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Baptisia tinctoria (L.) R.Vent
Wild Indigo

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Wild Indigo – *Baptisia tinctoria* (L.) R.Vent

1. Taxonomy

Baptisia tinctoria (L.) R.Vent.
Family: Fabaceae
Common names: Wild indigo, yellow wild indigo, dyer's baptisia, false indigo, horsefly weed, indigo broom, indigo weed, rattlebush, rattle weed, yellow broom, clover bloom.
Synonyms: *Baptisia gibbesii* Small, *Podalyria tinctoria* (L.) Willd., *Sophora tinctoria* L.

2. Botany, distribution,

Baptisia tinctoria is a small, upright perennial attaining a maximum height of four feet. It has smooth, erect stems bearing small trifoliate leaves attached alternately by very short petioles, with small yellow pea-shaped flowers borne on racemes during late spring and summer. The flowers are followed by 1-2 inch long cylindrical pods, which 'rattle' when dry. In the fall the leaves and stems die back. The root system forms slowly expanding clumps, consisting of numerous branching fleshy roots and rootlets. The roots have a thick scaly, dark-colored bark (Krochmal, Walters, & Doughty, 1969; USDA, n.d.). The range of distribution extends from Southern Canada to Georgia and as far west as Iowa, preferring dry fields, clearings and on the edges of woodlands (Rural Action, 2006).

Part Used

The dried root, generally harvested in the fall.

3. Traditional Uses

Traditional use in Appalachia

B. tinctoria is used as an antiseptic, diaphoretic and purgative, and applied to the treatment of ulcers of all kinds (Jacobs & Burlage, 1958). Historically, a tea of the root was used as a laxative and antiseptic, as a wash for cramps and wounds, and gargled for sore throats. It has also historically been used to treat typhus and scarlet fever (Foster & Duke, 2000).

Traditional use outside of Appalachia

Native American

A common use of *B. tinctoria* was as a topical application for cuts, scrapes, bruises and sprains to speed the healing process. It was said to clean cuts and ulcers, keep infection to a minimum and reduce inflammation (Rural Action, 2006). Amongst the Cherokee, it was commonly prepared as a remedy for toothaches by simply pulping the root and pressing against the tooth (Banks, 2004). A decoction of the root was said to allay cramps of the stomach and intestines when rubbed directly on the area. Internally, a decoction was made to address severe coughing with blood, and also used as a tonic kidney remedy (Moerman, 1998). According to Bunting (2000), the Penobscot used *B. tinctoria* as part of a compound decoction.

Folklore & Home

Beach (1851) recommended using the bark in a strong decoction to treat nearly every kind of sore, from sprains and bites to sore eyes and gangrene. *B. tinctoria* was an excellent astringent, antiseptic and stimulant for the healing process not only externally, but internally as well (although not as common). Beach recommends a preparation of a strong decoction thickened with slippery elm (*Ulmus rubra* Muhl.) and applied locally to irritated or inflamed tissues (Beach, 1851). *B. tinctoria* also has a reputation for protecting horses and mules from flies by attaching the plant to the harness – explaining the common name of 'horsefly weed' (USDA, n.d.).

Eclectic

Perhaps the most descriptive indication for the use of *B. tinctoria* was given by Felter & Lloyd (1898) for use in pathological conditions characterized by "feeble vitality with tendency to disintegration of tissue". The keynote of this drug is *sepsis*, accompanied by dark or purplish discoloration of skin and mucous membranes. The appearance of the face is swollen, dusky, and expressionless—has the appearance of "having been long exposed to cold". They commonly used this herb in conditions of weak secretions, "fullness of tissues", stagnation of the bowels and hepatic circulation.

Eclectic physicians recognized *B. tinctoria* as a fairly dangerous herb to use in high doses, as it can provoke an emetic effect with severe vomiting and purging. In low-moderate doses it is stimulating to the digestive tract, causing an increase in saliva and bile secretions. Ellingwood (1919) gave the following description as a specific indication, "…where, with suppressed secretion and marked evidence of sepsis, there is ulceration of the mucous membranes of the mouth, or intestinal ulceration". He also recommended *B. tinctoria* in the early treatment of smallpox and scarlet fever.

Physiomedical

B. tinctoria was regarded as a glandular remedy and antiseptic, particularly in cases marked by tissue destruction. It was applied in typhoid fever, peritonitis, typhus and venereal diseases. The powdered herb was applied to "scrofulous swellings" and abscesses (Lyle, 1897).

