectiveness. The taking in large amounts or over a long period of time is not harmful to man. If one wishes to take the material weight from the body, to supplement the influences [circulating in the body], and to prolong the years of life without aging” these herbs should be used (Unschuld 1986). Additionally, astragalus was said to be used for “hundreds of diseases in children.” (Yang 1998).

One account from the governmental period [chia-ching] (AD 1522-1566) reported that governmental authorities issued an order demanding delivery of astragalus. As the plant could not be found, a different plant was substituted. This was considered to represent an infraction of such magnitude that the physician who delivered the adulterant was almost beaten to death and was freed only after payment of 30 to 40 pieces of gold (Unschuld 1986).

Other uses ascribed to astragalus in ancient texts include its ability to heal chronic sores, expel pus, act as a tonic to supplement deficiencies, and treat childhood illnesses. In the *Ben-cao Gang-mu* of Li Shi-zhen, one of the most important materia medicas of Chinese medical history, astragalus is described as having “great repute as a tonic, pectoral, and diuretic medicine” (Li 1578). In the works of other Chinese authorities, including Sun Hua, Yuan Su, and Hao Gu, many uses of astragalus are described. These include its ability to treat phlegm and coughing, enhance breathing, prevent unnecessary growths, treat certain types of leukorrhea, arrest spontaneous sweating, improve digestion, and treat various post-partum syndromes.

Traditionally, astragalus continues to be used as one of the primary tonifiers of Chinese herbal medicine. In modern Chinese medicine it is widely used as an immune modulator, especially to support immune health for various chronic degenerative diseases, and it is commonly used as an adjunctive therapy to chemo- and radiation therapy in cancer. Astragalus is listed in the pharmacopoeias of the People’s Republic of China and Japan.
IDENTIFICATION

Botanical Identification

*Astragalus membranaceus* (Fisch.) Bge. var. *mongholicus* (Bge.) Hsiao. Herbaceous perennial from taproot. Stem: 25-80 cm; scandent; with sparse, appressed, white hairs. Leaf: Alternate, sessile, stipulate, odd-mono-pinnately compound, 3-7 cm long, leaflets in 12-18 pairs with terminal leaflet; each leaflet elliptic to oblance-obovate, 5-23 mm long, 3-10 mm wide, glabrous above, white hairs below. Inflorescence: Axillary raceme, 4-5 cm long, peduncle erect, same length as or surpassing leaves, 2-22 dark yellow flowers. Flower: Calyx campanulate, 8-9 mm long, tube 3 times longer than linear-subulate lobes, petals 5, 18-20 mm long, wings (lateral 2 petals) clawed, claw 1.5 times length of limb, lowermost 2 petals fused into 1 strongly keeled petal, stamens 10, 9 fused, 1 free. Fruit: Legume, 10-13 mm long, papery, glabrous. Seed: Reniform, 7-8 mm long, dark brown.

Distribution: Sunny grassland, mountainsides. North-eastern China (Foster and Chongxi 1992), Siberia, and Central Mongolia (Scholz 1992).

**Figure 2a** Wild astragalus [huang qi] (unidentified species) growing in the Ba Shan Mountains, China
Photograph ©1999 Roy Upton, Soquel, CA

**Figure 2b** *Astragalus membranaceus*
Photograph courtesy of Bill Brevoort East Earth Herb, Eugene, OR

**Figure 2c** *Astragalus membranaceus* cultivated Trout Lake Farms, Trout Lake, WA
Photograph ©1999 Roy Upton, Soquel, CA

**Figure 2d** *Astragalus membranaceus* cultivated in Anguo, China
Photograph courtesy of Mark Taylor, Santa Cruz, CA and MayWay Corporation, Oakland, CA
Macroscopic Identification

Astragalus is traded as whole or sliced roots. This material varies significantly in quality with whole roots generally representing the highest quality and the leftover shavings from sliced roots representing the lowest quality (see Figure 3). There are a variety of Astragalus spp. that are traded. For macroscopic differentiation between species see Table 1.

Whole Root (Figure 3): Nearly cylindrical tap roots 30-100 cm long and 0.5-2 (rarely 2.5) cm in diameter, wider at the top, cleaned and stripped of secondary rootlets; twist-
ed near the crown. The outer surface is light grayish-yellow to yellowish-beige in color. Longitudinal wrinkles irregularly dispersed throughout and horizontal lenticel-like patterns are present. A cross section of the top portion of the root reveals the following characteristics: a 2-3 mm-thick light yellowish-white outer cortex; a light yellow xylem appearing as fine medullary rays in smaller roots and appearing as cracks in larger roots; a 1 mm-thick grayish-brown cambium; a pith that is brown but often unobserv-

Figure 3 a-i  Commercial samples of astragalus
Samples courtesy of Asia Naturals, San Francisco, CA; Horizon Herbs, Williams, OR; Pacific Botanicals, Grants Pass, OR; Tai Sang Trading, San Francisco, CA; Lotus Herbs, La Puente, CA. Photographs by Joanne Thompson and Roy Upton, Santa Cruz, CA ©1999 American Herbal Pharmacopoeia™
able. The thickness of the cortex is from one-third to one-half of the diameter of the xylem. The root is difficult to break; the fracture is fibrous (Japanese Pharmacopoeia 1998). Aroma: Slight, starchy. Taste: Starchy, mildly sweet, and bean-like; sometimes accompanied by a slight acridness.

Sliced Root (Figure 3): There are four primary types of slices traded in the United States. The most common are slices that are prepared by soaking and pressing or pounding. These are reminiscent of medical tongue depressors and range in size from 1.5-3 cm wide by 8-18 cm long and from 0.6-4 cm thick. The second most common type of sliced roots are those which are transversely or diagonally sliced from whole roots of varying size and are not otherwise processed. Less common are slices that are pounded and pressed paper thin and are often a deep yellow (sample not available). The lowest quality material is derived from the shavings left over from the slicing process. These consist of the very ends and outer edges of whole roots which are cut away to enhance the cosmetic appearance of the full slices. These slices are very thin and the outer edges are often black or beige. Internally, the color of the various sliced roots range from a pale beige to a pale or deep yellow. The external bark of the sliced roots is a pale grayish-yellow, or pale to dark brown or black, with irregular longitudinal wrinkles or furrows. Roots that are supple and pliable are preferred. The roots are sometimes hard and difficult to break. Roots stored for prolonged periods are brittle and snap easily. The fracture surface is fibrous or splintery.

Powder: White to pale yellow; splintery and fibrous.

Figure 3 j-n Commercial samples of astragalus
Samples courtesy of Asia Naturals, San Francisco, CA; Horizon Herbs, Williams, OR; Pacific Botanicals, Grants Pass, OR; Tai Sang Trading, San Francisco, CA; Lotus Herbs, La Puente, CA. Photographs by Joanne Thompson and Roy Upton, Santa Cruz, CA ©1999 American Herbal Pharmacopoeia™
Table 1 Macroscopic characteristics of Astragalus spp.

|                      | A. membranaceus var. mongholicus | A. membranaceus | A. floridus | A. tongolensis | A. chrysogaster |
|----------------------|----------------------------------|-----------------|-------------|---------------|----------------|-----------------|
| Diameter of midsection (cm) | 1.0-3.5                          | 1.0-3.0         | 1.0-1.5     | 0.8-1.2       | 0.8-1.2        |
| Color of surface      | Light yellow or grayish-yellow    | Yellow or pinkish-yellow | Yellowish-brown or light brown | Dark brown or reddish-brown | Light brown or grayish-brown |
| Surface striations    | Bark hard with shallow and irregular striae | Vertical striae relatively deep and straight with angular grooves | Bark relatively hard and smooth with fine striae | Rough with scars, vertical striae twisted | Bark loose with distinct vertical striae |
| Texture               | Hard, pliable, breakable          | Hard, difficult to break | Hard, difficult to break | Hard, difficult to break | Light and soft, easy to break |
| Section               | Bark white; wood light yellow with a peripheral brown ring | No peripheral brown ring | Wood contains dense concentric alternating yellow and white rings | Wood contains loose concentric alternating brown and yellow rings | Wood golden or orange with many cracks |

Source: Li and others (1994).

Microscopic Identification

Whole Root: When cut transversely, many rows of cork cells with 3-5 rows of collenchymatous cells making up the phellosiderm are observable. The phloem rays are often curved and fissured along the outer part with fibers occurring in bundles. The walls are arranged alternately with sieve tube groups and are either thick or slightly lignified. Stone cells are occasionally visible near the phellosiderm. The cambium forms a ring, and the xylem vessels are either scattered singly or 2-3 vessels occur aggregated in a group. Wood fibers are present among the vessels, and starch grains are contained in the parenchymatous cells (Pharmacopoeia of the People’s Republic of China 1997). Fibers abundant, occurring in bundles or scattered; these are colorless or orange-yellow, ranging from 6-22 µm in diameter, with characteristic thick walls, longitudinal fissures, and truncate or brush-like ends. Stone cells are isodiametric or elongated, with thick, striated walls and simple pits. Xylem mainly bordered-pitted, up to 224 µm in diameter, or occasionally reticulately thickened vessels. Cork thin-walled, several layers deep. Starch grains usually simple, with visible linear or punctate hilum. Calcium oxalate absent.

A. membranaceus var. mongholicus may be differentiated by its fibers which rarely occur scattered and whose secondary walls are often detached from the primary wall; the bordered-pitted vessels which are slightly smaller (up to 160 µm diameter); and fewer starch grains than A. membranaceus. For differentiation between species, particular attention should be paid to the arrangement and amount of the phloem fibers; the shape of the cambium; arrangement of the xylem vessels and fibers; and the presence or absence of stone cells (Feng and others 1996). For complete comparative information of various species see Li and others 1994, Acta Pharamaceutica Sinica 29(11). Hedysarum spp. is sometimes traded interchangeably with astragalus. Hedysarum spp. reportedly can be identified by its fiber bundles which are surrounded by parenchymatous cells containing prisms of calcium oxalate 7-14 µm in diameter and up to 22 µm long.

Figure 4 Microscopic characteristics of Astragalus spp.
1. Bundle of fibers showing truncated ends and adjacent parenchyma.
2. Cork in surface view.
4. Parenchyma of cortex.
5. Xylem vessels; bordered-pitted and reticulately thickened.
6. Bundles of fibers with medullary ray in sectional view.
7. Starch.

Powder: Fibers abundant, occurring in bundles or scattered; these are colorless or orange-yellow, ranging from 6-22 µm in diameter, with characteristic thick walls, longitudinal fissures, and truncate or brush-like ends. Stone cells are isodiametric or elongated with thick, striated walls and simple pits. Xylem mainly bordered-pitted, up to 224 µm in diameter, or occasionally reticulately thickened vessels. Cork thin-walled, several layers deep. Starch grains usually simple, with visible linear or punctate hilum. Calcium oxalate absent (Pharmacopoeia of the People’s Republic of China 1997).
Figure 5 Microscopic images of *Astragalus membranaceus*

- a. Bundle of fibers (400X).
- b. Cork in surface view (400X).
- c. Stone cells (400X).
- d. Parenchyma of cortex (400X).
- e. Xylem vessels (400X).
- f. Starch granules (1000X).
- g. Xylem parenchyma with conspicuous pith (800X).

Microscopic images courtesy of Alchemists Pharmaceuticals, Costa Mesa, CA and Botanicals International, Long Beach, CA

### Table 2 Comparative microscopic characteristics of *Astragalus* spp.

<table>
<thead>
<tr>
<th></th>
<th><em>A. membranaceus var. mongholicus</em></th>
<th><em>A. membranaceus</em></th>
<th><em>A. floridus</em></th>
<th><em>A. tongolensis</em></th>
<th><em>A. chrysopterus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of bark</td>
<td>64±</td>
<td>57±</td>
<td>44±</td>
<td>38±</td>
<td>29±</td>
</tr>
<tr>
<td>compared to radius</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of root (µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T (µm)*</td>
<td>100-140</td>
<td>260-340</td>
<td>140-175</td>
<td>40-80</td>
<td>140-240</td>
</tr>
<tr>
<td>L (µm)*</td>
<td>300-450</td>
<td>600-700</td>
<td>80-120</td>
<td>140-180</td>
<td>120-200</td>
</tr>
<tr>
<td>H (µm)*</td>
<td>350-400</td>
<td>280-490</td>
<td>18-35</td>
<td>70-105</td>
<td>170-195</td>
</tr>
<tr>
<td>TL:H</td>
<td>1:3:3</td>
<td>1:2:1</td>
<td>6:4:1</td>
<td>1:3:2</td>
<td>1:1:1</td>
</tr>
<tr>
<td>Xylem: Shape of section</td>
<td>Long and broad, fusiform</td>
<td>Medium length, fusiform</td>
<td>Thin and long, fusiform</td>
<td>Short, fusiform</td>
<td>Short and broad, fusiform</td>
</tr>
<tr>
<td>Shape of end</td>
<td>Gradually narrow</td>
<td>Gradually sharp</td>
<td>Acute</td>
<td>Slightly obtuse</td>
<td>Convex</td>
</tr>
<tr>
<td>Height - number of cells</td>
<td>58±</td>
<td>27±</td>
<td>39±</td>
<td>17±</td>
<td>21±</td>
</tr>
<tr>
<td>- µm</td>
<td>1200-2400</td>
<td>680-1700</td>
<td>600-2000</td>
<td>500-1000</td>
<td>550-1100</td>
</tr>
<tr>
<td>Width - number of cells</td>
<td>6-7</td>
<td>4-5</td>
<td>2-4</td>
<td>3-4</td>
<td>5-6</td>
</tr>
<tr>
<td>- µm</td>
<td>140-180</td>
<td>120-160</td>
<td>40-80</td>
<td>60-140</td>
<td>80-160</td>
</tr>
<tr>
<td>Length of vessel (µm)</td>
<td>72-360</td>
<td>48-200</td>
<td>100-180</td>
<td>100-200</td>
<td>60-160</td>
</tr>
<tr>
<td>Diameter of vessel (µm)</td>
<td>25-126</td>
<td>48-180</td>
<td>60-120</td>
<td>30-100</td>
<td>60-120</td>
</tr>
<tr>
<td>Distribution of xylem</td>
<td>Scattered, more in inner than outer layers</td>
<td>Crowded mostly in the center</td>
<td>Many in rings, distance between rings: 120-200</td>
<td>Many in rings, distance between rings: 440-520</td>
<td>Many, scattered</td>
</tr>
<tr>
<td>fiber bundles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter of starch</td>
<td>2-4-15</td>
<td>2-8-12</td>
<td>4-10-14</td>
<td>2-6-8</td>
<td>4-10-14</td>
</tr>
<tr>
<td>grains (µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* T = the distance between cambium and the first layer of phloem fiber bundle
* L = length of dense phloem fiber bundle close to cambium
* H = the distance between two dense phloem fiber bundles close to cambium

Source: Li and others (1994).
COMMERCIAL SOURCES AND HANDLING

The roots of A. membranaceous (Fisch.) Bge. and A. membranaceous (Fisch.) Bge. var. mongolicus (Bge.) Hsiao are official in the 1997 edition of the Pharmacopoeia of the People’s Republic of China. Many other species of astragalus are traded as huang qi. These include A. ernestii Comb., A. adsurgens Pall., A. tongolensis Ulbr., A. tibetanus Benth. ex Bge., A. yunnanensis Franch., A. campydotontus Franch., A. aksuensis Bge., A. chrysopterus Bge.

Collection

Traditionally, the roots of 4- to 5-year-old plants are preferred and should be collected in the spring or autumn. Roots harvested in the autumn are reported to be superior (Ling and Yan 1994). After gathering, the roots are cleaned and graded according to size. Some roots are cut and sliced, others are dried whole.

Qualitative Differentiation

Several authoritative sources were consulted regarding the qualitative characteristics of astragalus. The roots from Hun-yuan county of Shanxi Province and the western part of Northeast China are considered to be authentic huang qi (Hu 1995). There are varying opinions as to the true qualitative markers of astragalus with most authorities reporting increased potency with increased root size. In contrast to this opinion, comparative chemical analyses of roots of varying age show that isoflavone and astragaloside concentrations, constituents correlated with activity, decrease as the diameter of the roots increases (Anetai and others 1994). In our samples, increasing age was correlated with a decrease in concentration of most constituents (see Thin Layer Chromatography). Information regarding the effect of aging on polysaccharide concentration was not available.

High quality roots should be dry, but supple, and resist snapping. The outer surface should be relatively unwrinkled. The roots should have a floury texture and a solid deep yellow core, in contrast to material which is lacking a core or in which the core is black or pithy (Yen 1992). Varying cultivation and processing techniques also alter the constituent profile and activity of the plant (see Cultivation and Processing).

According to Professor Shilin Hu, pharmacognostist of the Institute for Chinese Materia Medica in Beijing, astragalus is graded according to the guidelines presented in Figure 6.

Slices: Sliced roots are very common in American trade. They vary in quality. Most are carefully prepared by soaking them in honey water and then pounding them flat, sometimes into tongue depressor-like slices, some pressed paper thin. Some herb processors feel the concentration of constituents is reduced in the soaking process.

It is mistakenly believed that a deep yellow color, a broad width, and a sweet taste are signs of quality. Even relatively thin roots can be flattened wide (see Figure 3) and roots possessing a marked sweet taste have been treated with honey.

Drying

In China, astragalus roots are typically dried in the sun. In the United States, drying at 40 °C in a drying chamber for 3 days has been reported and maintains the relative constituent profile of the whole root (see Figures 10-f-i).

Figure 6 Qualitative grading of astragalus

I. Superior Grade: Cylindrical with no rootlets; before processing, the length is no less than 30 cm long and the diameter, measured at the middle point of the root, is 2-2.5 cm. The surface color is whitish-yellow to brown with faint vertical wrinkles. The thickness of the bark, when viewing the cross section, is no less than that of the central woody part. It is relatively starchy and woody with few fibers and is flexible. It is sweetish tasting with a distinct pea-like aroma. After chewing, not many remnants are left.

II. Median Grade: Cylindrical with no rootlets; before processing, the length is no less than 20 cm and the diameter, measured at the middle, from 1-1.5 cm. The surface color is whitish-yellow to brown with obvious vertical wrinkles. The thickness of the bark when viewing the cross section is approximately one-third that of the central woody part. It is sometimes starchy and less woody than the superior grade. It has a weak sweetish taste and a pea-like aroma. After chewing, some remnants are left.

III. Inferior Grade: Rootlets are present; the diameter, measured at the center, is approximately 1.0 cm or smaller. The surface color is whitish-yellow to brown and has many obvious vertical wrinkles. The thickness of the bark when viewing the cross section is smaller than that of the central woody part. It is relatively woody and inflexible. It is bland tasting with no aroma. When chewing, only fibers will be felt (Hu 1995).

Note: We were unable to obtain superior grade roots according to the parameters described above. Other authorities feel the diameter of the root should be measured at its widest point which is at the head of the root. Roots measuring almost 2 cm in diameter at widest point were obtained. Even the highest quality roots found on the American market may not entirely meet the specifications outlined. It has been estimated that less than 0.5% of all roots meet the superior width specifications. Some authorities feel that roots over 1 cm in diameter are considered to be superior. Much emphasis is placed on the other qualitative parameters as described and careful organoleptic analysis is required.
Cultivation

The concentrations of astragalosides, isoflavones, and alcohol-soluble constituents were assayed in astragalus grown on four different soils: sandy, red, ando, and brown. Astragalus grown in sandy and brown soil with a relatively high concentration of phosphoric acid (5-15 kg/10 acres) yielded the highest concentration of isoflavones and had the best growth. This concentration increased as phosphorus increased. Roots grown in the red and ando soils yielded the highest concentrations of astragalosides. Astragaloside content was also reportedly higher in the more slender roots. There was no difference in alcohol-soluble components between the different groups (Shibata and others 1996a). Polysaccharide concentration was not assessed.

Different constituent profiles were also observed with four different types of plowing techniques: trencher, backhoe, tractor, and no plowing before sowing. The longest roots (up to 80 cm with few lateral roots) were obtained from the trencher plots, whereas in the other three plots the roots reached a length of 40 cm (with frequent lateral roots). Root elongation and lateral root development were correlated with soil hardness (penetration resistance); the harder soils (penetration resistance of more than 6-14 kg/cm²) produced shorter roots with numerous lateral roots. Roots produced in the trencher plots contained high amounts of astragalosides (amounts not given) and relatively low amounts of isoflavonoids. The researchers concluded that astragalus should be grown in fields with good drainage, little water, and low penetration resistance in order to produce longer roots with fewer lateral roots (Shibata and others 1996b). Other researchers reported that neither nitrogen nor potassium fertilizers affect growth or constituent yields (Anetai and others 1995).