Homeopathic

Homeopathic physicians employed *B. tinctoria* in cases of sepsis, sore muscles, typhoid sicknesses and to stimulate fevers. Keynote symptoms are muscular soreness and "putrid phenomena" (Boericke, 1927).

Regulars (Allopathic and practicing physicians)

By the early in the 19th century *B. tinctoria* had gained a reputation in the medical community as an antiseptic application for wounds and ulcers, as a gargle in scarlatinal sore throat and as an internal medicine for typhus and scarlet fevers (Johnson, 1884). It was included in the first revision of the United States Pharmacopoeia in 1830, but was omitted from the second revision in 1842 (Bunting, 2000). It was included in the National Formulary between 1916-1936, classed as an emetic cathartic, stimulant, astringent and antiseptic.

4. Scientific research

Phytochemistry

Alkaloids

Analytical studies were conducted on alkaloids of the *Baptisia* genus in the late 19th and early 20th centuries, much of which was published in German (eg. Gorter, 1897). *B. tinctoria* contains quinolizidine alkaloids (also known as lupine alkaloids) including sparteine, cytisin (previously known as baptitoxon), n-methylcytisin and anagyrine (Cranmer & Mabry, 1966). Sparteine, a major constituent in Scotch broom (*Cytisus scoparius* (L.) Link., is cardioactive and oxytocic (Bruneton, 2002).

Phenolics

Gorter (1897) described the isolation of a phenol glycoside from *B. tinctoria*, which he named baptisin, along with its aglycone baptigenin, with a formula of $C_{14}H_{12}O_5$. This compound was later characterized as an isoflavone (see below) (Wack, 2003). In 1915 Clark described the isolation of another new phenol from *B. tinctoria* leaves which he named baptisol ($C_{15}H_{12}O_5$), the compound responsible for the characteristic blackening of the leaves following bruising or frost damage (Clark, 1915). Subsequently the simple coumarin scopoletin has also been identified in the species (Scenderi, 2003).

Flavonoids

In common with other leguminous plants, *B. tinctoria* aerial parts are rich in isoflavones, including genistein, biochanin A, baptisin, maackiain and formononetin (Alston, 1965; Markham, Mabry, & Swift, 1970; Harborne, Baxter, & Moss, 1999; Wack, 2003). A thin layer chromatography (TLC) method for separating flavonoids in *B. tinctoria* extracts has been published (Gocan, Cimpan, & Muresan, 1996).

Polysaccharides

Wagner and co-workers isolated water-soluble acidic polysaccharides in *B. tinctoria*, (Wagner et al., 1984; Wagner & Jurcic, 1991). Further characterization of high molecular weight fractions from water soluble extracts of *B. tinctoria* roots revealed the presence of arabinogalactan-proteins (AGPs), similar to those previously identified in *Echinacea* species (Wack, Classen, & Blaschek, 2005). These AGPs typically have high carbohydrate levels (about 90%) with less than 10% protein (Classen, Thude, Blaschek, Wack, & Bodinet, 2006). Full characterizations of AGPs in *B. tinctoria* and *B. australis* are presented in a dissertation by Maren Wack (Wack, 2003).

Glycoproteins

Chromatographic separation of aqueous-ethanolic fractions of *B. tinctoria* roots revealed the presence of four glycoproteins, each consisting of several common amino acids and levels of sugars that varied between 8% and 27% (Beuscher, Scheit, Bodinet, & Kopanski, 1989). Quantification of the compounds was performed with a highly sensitive enzyme immunoassay method (ELISA) (Egbert, Bodinet, & Beuscher, 1989; Egert & Beuscher, 1992). Further purification of the glycoproteins was achieved using immune-affinity chromatography and preparative isoelectric focussing techniques (Bodinet, Beuscher, & Kopanski, 1989).

Triterpenes

Analysis of root extracts of the North American species *Baptisia australis*, revealed the presence of two triterpenoid saponins, kaikasaponin III and a new compound named

baptisiasaponin (Udayama, Kinjo, & Nohara, 1998). The presence of saponins in a closely related species suggests similar compounds may be present in *B. tinctoria*.

Pharmacology

Investigative research has centered on immunomodulatory effects of *B. tinctoria*, either alone, or, more commonly, in conjunction with other botanicals such as *Echinacea* spp. The majority of the studies have been conducted in Germany and published in German language. Isoflavones in *B. tinctoria* are known to have estrogenic properties, but there are no specific studies conducted on this species (Duke, 2002).