Thirty-nine samples of astragalus root grown in different regions of China were tested for their effect on antibody production in in vitro assays. Though complete data are lacking, the authors reported the samples from Shanshi and Nei Mongol [Inner Mongolia] provinces effectively enhanced antibody production, whereas samples from Hsiashi had a weak effect. According to these researchers, activity was not found to be correlated with root diameter, concentration of isoflavonoids, or γ-aminobutyric acid (GABA) concentration, characteristics typically correlated with assessment of quality. The acidic polysaccharide fraction was shown to enhance antibody productions while the weakly acidic fraction suppressed it (Kajimura and others 1997).

Domestic Supplies: Production of organically grown A. membranaceus has begun in the United States. These roots share the same morphological characteristics as Chinese astragalus. Professor S Hu of the Beijing Institute of Chinese Materia Medica conducted an organoleptic analysis of the material. His opinion was that the taproots of the domestic material cultivated at one farm were not as well developed as Chinese astragalus and that the plants were overfertilized and overwatered. It should be noted that astragalus is a member of the Fabaceae family of which many species prefer growing in poor soil conditions.

However, chemical analysis of 2-, 4-, and 6-year-old domestically grown roots at a different location revealed a similar constituent profile as authenticated A. membranaceus. Moreover, the 2-year old roots possessed the highest concentration of astragaloside IV and all other detectable compounds of all the samples analyzed. This analysis showed a quantitative decrease in the primary compounds with increased age (see Figure 10f-i). Most of the bands of the domestically grown material were more prominent than the highest quality commercial Chinese astragalus obtained.

Processing

Slices: The whole roots are soaked in water or a decoction of Koelreuteria paniculata Lax., sliced, and pounded flat (Wagner and others 1997; Yen 1992). Processing with Honey: Astragalus can be either baked or stir-fried with honey and water. The addition of heat and honey is a traditional process employed to enhance the tonifying and nourishing aspects of the medicine (Pharmacopeia of the People's Republic of China 1997). However, processing in this manner has been shown to decrease the macrophage-modulating activity of astragalus (Lau and others 1989).

Adulteration

Hedysarum polybotrys Hand.-Mazz. [hong qi, jin qi, mian huang qi] is medicinally similar and is often traded interchangeably as huang qi. It is produced in the Min County and surrounding areas in Gansu Province in China (Yen 1992). Its surface color is reddish-brown. Like astragalus, it is woolly and fibrous with a sweetish taste and faint pellagra-like aroma. TLC analyses reveal some similarities with astragalus but show that it is lacking in astragaloside IV, the primary compound used as an identifying marker. These findings need to be confirmed through additional analyses with multiple botanically authenticated specimens. According to the literature, Hedysarum is reported to contain some of the flavonoids of astragalus. It also contains polysaccharides which have been shown to stimulate an increase in peritoneal macrophages at concentrations of 500 mg/kg and, like A. membranaceus, has been reported to possess hypotensive activity. Hedysarum vicioides Turcz. is also reported as an adulterant.

Storage

Roots should be stored in a dry, cool area protected from moisture, light, air, and insect infestation. Exposure to sunlight for as little as 30 minutes can bleach out the yellow color.

Preparations

In traditional Chinese medicine (TCM), astragalus is most often used in combination with other herbs in soups, teas, pills, and extracts. In North America, astragalus is used in capsules, pills, tablets, and liquid extracts, both singularly and in combination with other herbs. Specific data for making the various preparations are lacking.
C O N S T I T U E N T S

The constituents most often associated with the activity of astragalus are polysaccharides, triterpene glycosides, flavonoids, and isoflavonoids. The following constituents are reported in the literature for A. membranaceus.

Polysaccharides
The literature is quite confusing concerning the polysaccharide components of astragalus. Often mentioned are: astragalans I-III, AMon-S, AMem-P (Shimuzu and others 1991), AH-1, AH-2 (Fang and others 1982; Morazzoni and Bombardelli 1994; Shimuzu and others 1991; Tomoda and others 1992). These components are generally referred to as polysaccharides A-D or astragalans I-IV and collectively as astragaloglcans. Astragalans I appears to be composed of a mixture of D-glucose, D-galactose, and L-arabinose with a molecular weight in the 36 kDa range. Astragalans II and III are composed solely of D-glucose residues with an average molecular weight of 12.3 and 36.3 kDa, respectively. The glucose units appear to be primarily α-(1-4)-linked with periodic α-(1-6)-linked branches (Huang and others 1981, 1982).

Triterpene Glycosides (Aglcone and Glycosides)
The triterpene components of astragalus are among the most widely studied chemically. A number of related compounds have been isolated from the plant including: atractalosides I-VIII (He and Findlay 1991; Kitagawa and others 1983a, 1983b; Morazzoni and Bombardelli 1994; Wang and others 1987), acetylastragaloside I, isostragalosides I-IV, agroastragalosides I-IV, astraemembranins I and II, astraemembragenin, astraiversianin, daucosterol, β-sitosterol, dancosterol, lupenone, soysaponin (Morazzoni and Bombardelli 1994).

The triterpene glycosides vary by the position, number, and type of sugar residues at positions 3, 6, and 25. Several astragalosides are composed of a single xylopyranosyl substituent at the 3-position which may or may not be acetylated. Others are composed of a disaccharide at this position with a glucopyranosyl residue linked 2-2 to the xylose. Astragaloside VIII appears to be unique in that it possesses a trisaccharide substituent (3-O-α-L-rhamnopyranosyl(2-6)β-D-xylopyranosyl(2-6)β-D-glucuronopyranosyl) at position 3 (Kitagawa and others 1983c). All the astragalosides and close analogs possess the chemically reactive epoxide at the 9-10 position of the steroid nucleus (the pharmacological significance of this highly reactive structural feature is not known, though the safety of astragalus has been well established through empirical use and modern toxicologic investigation (see Safety Profile). Triterpenoids designated as astragaloside A and B have also been isolated (Cao and others 1983, 1985). The stereochemical structures of these two compounds are different from those of astragalosides I-IV.
Isoflavonoids (Aglcycones and Glycosides)
Characteristic isoflavonoid constituents include: mucronulatol, isomucronulatol, demethoxyisoflavon (and numerous methylated and glycosylated derivatives), and formononetin (Kim and Kim 1997; Lu and others 1984; Subarnas and others 1991a; Yu and Liu 1993). The isoflavonoid content of various astragalus samples varies greatly (see Table 3).

**Table 3 Contents of isoflavonoids in various samples of astragalus root**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Habitat</th>
<th>Isoflavonoid Content (μg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>110 25 82 220 108</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>225 89 47 27 56</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>554 132 167 116 277</td>
</tr>
<tr>
<td>4</td>
<td>China</td>
<td>366 55 108 299 109</td>
</tr>
<tr>
<td>5</td>
<td>China</td>
<td>523 549 124 70 50</td>
</tr>
<tr>
<td>6</td>
<td>China</td>
<td>47 71 125 78 85</td>
</tr>
<tr>
<td>7</td>
<td>China</td>
<td>345 108 94 47 355</td>
</tr>
<tr>
<td>8</td>
<td>China</td>
<td>355 35 215 315 187</td>
</tr>
<tr>
<td>9</td>
<td>China</td>
<td>147 19 105 121 185</td>
</tr>
<tr>
<td>10</td>
<td>Korea</td>
<td>236 51 115 165 80</td>
</tr>
<tr>
<td>11</td>
<td>Japan</td>
<td>296 201 92 124 16</td>
</tr>
<tr>
<td>12</td>
<td>Japan</td>
<td>523 214 324 449 79</td>
</tr>
<tr>
<td>13</td>
<td>Japan</td>
<td>383 223 337 467 77</td>
</tr>
</tbody>
</table>


A**N**A**LYTICAL**

TLC/HPTLC

Various TLC systems were compared including the method of the **Pharmacopoeia of the People’s Republic of China** (1997). The method of the Chinese pharmacopoeia was used as the basis for this analysis. The sample preparation was simplified and the ratios of the solvents of the mobile phase and derivatizing agents were modified to enhance reproducibility and performance.

Note: The reference standard astragaloside IV used in the substantiation of this method was isolated by an **American Herbal Pharmacopoeia** (AHP) participating laboratory (Gaia Herbs) and was confirmed by nuclear magnetic resonance analysis. Astragaloside IV was presumably chosen as the reference standard in order to differentiate astragalus from hedyasarum.

Sample Preparation

In an Erlenmeyer flask 1 g of powdered root is extracted with 20 mL of a mixture of ethanol and water (57:43). Shake the flask several times. Filter and evaporate filtrate under vacuum at 45 °C, leaving a concentrate. Remove lipids from the concentrate by treating it with 5 mL of a mixture of ethyl acetate and water (1:1). Remove the upper phase (ethyl acetate) and extract the remaining lower phase (water) with two 2.5 mL portions of fresh ethyl acetate. Discard the ethyl acetate layers. The aqueous phase is extracted 3 times with 5 mL portions of l-butanol. The combined l-butanol extracts are gently washed with three 1 mL portions of water (water and butanol easily form emulsions when agitated vigorously). l-butanol is removed under vacuum and the residue is dissolved in 0.5 mL of methanol. The solution is transferred to a small sample vial. This is the test solution.

Note: Samples of astragalus and hedyasarum were run in order to provide a differentiation between the two. Samples were provided by Asia Naturals, San Francisco, CA; Horizon Herbs, Williams OR; Lotus Herbs, La Puente, CA; Spring Wind Herbs, Berkeley, CA.

Standard Preparation

Astragaloside IV. Prepare standard at a concentration of 1 mg/mL in methanol. This is the standard solution.

Reagent Preparation

**Sulfuric Acid Reagent:**

While cooling with ice, carefully add 5 mL of sulfuric acid to 95 mL of cold methanol.

**Anisaldehyde Reagent:**

While cooling with ice, 9 mL of sulfuric acid are added carefully to a cold mixture of 85 mL methanol and 10 mL acetic acid. To this mixture 0.5 mL of anisaldehyde are added.

Stability and Storage of Preparations

The standard is stable at room temperature and is not photosensitive. (continued on pg 12)
Figure 10a  HPTLC of astragalus and hedysarum, UV 254; read left to right
Lane 1: Astragalus (Chinese sample).  Lane 2: Astragaloside IV.  Lane 3: Astragalus (6-year-old
domestically cultivated root).  Lane 4: Astragaloside IV.  Lane 5: Hedysarum (Taiwanese sample).
Close to the solvent front two very weak bands are visible in the astragalus sample. At the same position
hedysarum shows one or two bands. There are three bands evenly spaced between 0.4 and 0.7
in all samples. Of those bands, the middle is the strongest for astragalus and the lowest is strongest
for hedysarum. Astragalus shows a strong band at 0.15 whereas hedysarum has bands at 0.1 and 0.3.
At this spectra, astragaloside IV is not visible.

Figure 10b  HPTLC of astragalus and hedysarum, UV 366; read left to right
Lane 1: Astragalus (Chinese sample).  Lane 2: Astragaloside IV.  Lane 3: Astragalus (6-year-old
domestically cultivated root).  Lane 4: Astragaloside IV.  Lane 5: Hedysarum (Taiwanese sample).
The two bands close to the solvent front show blue fluorescence. In hedysarum the lower of the two
bands is more intense. Hedysarum can be identified through the presence of a green band at 0.63. At
this spectra, astragaloside IV is not visible.

Figure 10e  HPTLC of astragalus and hedysarum, anisaldehyde reagent, visible light; read
left to right
Lane 1: Astragalus (Chinese sample).  Lane 2: Astragaloside IV.  Lane 3: Astragalus (6-year-old
domestically cultivated root).  Lane 4: Astragaloside IV.  Lane 5: Hedysarum (Taiwanese sample).
Two or three bands close to the solvent front show a violet color. In hedysarum the lowest of these
bands is most intense. In the astragalus sample, two gray bands at 0.7 and several bands between
0.4 and 0.7 are visible. The most characteristic of these is a pink to orange band at 0.63. In the
hedysarum sample there is a single gray band at 0.7 and only a single dark violet band below 0.7.
Astragaloside IV is visible as a dark band at 0.34. This band is present in astragalus and is lacking in
hedysarum. There is a strong dark olive band below 0.1 in all samples.
Note: A comparison of these findings with the TLC work of Wagner and others (1997) suggests that the prominent
bands falling between R, 0.34 (corresponding to astragaloside IV) and R, 0.7 correspond to astragalosides II, the
primary saponins of astragalus. The bands above these are likely due to flavonoid glycosides and saponins.
Since many of these reference standards are not commercially available, these compounds could not be defini-
tively identified.

Figure 10d  HPTLC of astragalus and hedysarum, sulfuric acid reagent,
UV 366; read left to right
Lane 1: Astragalus (Chinese sample).  Lane 2: Astragaloside IV.  Lane 3: Astragalus (6-year-old
domestically cultivated root).  Lane 4: Astragaloside IV.  Lane 5: Hedysarum (Taiwanese sample).
Three bands close to the solvent front show white fluorescence. In hedysarum the lowest of these
bands is most intense. At 0.7 there is an orange band below a white band in astragalus. In the
hedysarum sample only the white band is present. In astragalus the bands between 0.4 and 0.7 show
orange or brown fluorescence. Astragaloside IV has an orange band at 0.34. This band is observable
in the astragalus sample and is lacking in the hedysarum sample. Hedysarum has two characteristic
greenish bands at 0.6 and another greenish band below 0.3. There is a strong dark band below 0.1 in
all samples.

Figure 10c  HPTLC of astragalus and hedysarum, sulfuric acid reagent, visible light; read
left to right
Lane 1: Astragalus (Chinese sample).  Lane 2: Astragaloside IV.  Lane 3: Astragalus (6-year-old
domestically cultivated root).  Lane 4: Astragaloside IV.  Lane 5: Hedysarum (Taiwanese sample).
The two bands close to the solvent front show violet to brown color. Astragalus shows three or four
violet bands between 0.4 and 0.7. Astragaloside IV shows a violet band at 0.34. The astragalus sam-
ple shows a violet band corresponding to astragaloside IV. In hedysarum two intense bands in the
lower portion of the chromatogram and an intense violet band at 0.7 are seen. There is a very strong
dark band at 0.1 in both samples.

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Chromatographic Conditions
Stationary Phase:
HPTLC plates 10 x 10 cm silica gel 60 with fluorescence indicator (EM Science, Whatman, Machery or equivalent).
Note: HPTLC plates allow for better separation, sharper zones, reduced development time, and require less solvent consumption per plate than conventional TLC plates. The method can also be run on standard TLC plates.
Mobile Phase:
Chloroform:methanol:water (18:8:1).
Sample Application:
3 μl volumes of test solution and standard are applied each as an 8 mm band. Space bands 7 mm apart. Application position 8 mm from lower edge of plate.
Development:
10 x 10 cm Twin Trough Chambers (or equivalent), saturated (with filter paper) for 10 minutes, 5 mL developing solvent per trough (or enough solvent to have a level of 5 mm in chamber), developing distance 70 mm from lower edge of plate. Dry plate with cold air for 5 minutes.
Detection:
a) UV 254 nm.
b) UV 366 nm.
c) Sulfuric acid reagent: Immersed plate in reagent for 1 second, dry in stream of cold air, heat to 130 °C for 2-5 minutes. Examine plate in visible light.
d) Examine derivatized plate under UV 366 nm.
e) Anisaldehyde reagent: Immersed plate in reagent for 1 second, dry in a stream of cold air, heat to 110 °C for 2 minutes. Examine plate in visible light.
Rf Values:
Compare to the chromatograms below (see Figures 10a-e).

Note: The 1997 edition of the Pharmacopoeia of the People’s Republic of China includes a quantitative TLC analysis and states that the astragaloside IV content should be no less than 0.04% on a dried weight basis (Pharmacopoeia of the People’s Republic of China 1997). This quantitation was not substantiated by AHP collaborating laboratories.

Figures 10f-i HPTLC of various samples of astragalus (f: UV 254; g: UV 366; h: sulfuric acid reagent, visible light; i: sulfuric acid reagent, UV 366; j: anisaldehyde, visible light; read left to right

Note: All of the samples tested with the exception of the sample designated as hedysarum were labeled as astragalus (huang qi).

There are similarities in all of the samples tested. The sample in lane 2 is unique due to the presence of a strong yellow band which is due to at least two compounds co-eluting in this particular sample (underivatized, UV 366). The same band is present in samples of lanes 4-6 but is of weaker intensity and is likely due to a single compound. These samples, though treated as astragalus, may be hedysarum since the pink band characteristic of astragalus is missing and astragaloside IV is not present (anisaldehyde). Most of the bands of lane 3 are very faint or are lacking. Lanes 10-12 appear to indicate that the intensity of the bands, including the concentration of astragaloside IV, decrease with increasing age of the root. The constituent profile of the root and underground stem sample of lane 14 appears weaker than the other cultivated samples.
High Performance Liquid Chromatography (HPLC)

The HPLC fingerprint analysis of Wagner and others (1997) was adopted. This method identifies both flavonoids and saponins, two classes of compounds most widely associated with the activity of astragalus. The flavonoid fingerprint is characterized by the isoflavones calycosin-7-O-β-D-glucoside and calycosin, the isoflavones isomucronulatol-7-O-β-D-glucoside and isomucronulatol, the pterocarpan 9-methoxy-nissolin-3-O-β-D-glucoside and 9-methoxy-nissolin, and the isoflavone formononetin. Astragalosides are eluted in the following order: astragaloside VI, astragaloside V, astragaloside IV, astragaloside III, isoastragaloside II, astragaloside II, astragaloside I, and acetylastragaloside I. Using this method, the flavonoids elute first with retention times of 10 and 25 minutes and the astragalosides elute later, from 25-50 minutes. Many of the reference standards are not commercially available. Because of the relatively low saponin content in astragalus, it is necessary to enrich the concentration of astragalosides prior to analysis.

Sample Preparation
20 g of coarsely ground astragalus is soxhlet extracted with 200 mL methanol for 1 hour and filtered. The methanol is evaporated under vacuum and the viscous residue suspended in 25 mL hot water. The suspension is extracted twice with water-saturated n-butanol in a separation funnel, first with 10 mL and then with 5 mL.

a) For flavonoids: 250 μL of the n-butanol phase (20 g drug/15 mL n-BuOH) is applied to a C18-cartridge (SepPak) which has been pre-equilibrated and previously eluted with 1 mL methanol. Elute the SepPak with 0.5 mL fresh distilled water to give a butanol:water:eluate solution for HPLC analysis (the sapogenins are retained on the RP-C18 column). The eluate is filtered through a Millipore filtration unit type HV 0.45 μm before injection into the HPLC.

b) For saponins: The total n-butanol phase (20 g drug/15 mL) solvent is evaporated and the residue dissolved in a minimal volume of MeOH (3 mL). This solution is dropped into 50 mL ice-cooled ether:acetone (1:1) mixture. The resulting precipitate (containing the major part of the saponins) is separated by centrifugation, dissolved in 1 mL hot MeOH, and injected into the HPLC.

Standard Preparation
Reference standards are generally not commercially available. If available, prepare standards in stock solutions of 1 mg/1 mL in MeOH (1%).

Stability and Storage of Preparation
Stability unknown. Use standard precautions for storage.

Chromatographic Conditions
Apparatus:
Liquid chromatograph HP 1090 or equivalent.
Photodiode array detector HP 1040 A or equivalent.

Column:
Precolumn: LiChroCART 4-4 with LiChrospher 100 RP 18 (5 μm) (Merck) or equivalent.
Separation column: LiChroCART 125-4 with LiChrospher 100 RP 18 (5 μm) (Merck) or equivalent.

Mobile Phase:
A) Distilled water (+1% 0.1 N-H₂PO₄).
B) Acetonitrile (+1% 0.1 N-H₂PO₄).