Polysaccharides from *B. tinctoria* showed significant immunostimulating activity as assessed by the *in vitro* granulocyte test and the *in vivo* carbon-clearance test (Wagner et al., 1984). Beuscher & Kopanski (1985) found that aqueous-ethanolic extracts of *B. tinctoria* had immunostimulatory activity, exhibiting significant potential for lymphoblastoid transformation *in vitro*, while the polysaccharide fraction stimulated antibody production against sheep erythrocytes. Further purification of high molecular weight fraction led to separation of glycoproteins, which were potent lymphocyte DNA synthesis-stimulants (Beuscher et al., 1989). AGPs and glycoproteins from *B. tinctoria* stimulated enhanced secretion of the endogenous immunostimulant interleukin 1 (IL-1) (Beuscher, Beuscher, & Bodinet, 1989). In combination with *Echinacea angustifolia* DC., *B. tinctoria* demonstrated significant phagocytocic activity in the granulocyte carbon-clearance tests (Wagner & Jurcic, 1991). The combination of the two extracts was notably more potent compared to the *Echinacea* extract used alone.

Using an ELISA method it was shown that there was no cross-reactivity to lipopolysaccharide (LPS) contaminants or polysaccharides of *Echinacea* or others species used in combination with previous *B. tinctoria* experiments, indicating the antibodies raised during the experiments are highly specific for the polysaccharides of each species (Egert & Beuscher, 1992). AGPs from *B. tinctoria* also demonstrated significant proliferation and IgM-production of mouse lymphocytes and nitrite- and interleukin 6 (IL-6) production in alveolar mouse macrophage cultures (Classen, Thude, Blaschek, Wack, & Bodinet, 2006).

An herbal immunomodulating formula consisting of *Echinacea purpurea* L., *E. pallida* NUTT., *B. tinctoria and Thuja occidentalis* L. was tested for cytokine activity in mice. While there was no systemic enhancement of cytokine titers, localized activation of cytokines in the gut and upper respiratory tract occurred. The treatment also led to significantly increased spleen weight and other immune parameters in immunosuppressed mice, but there were no changes in normal mice (Bodinet, Lindequist, Teuscher, & Freudenstein, 2002).

Clinical studies

Human research into *B. tinctoria* has been limited to use in German proprietary polyformula products under the name of Esberitox®, consisting of *Echinacea* spp., *Thuja occidentalis* and *B. tinctoria* standardized for polysaccharide and glycoprotein content. Several earlier studies published in European Journals have supported the use of Esberitox® for upper respiratory tract infections (see summary in Blumenthal, 2003 pp. 94-95), while recent studies confirm that treatment with the polyformula leads to reduction of common cold symptoms (Naser et al., 2005), as well as to faster recovery in

chronic bronchitis patients when given in conjunction with antibiotic therapy (Hauke, Kohler, Henneicke-von Zepelin, & Freudenstein, 2002). No serious adverse reactions were reported in these studies.

5. Modern Phytotherapy

Modern therapeutic use of *B. tinctoria* reflects traditional indications. The *British Herbal Pharmacopoeia* (BMHA, 1983) lists upper respiratory infections as the most specific indication, but suggests *B. tinctoria* to be of benefit in a wide-variety of inflammatory and infectious conditions of the mouth, throat and skin. It has been used as an immune-enhancing remedy to support convalescence (Mills & Bone 2000). The naturopathic literature (Kuts-Cheraux 1953) supports the above uses and describes *B. tinctoria* as an alterative and a circulatory stimulant, particularly useful in "septic conditions associated with areas of degeneration and tendencies to breakdown and ulcerate". It is highly regarded for acute and recurring tonsillitis in children (Santich & Bone, 2008). The strong reputation of this herb in minimizing tissue destruction while stimulating endogenous repair mechanisms makes *B. tinctoria* an intriguing choice for further research.