Gradient:
10% B in 5 minutes (isocratic).
10% to 20% B in 10 minutes (linear).
20% to 30% B in 20 minutes (linear).
25% to 33% B in 30 minutes (linear).
33% to 35% B in 40 minutes (linear).
35% to 60% B in 50 minutes (linear).

Flow Rate:
1.0 mL/minute.

Detection:
200 nm.

Injection Volume:
25 μl butanol:water eluate (concentration: 20 g drug/15 mL n-BuOH). 25 μl reference solution (concentration: 1 mg/1 mL MeOH [0.1%]). 25 μl precipitate solution (concentration: 100 mg/1 mL MeOH).

Run Time:
50 minutes.

Elution Order:
Flavonoids elute between 10 and 25 minutes.
Astragalosides elute between 25 and 50 minutes. See Tables 4 and 5 below for specific details.

Note: Varying samples of authentically identified astragalus show almost identical flavonoid profiles and differ only in quantities of calycosin and isomucronulatol-7-O-β-D-glucoside (Wagner and others 1997).

Qualitative Standards
Total Ash:
Not more than 5% (Pharmacopoeia of the People’s Republic of China 1997).

Acid Insoluble Ash:
Not more than 1% (Japanese Pharmacopoeia 1998; Pharmacopoeia of the People’s Republic of China 1997).

Loss of Moisture Drying:
Not more than 13% in 6 hours (Japanese Pharmacopoeia 1998).

Moisture:
Not more than 6% (Japanese Pharmacopoeia 1998).

Extractive Matter:
Not less than 17% (Pharmacopoeia of the People’s Republic of China 1997).
**Therapeutics**

**Pharmacokinetics**

Studies on the metabolism, distribution, and excretion of astragalus preparations are not available.

**Pharmacodynamics**

The majority of research on astragalus has focused on its immunostimulatory activity and its seemingly remarkable ability to restore the activity of a suppressed immune system. Both clinical trials and pharmacological data provide evidence for its usefulness in the prevention of the common cold and as an adjunct to cancer therapies. There is also evidence for benefit to the cardiovascular system with improvement in clinical parameters associated with angina, congestive heart failure, and acute myocardial infarct, perhaps due to antioxidant activity. Its use in the treatment of hepatitis in modern Chinese medicine is supported by the demonstration of hepatoprotective activity in animal studies.

Many of the pharmacological studies included in this section were published in Chinese and as a result have been cited from translations, review articles, or English abstracts, rather than the complete primary literature. Numerous original studies were also reviewed. The reports obtained from secondary sources are considered to be authoritative, and the findings cited are consistent with the clinical use of astragalus in the United States and Asia. Several Chinese pharmacologists have reviewed this material to insure its accuracy. Nevertheless, a critical evaluation of much of the secondary literature was not conducted.

**Immunomodulatory Effects**

**Human Clinical Studies**

A number of clinical studies have been reported regarding the use of astragalus for colds and upper respiratory infections. A prophylactic effect against the common cold was reported in an epidemiological study in China involving 1000 subjects. Administration of astragalus, given either orally or as a nasal spray, decreased the incidence of disease and shortened the length of its course. Studies exploring this protective effect found that oral administration of the preparation to subjects for 2 weeks enhanced the induction of interferon by peripheral white blood cells. Levels of IgA and IgG antibodies in nasal secretions were reported to be increased following 2 months of treatment (Chang and But 1987). The effect of astragalus on the induction of interferon was studied in a placebo-controlled study involving 28 people. Fourteen volunteers were given an extract equivalent to 8 g of dried root per day and 14 were given placebos. Blood samples were drawn before treatment, then 2 weeks and 2 months after treatment.

**Table 4** Retention times of the main peaks (flavonoids)

<table>
<thead>
<tr>
<th>Peak</th>
<th>Rt (min)</th>
<th>Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12.0</td>
<td>Calycosin-7-O-β-D-glucoside</td>
</tr>
<tr>
<td>2</td>
<td>20.2</td>
<td>9-methoxy-niasilin-3-O-β-D-glucoside</td>
</tr>
<tr>
<td>3</td>
<td>22.2</td>
<td>Isomoecurinol-7-O-β-D-glucoside</td>
</tr>
<tr>
<td>4</td>
<td>22.8</td>
<td>Calycosin</td>
</tr>
<tr>
<td>5</td>
<td>33.5</td>
<td>Formononetin</td>
</tr>
<tr>
<td>6</td>
<td>34.1</td>
<td>9-methoxy-niasilin</td>
</tr>
<tr>
<td>7</td>
<td>36.1</td>
<td>Isomoecurinol</td>
</tr>
</tbody>
</table>

**Table 5** Retention times of the main peaks (saponins)

<table>
<thead>
<tr>
<th>Peak</th>
<th>Rt (min)</th>
<th>Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27.5</td>
<td>Astragaloside VI</td>
</tr>
<tr>
<td>2</td>
<td>26.8</td>
<td>Astragaloside V</td>
</tr>
<tr>
<td>3</td>
<td>32.5</td>
<td>Astragaloside IV</td>
</tr>
<tr>
<td>4</td>
<td>33.5</td>
<td>Astragaloside III</td>
</tr>
<tr>
<td>5</td>
<td>43.6</td>
<td>Isoastragaloside II</td>
</tr>
<tr>
<td>6</td>
<td>45.8</td>
<td>Astragaloside II</td>
</tr>
<tr>
<td>7</td>
<td>46.6</td>
<td>Astragaloside I</td>
</tr>
<tr>
<td>8</td>
<td>48.0</td>
<td>Acetylasastragaloside I</td>
</tr>
</tbody>
</table>

Source: The HPLC method was developed and substantiated in the laboratory of Prof Dr Hildebert Wagner, Munich, Germany. The method and chromatograms were reproduced from Chinese Drug Monographs and Analyses (available from the American Botanical Council, Austin, TX) with the permission of Verlag für Chemische Medizin Dr Erich Wühe GmbH, Bayer, Wald, Germany (Wagner and others 1997).
Interferon production by leukocytes was statistically increased after both time periods (P < 0.01) (Hou and others 1981). In another study, astragalus was shown to potentiate the effects of interferon (α-IFN-1) in patients with chronic cervicitis (Qian and others 1990). No details of this study were available.

In China, astragalus is widely used in the treatment of cancer, both as a primary treatment and as an adjunct to conventional therapies. It is most often combined with other similarly acting immune-enhancing botanicals. A number of randomized prospective clinical studies of cancer patients were conducted using a combination of astragalus and ligusticum Ligusticum lucidum (undisclosed quantities). Examples of these data are provided here as they are representative of the use of astragalus in modern Chinese medicine. However, these effects are considered to be due to the cumulative effects of the two botanicals and cannot be presumed to occur with astragalus alone.

According to a review article, breast cancer patients given a combination of astragalus and ligusticum as an adjunct to irradiation treatments showed a statistically significant decrease in deaths from 1 in 2 to 1 in 10 (P < 0.05). These authors cited an additional study in which patients with stage II and stage III cervical carcinoma who were given the herbs as an adjunct to irradiation showed a slight, though not statistically significant, increase in survival and disease-free state. In another study of patients with advanced non-small-cell lung cancer, the effectiveness of conventional chemotherapy (chemotherapeutic regimen not reported) was compared to the effectiveness of chemotherapy in conjunction with the same astragalus-ligusticum preparation. Those with squamous carcinoma of the lung showed a significant increase in mean survival time from 204 to 465 days, and those with adenocarcinoma showed a less significant increase in survival from 192 to 324 days (Morazzoni and Bombardelli 1994).

In another review, it was reported that 53 cases of chronic leukopenia responded favorably to astragalus extract (1:1, 2 mL daily intramuscularly [im] for 1-2 weeks). Improvements in symptoms and white blood cell counts were observed, but specific data were lacking (Chang and But 1987).

Animal Studies
Prophylaxis against flu and modulation of endogenously produced interferon has been reported in several animal studies utilizing astragalus alone. Mice given a decoction (concentration not disclosed) of astragalus either orally or as nose drops were protected from infection with parainfluenza virus type 1. Results from 28 experiments with 1299 mice showed that while astragalus did not directly induce interferon it did promote the production of interferon in the mouse lung in response to parainfluenza virus type I (Chang and But 1987).

Potent immunorestorative activity was demonstrated in a xenogeneic graft-versus-host reaction (XGVHR - a measure of T-cell functioning) after administration of crude aqueous extract of astragalus. In this study, mononuclear cells from humans were grafted into rats immunocompromised with cyclophosphamide. The grafted cells survived, recognized host antigens, and reacted against them. The local reaction produced by mononuclear cells from healthy donors covered an area of 82.8 ± 41.1 mm². The reaction produced by cells from cancer patients was less, covering an area of 18.2 ± 15.8 mm². However, after pretreatment of the cells from cancer patients with astragalus extract (10 µg/mL), the reaction area increased to 112.9 ± 94.2 mm² (P < 0.01). The authors concluded the extract had restored to normal the immune response of the mononuclear cells from the cancer patients (Sun and others 1983a).

The astragalus extract used in the above-cited study was fractionated. An active fraction, identified as F3 (molecular weight 20,000-25,000) along with its crude extract precursor, fraction F7, and another crude extract derivative, fraction F8, similarly increased local XGVHR as compared to untreated cells (P < 0.001) (Chu and others 1988a).

In an extension of the above studies, the F3 fraction was injected intravenously (iv) into rats immunocompromised with cyclophosphamide. Mononuclear cells from healthy donors were then grafted into the animals. The same fraction given to the rats at a dosage of 5.55 mg iv for 8 days decreased the reaction size from 99.42 ± 9.2 mm² to 39.8 ± 8.3 mm² (P < 0.001). This reaction size was similar to that in rats not immunocompromised with cyclophosphamide (34.8 ± 5.7 mm²). The authors concluded that the F3 fraction reversed the immunosuppressive effect of cyclophosphamide (Chu and others 1988c). An additional study by the same primary investigator confirmed these findings and reported that the fraction exhibited similar activity as the crude extract in rats (Chu and others 1989).

The immunorestorative effects of astragalus were confirmed by another group using a polysaccharide fraction designated as FB. In a local graft-versus-host reaction, the reaction of cells from normal healthy individuals increased in area from 69.6 ± 20.8 mm² to 148.9 ± 40.8 mm² (P < 0.001). The reaction of cells from 9 advanced-stage cancer patients increased from what was defined as a negative reaction to that within the range of healthy individuals, for example from 29.3 ± 9.5 mm² to 137.2 ± 35.8 mm² (P < 0.001) (Wang 1989).

In another study, fraction F7, characterized as 4.6 mg carbohydrate/mL, increased the number of antibody-producing cells in mice. The F7 fraction was effective when injected immediately before, or up to 1 day after, immunization with the antigen. Immunosuppression induced by cyclophosphamide (100 mg/kg intraperitoneal [ip]), aging (3 months versus 14 months), and irradiation (300 cGy total body) was reversed by ip administration of 0.2 mL of F7 into mice (Zhao and others 1990).

Another group of researchers isolated a polysaccharide fraction, containing astragalans I and II, from the roots of A.
mongholicus. An unspecified quantity of the fraction increased the weight and number of cells in the spleens of mice, stimulated the phagocytosis activity of peritoneal macrophages, and increased the agglutination of sheep red blood cells. Astragalus I, tested separately, increased the weight and number of spleen cells, but inhibited the agglutination of sheep red blood cells (Fang and others 1982).

An acidic polysaccharide fraction derived from a crude hot water extract of A. mongholicus roots, designated as AMon-S, enhanced the ability of tissue macrophages to engulf carbon particles. AMon-S, at 20 mg/kg ip and 40 mg/kg ip increased phagocytosis (P < 0.001 and 0.005, respectively) in mice as measured by the carbon clearance test (the ability of macrophages to engulf carbon particles) (Shimizu and others 1991). A similar glycan designated as AMem-P also showed activity in the carbon clearance model (Tomoda and others 1992).

A decoction of astragalus was studied for its ability to stimulate the generation of blood and platelets from stem cells in the bone marrow of mature Kunming hybrid mice. Proliferation and differentiation of pluripotent stem cells and granulocytic progenitor cells in the bone marrow were enhanced by injection of 0.2 mL of the astragalus extract (equivalent to 0.2 g root) twice daily for 10 days. Increases in the bone marrow-nucleated cells, peripheral white blood cells, and granulocytes were also noted. It was postulated that the effect was not directly on the hematopoietic cells, but rather through uncharacterized humoral factor(s) which have colony-stimulating activity (Rou and Renfu 1983).

A combination of astragalus and ligustrum was shown to reduce tumor load in mice with implanted renal carcinoma. The preparation consisted of 500 µg of each botanical and was administered for 10 days. With an initial tumor load of 1 x 10³ cells, there was 100% inhibition of growth. With an initial tumor load of 2 x 10³ cells, the amount of inhibition was reduced to 57% (Lau and others 1994). In contrast to the aforementioned findings, the same combination was found to be ineffective in preventing cyclophosphamide-induced myelosuppression in rats (Khoo and Ang 1995).

In Vitro Studies
Crude aqueous extracts of astragalus (100 µg/mL) were reported to increase the proliferative response of mononuclear cells derived from 14 cancer patients to stimulus by phytohemagglutinin (PHA) (P < 0.01) (Sun and others 1983b). This finding was confirmed using the polysaccharide fraction designated as FB. Addition of 10 µg/mL FB increased the blastogenic response of lymphocytes obtained from 18 normal individuals and 9 cancer patients to suboptimal concentrations of PHA, concanavalin A, and pokeweed mitogen (P < 0.01 to 0.001). The increase in proliferative response was greater for lymphocytes obtained from normal individuals (Wang 1989). Similar increases in the proliferative rate of mixed lymphocyte cultures and the granulopexis of both macrophages and polymorphonucleates were reported for astragalus polysaccharides (10 µg/mL) (Bombardelli and Pozzi 1991).

In another study, an aqueous astragalus extract (10 g powder to 100 mL water) stimulated oxidative burst (an indicator of phagocytic activity) by a murine macrophage cell line (J774) in a dose-dependent manner. The dose-response curve was bell-shaped with significant enhancement beginning at 10 µg/mL and peak enhancement at 100 µg/mL. Photon emissions increased from 9.7 x 10⁶ to 33 x 10⁶ (P < 0.001) (Lau and others 1989; Lau and others 1990). In further studies these researchers observed a reversal of tumor-associated macrophage suppression of macrophage chemiluminescent oxidative burst. Suppression induced by the addition of viable cells or cell-free extracts of urological neoplasms (murine cell carcinoma and murine bladder tumor) were either completely or partially reversed by extracts of astragalus and ligustrum either alone or in combination (50-100 µg/mL) (Rittenhouse and others 1991).

Batches of crude root from pharmacies in Canada, Hong Kong, and the United States were also tested for their ability to stimulate macrophage activity. Hot water extracts prepared from these samples were found to exhibit a range of potencies, some being quite effective and others having no activity. Specific details were lacking. Honey-baked astragalus, a preparation used in traditional Chinese medicine, reportedly shows little to no effect on stimulating phagocytic activity in murine macrophage cell line (J774) (Lau and others 1989).

Astragalus was also studied for its ability to effect natural killer (NK) cell activity using an enzyme-release assay. The NK cell activity of peripheral blood mononuclear cells (PBMC) from 28 patients with systemic lupus erythematosus (SLE) was increased after in vitro incubation with an undefined astragalus preparation. Low levels of NK cell activity were correlated with disease activity. PBMC from patients with SLE had significantly decreased NK cell activity as compared to those from healthy donors. The extent of stimulation by the astragalus preparation was related to dose and the length of the preincubation period (Zhao 1992).

The effects of an astragalus preparation and α-interferon on NK cell cytotoxicity was studied using human gastric carcinoma cells as targets. Effector cells treated with either astragalus or α-interferon demonstrated increased cytotoxicity. When used together, cytotoxicity was increased 5- to 6-fold. When the target carcinoma cells were pretreated with either astragalus or α-interferon, they were protected from the NK cells. Cytotoxicity was again markedly increased when both the effector and target cells were treated (Jin and others 1983).

The ability of the fraction F3 to potentiate the effects of recombinant interleukin-2 (rIL-2) has been demonstrated. Lymphokine-activated-killer cells (LAK) were treated with a combination of 55 µg carbohydrate/mL of fraction F3 and 100 units/mL of rIL-2. The combination therapy
produced the same amount of tumor-cell killing activity as that generated by 1000 units/mL of rIL-2 on its own, thus showing the astragalus fraction to elicit a 10-fold potentiation of rIL-2 in this in vitro model (Chu and others 1988b). These findings were confirmed in a follow-up study by the same group of researchers using LAK cells from cancer and AIDS patients. In this study, the cytotoxicity of rIL-2 (50 µg/mL) against Hu294t melanoma cell line of LAK cells was comparable to the activity of 500 µg/mL of rIL-2 alone. With the combination, the effector-target cell ratio could be reduced to one-half to obtain a level of cytotoxicity that was equivalent to the use of rIL-2 alone. Additionally, F3 was also shown to increase the responsiveness of peripheral blood lymphocytes that were not effected by rIL-2. In this study, and in another by the same researchers, the authors concluded that the F3 fraction potentiates the activity of LAK cells and allows for the reduction of rIL-2, thus minimizing the toxicity of rIL-2 therapy (Chu and others 1990; Chu and others 1994). Almost identical findings (a 10-fold potentiation) were reported by other researchers who concluded astragalus is effective in potentiating interleukin-2 generated LAK cell cytotoxicity in vitro (Wang and others 1992; Zhou and others 1995).

Astragalus was also found to enhance the secretion of tumor necrosis factor (TNF) from human PBMC. A polysaccharide fraction (molecular weight 20,000-25,000) increased secretion of TNFα and TNFβ after isolation of adherent and nonadherent mononuclear cells from PBMC (Zhao and Kong 1993). Specific details regarding the level of enhancement were lacking.

**Cardiovascular Effects**

**Human Clinical Studies**

Various cardioactive properties have been reported in the literature. In one study, 92 patients with ischemic heart disease were given an unidentified preparation of astragalus. Marked relief from angina pectoris and some improvements as measured by electrocardiogram (EKG) and impedance cardiogram were reported. Improvement in the EKG index was reported as 82.6%. Overall improvement was significant as compared to the control group (P < 0.05) (Li and others 1995). Similar improvement in cardiac performance was reported by other groups of researchers. In one study, 43 patients were hospitalized within 36 hours of acute myocardial infarct. After administration of an astragalus preparation (undefined profile), the ratio of pre-ejection period/left ventricular ejection time (PEP/LVET) was decreased, the antioxidant activity of superoxide dismutase (SOD) of red blood cells was increased, and the lipid peroxidation (LPO) content of plasma was reduced (Chen and others 1995). In another study, 20 patients with angina pectoris were given an undefined astragalus preparation. Cardiac output, as measured by Doppler Echocardiogram (DEC), increased from 5.09 ± 0.21 to 5.95 ± 0.18 L/minute 2 weeks after administration of astragalus (P < 0.01). In this study, no improvement in left ventricular diastolic function and no inhibition of adenosine triphosphate was observed (Lei and others 1994). Intravenous administration of astragalus (undefined preparation) was also reported to significantly shorten the duration of ventricular late potentials in cardiac patients (39.8 ± 3.3 ms versus 44.5 ± 5.9 ms; P < 0.01) (Shi and others 1991).

Patients with congestive heart failure were treated for 2 weeks with injections (unspecified amount) of astragaloside IV, a primary triepern of astragalus. Symptoms, such as tightness in the chest, difficulty in breathing, and exercise capacity, improved. Radionuclide ventriculography showed that left ventricular modeling improved and left ventricular end-diastolic and left ventricular end-systolic volume diminished significantly. The authors concluded that astragaloside IV is an effective positively inotropic agent (Luo and others 1995).

The effect of astragalus on erythrocyte sodium content and sodium transport in patients with coronary heart disease was investigated. Intravenous administration of 24 g/day of Astragalus infused into a 5% glucose solution (250 mL) significantly decreased erythrocyte sodium content and significantly increased sodium pump activity (P < 0.01) (Jin and Dai 1991).

**Animal Studies**

Astragalus saponins were reported to attenuate the scope of myocardial infarction and reduce infarct damage in an acute myocardial infarction model using anesthetized dogs. The authors suggested that the protection resulted from inhibition of the production of free radicals (Lei and others 1995).

In another study, a mild hypotensive effect occurred following iv administration of an undefined astragalus preparation to anesthetized rats. The magnitude of hypotensive effect was reported to be qualitative and quantitative although the exact decline in blood pressure was not reported. The researchers indicated that GABA was the constituent responsible for the hypotensive activity (Hikino and others 1976).

Dose-dependent inotropic effects on coronary flow have also been reported for saponin fractions of astragalus. Extracts were shown to exhibit a negative inotropic effect on the working hearts of rats at 30 µg/mL and a positive inotropic effect at concentrations of 50-200 µg/mL. The authors suggested that the inotropic action was due to a modulation of Na⁺-K⁺-ATPase and worked in a manner similar to strophanthin K (0.75 µg/mL) (Wang and others 1993; Zhong and others 1994).

Astragalus (1.0 g/day ip) was shown to ameliorate abnormal mRNA expressions in the aortic and renal cortex in aorticaval fistula-induced heart failure in rats. In this model, arginine vasopressin (AVP V₁a) mRNA expression levels were decreased in the aortic arch and renal medulla and increased in the renal cortex; levels of mRNA expressions of AVP V₂ receptor and aquaporin-2 increased in the renal cortex and decreased in the renal medulla. The authors concluded astragalus significantly improved the
renal reaction to atrial natriuretic peptide in rats with heart failure (Ma and others 1998).

In Vitro Studies
Astragalus inhibited chemically-induced lipid peroxidation in isolated heart mitochondria by approximately 40% at a concentration of 2 mg dried root/mL mitochondrial suspension (Hong and others 1994). A number of isoflavonoids have been identified as having free radical scavenging activity. This may account for some of the cardioprotective effects attributed to astragalus (Yu and Liu 1993). Astragalus polysaccharides were also reported to prevent free radical damage caused by xanthine/xanthine oxidase added to cultured cardiac cells (Sun and others 1996).

The use of astragalus was reported to be superior to the use of the calcium channel blocker verapamil and the corticosteroid dexamethasone in the treatment of acute viral myocarditis. All three agents decreased the calcium influx across the myocardial plasma membrane in cultured neonatal rat heart cells after infection with coxsackie virus B-3. However, only the astragalus treatment inhibited replication of the virus in this in vitro assay (Guo and others 1996). Additional research suggests astragalus may be used as prophylaxis and treatment of acute coxsackie B-2 virus-induced myocarditis (Yuan and others 1990). In one study, the effects of astragalus were assessed based on changes in morphologic and electric activity of the cells. Rhythm, beating frequency, beating percentage, cardiac cellular damage, and cytopathic effects (CPE) were monitored every 24 hours after challenge; electric activities parameters were measured by conventional intracellular microelectrode technique. Administration of an undefined astragalus preparation in the early period of infection was reported to result in significant protective effects.

Astragalus has been reported to influence blood clotting through two different mechanisms. Human umbilical vein endothelial cells (HUVECs) were pretreated with the saponin astragaloside IV (0.01-100 μg/mL). Upregulation of tissue plasminogen activator (t-PA), which is involved with the breakdown of freshly formed clots (within the first 4 hours), and a downregulation of plasminogen activator inhibitor I (PAI-1), a potent inhibitor of t-PA, was observed. The clinical relevance of this, if any, is not known since this activity is not consistent with the traditional or modern use of astragalus (Zhang and others 1997).

Hepatoprotective Effects

Human Clinical Studies
In China, astragalus is widely used in the treatment of chronic hepatitis. According to a review article, elevated serum levels of glutamate pyruvate transaminase (SGPT) were reported to return to normal, and symptoms associated with the disease subsided within 1-2 months of treatment with an unspecified astragalus preparation (Tang and Eisenbrand 1992). In another report, an aggregate effective rate of 85.7% (significantly effective rate 61.2%) was observed in 49 cases of chronic hepatitis. Normalization of GPT levels was observed in 80% of the responsive patients within 1-2 months of treatment with an undefined injectable astragalus preparation (Chang and But 1987). More detailed data regarding these findings were not available. Positive effects of oral administration of astragalus polysaccharides for treatment of hepatitis were reported by a group of researchers who demonstrated enhanced interferon production in a manner similar to that demonstrated in in vitro studies (Zhang and others 1995).

Animal Studies
In one study, oral administration of an ethanol extract of astragalus reportedly prevented hepatic injury induced by stilbenemide, a hepatotoxic chemotherapeutic agent. Mice given 3 g/kg/day for 11 days had significantly reduced SGPT levels. Histological changes in hepatic tissue, including fatty infiltration, vascular degeneration, and hepatocellular necrosis, were also reduced (Zhang and others 1990).

In another study, fractionated saponins (ASI and SK) isolated from A. membranaceus Bge. and A. sieversianus Pull., respectively, were shown to exhibit marked hepatoprotective effects against liver damage induced by carbon tetrachloride (CCL4), Escherichia coli endotoxin, D-galactosamine, and acetaminophen in mice. The saponins were shown to inhibit the elevation of SGPT levels, decrease malondialdehyde (MDA) content, and increase glutathione (GSH) concentration in mouse livers. In addition, the level of microsomal cytochrome P-450 in all mice given the saponin fractions was significantly increased. The same findings were observed using primary cultured rat hepatocytes. The authors believed this activity was due either to antioxidant or immunomodulating activity (Zhang and others 1992).

In Vitro Studies
A single study exploring the possible effects of astragalus in the treatment of hepatitis B reported significant inhibition of viral protein expression and little effect on viral DNA synthesis (Fan and others 1996). No additional data regarding this study were available.

Antiviral Effects

Animal Studies
Astragalus (250 mg/kg/day for 5 days) in combination with acyclovir (50 mg/kg/day for 5 days) was tested against Herpes Simplex Virus type-1 (HSV-1). The mortality of HSV-1 infected mice was reduced by 46.88% in those treated with the combination therapy. When treated with astragalus or acyclovir alone, reduction in mortality was 34.38 and 21.88%, respectively. In addition, the mean sur-
vival time was extended by 6.16 days with the combined therapy as compared to 4.39 and 2.37 days with the astragalus and acyclovir, respectively (Zuo and others 1995).

In Vitro Studies
One study on the effects of astragalus on a cold virus found that a 0.3% astragalus solution increased the cytopathic inhibitory effects of interferon α2b against rhinovirus type 14 in WI-38, MRC-5, and 2BC human diploid cell cultures by 2.4 times (Zhang and others 1996). No additional data regarding this study were available.

Antioxidant Effects
Animal and In Vitro Studies
The antioxidant potential of components of astragalus has been examined in a series of studies. The findings reported here are in addition to the antioxidant activities cited previously in the review of the cardiovascular and hepatoprotective effects of astragalus. The models used included production of luminol chemiluminescence by xanthine/xanthine-oxidase (Xan/Xo), PMA-stimulated polymorphonuclear leukocytes (PMNs), and hydrogen peroxide ion-induced lipid peroxidation of rat liver homogenate. Flavonoid and saponin extracts were reported to inhibit production of free radicals in all three models. A polysaccharide extract caused a slight inhibition of Xan/Xo emitted chemiluminescence, but it increased the respiratory burst of PMA-stimulated PMNs and lipid peroxidation (Wang and others 1994). In a further study, flavonoid and saponin extracts were reported to inhibit lipid peroxidation in purified human erythrocyte membranes stimulated by oxygen, peroxide, and ultraviolet irradiation (Wang and others 1996a). Atragalosides VI, IV, and III were active in the Xan/Xo model with the LC50 values cited as 11, 50, and 80 μg/mL, respectively (Liu and others 1991). Calycosin, an isolavone isolated from the roots of astragalus, was found to inhibit lecitin peroxidation induced by hemoglobin and hydrogen peroxide with an IC50 of 23.5 μM. This activity was greater than that of both ethylenediaminetetra-aceitic acid (EDTA) (IC50 191.5 μM) and α-tocopherol (IC50 2.6 mM) (Toda and Shirakata 1998).

A flavonoid-rich astragalus preparation was reported to protect DNA in V79 cells against damage by γ-irradiation or hydroxyl radicals at concentrations from 0.6-1.2 mg/mL (Wang and others 1995a, 1995b). Although these concentrations are quite high, this group explored the possibility that this flavonoid mixture might be effective in protecting tissue from free radical damage during radiotherapy treatment of inoperative lung cancer (Wang and others 1996b).

Other Effects
In vitro antibacterial activity of astragalus has been reported against a wide spectrum of bacteria, including Bacillus anthracis, B. subtilis, Corynebacterium diptheriae, C. pseudodiptheriae, Diplococcus pneumoniae, Shigella shigae, Staphylococcus aureus, S. citreus, and S. hemolyticus. No information about the preparation used was reported (Chang and But 1987).

In an attempt to identify Chinese medicinal herbs that might improve human sperm motility, water extracts of 18 herbs were screened with a trans-membrane migration method. The method measures the percentage of sperm that moves across the 5 μm pores of a nuleopore membrane from a semen-extract mixture into phosphate buffered saline during incubation for 2 hours. Astragalus, at a concentration of 10 mg/mL, was the only herb of the 18 tested shown to increase sperm motility when added to both washed and unwashed fractions of human sperm (Hong and others 1992).

In a mouse model for senility, which involved inhalation of ozone and resultant induction of free radicals, administration of astragalus restored the balance of the intestinal flora (Yan and others 1995).

Astragalus root was reported to significantly lower blood sugar levels in streptozotocin-induced diabetic rats (Park and others 1997).

Conclusion
Evidence to support the oral administration of astragalus for treatment of colds, upper respiratory infections, and as an adjunct to cancer therapies comes from its apparent remarkable ability to restore the functioning of a suppressed immune system. Xenogeneic graft-versus-host experiments have demonstrated the ability of astragalus polysaccharides to restore the responsiveness of mononuclear cells obtained from cancer patients. A corroborating in vitro study demonstrated reversal of suppression of macrophage function caused by either tumor cells or cell-free extracts.

Restoration of immune function was also demonstrated in animal models of immunosuppression induced by cyclophosphamide, aging, or irradiation. Other studies report general immune stimulation including; increased stem cell generation of blood cells and platelets, increased lymphocyte proliferation, increased numbers of antibody-producing cells, increased numbers of spleen cells, stimulation of phagocytic activity by macrophages and leukocytes, and increased cytotoxicity by natural killer cells.

The benefits of astragalus to cardiovascular health with relief from angina, congestive heart failure, and improvement in clinical parameters following acute myocardial infarct are demonstrated. Cardiovascular benefits may be due in part to antioxidant properties of astragalus preparations. It is important to note here that, in both clinical and animal studies, astragalus was administered by injection which may preclude application of these findings to dietary supplement products. Animal studies demonstrating protection against hepatotoxic agents support the modern clinical use of the herb for liver diseases.

From the studies cited here it is evident that astragalus preparations have significant therapeutic potential. More
studies are warranted, especially human clinical trials exploring the possible benefits of astragalus to cancer patients and immunocompromised individuals.

**Actions**

Immunostimulant (Chu and others 1988a, 1988b; Hou and others 1981; Jin and others 1983; Sun and others 1983a, 1983b), anticarcinogenic (Lau and others 1994), antiviral (Guo and others 1996; Zuo and others 1995), antioxidant (Hong and others 1994; Wang and others 1996a, 1996b; Yu and Liu 1993), hepatoprotective (Zhang and others 1990; Zhang and others 1992), mild hypotensive (Hikino and others 1976).

**Indications**

Astragalus is most commonly used as a general tonic and specifically for immune enhancement. It has been used to treat the common cold and other upper respiratory tract infections (Hou and others 1981), and it is commonly used to enhance immune resistance in those experiencing recurring upper respiratory infections. Astragalus potentiates rIL-2 (Chu and others 1988b) and α-IFN-1 and -2 immunotherapy (Hou and others 1981; Qian and others 1990) and by lowering the therapeutic thresholds, can reduce the side effects normally associated with these therapies (Chu and others 1988b). It is useful as a complementary treatment during chemotherapy, radiation therapy, and immune deficiency syndromes (Rou and Renfu 1983; Sun and others 1983a, 1983b).

In traditional Chinese medicine and Western clinical herbal medicine, astragalus is most commonly used in combination with other botanicals and is very seldom used as a single agent. Pharmacological research of astragalus in combination with ligustrum provides evidence for activity against cancers of the breast, cervix, and lung. Astragalus has been shown to support hematopoiesis which can lessen side effects and reduce the immunosuppression commonly caused by chemotherapy and radiation therapies for cancer (Rou and Renfu 1983; Zhao and others 1990).

**Substantiated Structure and Function Claim**

Supports immune function, enhances macrophage activity (Hou and others 1981; Shimizu and others 1991; Sun and others 1983a; Tomoda and others 1992).

**Dosages**

Powder:

- 9-30 g daily (Pharmacopoeia of the People’s Republic of China 1997). In serious conditions, 30-60 g daily (Bensky and others 1993). According to the findings of one group of researchers, the optimal dosage for enhancement of macrophage activity is 4-7 g daily for a 79 kg human* (Lau and others 1990).

Decoction:

- 0.5-1 L daily (up to 120 g of whole root/L of water).

Use in Formulas:

- 1.5-9 g (Bensky and Barolet 1990; see TCM Supplement).

Soup:

- Approximately 30 g/3.5 L of soup (simmer with other food ingredients).

*A Lau and others found astragalus to possess an inverted-U dose response curve with lower dosages eliciting significant enhancement of macrophage activity while larger doses had no effect or were immunosuppressive. These researchers suggest that dosages in excess of 28 g per day should be avoided (Lau and others 1990).

**Safety Profile**

**Classification of the American Herbal Products Association**

Class 1: Herbs that can be safely consumed when used appropriately (McGuffin and others 1997).

**Side Effects**

None cited in the literature.

**Contraindications**

None cited in the literature (see TCM Supplement).

**Interactions**

Potentiates the effects of acyclovir (Zuo and others 1995), rIL-2 (Chu and others 1988b), and α-IFN-1 and -2 therapies (Hou and others 1981; Qian and others 1990). May be incompatible with immunosuppressive agents.

**Pregnancy, Mutagenicity, and Reproductive Toxicity**

Specific data are lacking. According to one report, astragalus is reported to have no mutagenic effects (Wagner and others 1997).

**Lactation**

Specific data are lacking. Based on a review of the available pharmacologic and toxicologic literature, no limitation is to be expected.

**Carcinogenicity**

Specific data are lacking.

**Influence on Driving**

Specific data are lacking. Based on the available pharmacologic and toxicologic literature, no limitation is to be expected.

**Precautions**

May not be appropriate for the treatment of autoimmune diseases or following organ transplantation. Since
immunostimulating polysaccharides may stimulate histamine release, allergic symptoms may be aggravated by the use of astragalus.

**Overdose**
Specific data are lacking.

**Treatment of Overdose**
Specific data are lacking.

**Toxicology**
Information on the toxicologic profile of astragalus was reviewed from the available English language literature and is as follows. A crude astragalus extract, prepared by reflux of 100 g coarsely ground root for 6 hours with 1000 mL distilled water and concentrated to 100 mL by rotary evaporation, was administered to rats by lavage at a dosage equivalent to 75-100 g/kg. In this model, no toxicity was reported (Chang and But 1987; Wagner and others 1997). Injection of 50 g/kg ip to mice reportedly elicited no significant toxic reactions though prostration, paralysis, dyspnea, cyanosis, and in some animals, contracture of the extremities, were observed before the death of the animals. The LD$_{50}$ in mice is reported to be approximately 40 g/kg ip (Chang and But 1987). Specific fractions show no or little toxicity (Chu and others 1988b).

**INTERNATIONAL STATUS**

**United States:** Regulated as a dietary supplement.

**China:** Listed in the 1997 Pharmacopoeia of the People's Republic of China (see TCM Supplement for indications).


**Taiwan:** Available with and without a prescription.
Astragalus Root

Huang Qi

**Therapeutics**

Taste and properties: Sweet, slightly warm.

Channels of entry: Lung, spleen.

**Spleen Qi Tonification**

Astragalus supports the transformative and transportive functions of the spleen and uplifts the yang qi of the spleen and stomach. It treats spleen qi deficiency characterized by poor digestion and poor assimilation, abdominal pain due to spleen qi deficiency, general fatigue, poor appetite, anorexia, prolapsed organs, uterine bleeding due to spleen qi deficiency, and chronic diarrhea. Because astragalus is used to tonify the spleen, it is also used to engender blood. It is useful for postpartum fever due to blood and qi deficiency and can be used to assist recovery after severe blood loss (Bensky and others 1993; Li 1590; Pharmacopoeia of the People’s Republic of China 1997).

**Lung Qi Tonification and Securing the Exterior**

Astragalus tonifies the lungs which govern the protective qi, which in turn governs and secures the exterior. It is used to alleviate qi deficiency edema, protect against wind cold external patterns, and treat excessive sweating and shortness of breath caused by qi deficiency. It may also be used to promote sweating in instances when diaphoretics are ineffective (Bensky and others 1993; Li 1590; Pharmacopoeia of the People’s Republic of China 1997).

**Promotes Discharge of Pus and Growth of New Tissue**

Astragalus enhances the eliminative functions of the skin, especially in promoting the healing or elimination of non-healing or nonsuppurative chronic sores or ulcerations caused by deficiency (Bensky and others 1993; Pharmacopoeia of the People’s Republic of China 1997).

**Immune Support**

In China, astragalus is often used to prevent the collapse of immune function associated with conventional chemotherapy and radiation therapy for cancer (Wang 1989). These immune-enhancing therapies are known as *fu zheng gu ben*, which means to “restore the correct and secure the root”. Such therapies are used to enhance nonspecific immunity, protect adrenal cortical function during radiation and chemotherapy, and ameliorate bone marrow depression (Lau and others 1989).

**Actions**

Astragalus tonifies spleen, lung, and vital qi: engenders blood; uplifts yang; secures the exterior and reinforces the protective qi; promotes growth of new tissue; promotes urination; promotes suppuration; reduces edema. In addition to these classically recognized uses, a review of the traditional literature reveals that it drains yin fire (Ang 1694; Li 1590) and that its effects are numerous depending upon with which herbs it is combined.

The honey-fried root is used to tonify qi, uplift yang, and invigorate the spleen (Bensky and others 1993; Li 1590; Pharmacopoeia of the People’s Republic of China 1997).
Indications
Qi deficiency; general weakness, lethargy. Lung qi and wei qi deficiency; shortness of breath, recurring colds, excessive sweating, and inhibited urination. Spleen qi deficiency; anorexia, loose stools, chronic diarrhea, organ prolapse. Astragalus also treats wasting thirst syndromes such as diabetes (Bensky and others 1993; Li 1590; Pharmacopoeia of the People’s Republic of China 1997). Immunologic diseases.

Many references state that astragalus is contraindicat-ed for hot pathologies due to its warming and tonifying nature. However, various classic references specifically cite its use in draining heart and lung fire, draining deficiency fire, and for treating wind heat toxin (Ang 1694; Li 1590). According to Wang An the actions of astragalus vary depending upon which herbs it is combined. He reports, “When used in harmonizing preparations, it tonifies and supplements; in sweating preparations, it relieves the surface; in cooling preparations, it drains pathogenic heat; in moistening preparations, it nourishes the yin and blood.” According to the Pharmacopoeia of the People’s Republic of China (1997), astragalus is additionally used for albuminuria in chronic nephritis and diabetes mellitus.

Standard Formulas
• Tonify the Middle and Augment the Qi Decoction [bu zhong yi qi tang]: tonifies middle burner qi, uplifts yang.
• Jade Windscreen Powder [yu ping feng san]: augments qi, secures the exterior, stops sweating.
• Astragalus and Cinnamon Twig Five Substance Decoction [huang qi gui zhi wu wu tang]: tonifies qi, warms and harmonizes the channels, unblocks painful [bi patterns] obstructions.
• Astragalus Decoction to Construct the Middle [huang qi jian zhong tang]: warms and tonifies the middle burner, moderates spasmodic abdominal pain. Used in severe qi deficiency (Bensky and Barolet 1990).

Safety Profile
Contraindications
Astragalus should be used with care in most excess heat pathologies. It is contraindicated for qi stagnation, damp obstruction, and food stagnation. When the exterior is excess and the pathogen is flourishing, astragalus is also contraindicated for hot toxic skin lesions (Bensky and others 1993).
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