Table 1: Modern phytotherapeutic uses of *B. tinctoria*

ACTIONS	
Antimicrobial	Cathartic
Immunostimulant	Cholagogue
Antipyretic	Mild cardioactive
Antiseptic	Alterative
THERAPEUTIC INDICATIONS	
Upper respiratory tract infections : laryngitis, tonsillitis, pharygitis, sinusitis, lymphadenitis, nasal catarrh, common cold	
Oral cavity: Mouth ulcers, gingivitis, stomatitis pyorrhea	
Skin: Boils, carbuncles, cysts; As a poultice for wounds and gangrenous ulcers, sore nipples.	
Chronic viral infections, chronic fatigue syndrome	

(BMHA, 1983; Chevallier, 1996; Scenderi, 2003; Foster & Duke, 2000)

Specific indications

Septic conditions with lymphatic involvement (Felter, 1922)

Combinations
Used in combination with *Echinacea spp.*, *Capsicum spp.* and *Commiphora myrrha* (Nees) Engl. for throat infections (BHMA, 1983)
With *Echinacea angustifolia* for chronic viral conditions and chronic fatigue syndrome (Chevallier, 1996).
With *Thuja occidentalis* and *Echinacea* spp. in Esberitox®

Toxicity and contra-indications
The *Botanical Safety Handbook* classifies *B.tinctoria* in Class 2(b): "Not to be used during pregnancy" and Class 2d: "Not for long-term use except under medical supervision" (McGuffin, Hobbs, Upton, & Goldberg, 1997).
Large doses may cause vomiting and diarrhoea.

Preparation and dose
Dried root: 0.5-1g three times daily as a powder or by decoction
Fluid Extract 1:1 0.3-1.3mL three times daily (BHMA, 1983).
Fresh root extract 1:2 (fresh). 0.5-1ml, three times daily.

Regulatory Status
B. tinctoria is regulated in the U.S.A. as a Dietary Supplement.

6. Sustainability considerations

Ecological status / RTE status
B. tinctoria is considered widespread, abundant and secure globally, being critically endangered only in the northernmost limits of its range in Maine (USDA, 2008). It is listed as "at risk" in Iowa and Ontario (Maine Dept. of Conservation, 2008), threatened in Illinois (IL DNR, 2004) and Kentucky (White, 2010) and on the watch list for Indiana (IN NHDC, 2010) (See Appendix-1). It is on the United Plant Savers "to watch" list.

In Maryland *B. australis* or wild false indigo is considered the threatened species but it is readily distinguished by its blue flowers (MD WHS, 2010).

Harvesting and collection regulations
The only restrictions found were for North Carolina which limits wild harvesting of *B. tinctoria* roots to 100 pounds, according to standard restrictions for gathering medicinal plants (NCNFS, 2005).

Market data

Harvesting impact
Historically most *B. tinctoria* from the United States has been harvested from the wild, but there is growing interest in its potential as a cultivated crop (Drabik, 2006) - especially in Germany (Grotkass, Hutter & Feldman, 2000). In a report prepared for North Carolina, 21 companies were surveyed regarding their use and purchasing of medicinal plants for *B. tinctoria*. Only the whole root was purchased direct with 50% coming from wild-gathered and 50% from cultivated sources (Greenfield & Davis, 2003).

Table 2. Pricing and marketing data for *B. tinctoria* dried root

	2001 (Greenfield & Davis 2004)	**2004 (Drabik, 2006)**
bulk sales/	$4.50-$5.00	$2.00-4.00 /lb
wholesale		$12.00-13.00/lb
retail		$15.30/lb
Internet		$7.00/oz
Total pounds consumed/year	12,000 lbs in NC	

The data in Table 2 reflects the Greenfield and Davis (2003) prediction that prices would gradually fall as European demand is met increasingly by cultivated sources from small farms in Europe.

Cultivation

Habitat

Wild indigo grows in well-drained soil in full sun to partial shade in dry open woods (Greenbelt & Davis, 2005; Belt, n.d.). Wet soils should be avoided as they may cause root rot and crop loss.

Seeds

Greenfield & Davis (2003) noted that seed stock was not readily available for commercial growers and seeds are difficult to germinate. Seed germination can be increased by scarification using sandpaper and then immediately soaking the scarred seeds for 24-hours. Belt (n.d.) recommends maintaining soil temperatures at 50 degrees F. Once germination has been successful, plants are ready for the field in about 3 months Plants dislike soil disturbances and do not respond well to mechanical cultivation (Belt, n.d.)

Roots

Roots can be divided into two- to three-inch pieces, either in spring or fall and transplanted into beds spaced about 18 inches apart. Beds are covered with mulch or leaves (Greenfield & Davis, 2004).

Cuttings

Cuttings can also be made from the plants. Blakley takes his cuttings in late spring or late summer, then transplants to the field twelve weeks later (Sturdivant & Blakley, 1999).

Meristem cultivation

Because of the difficulty in germinating the seeds of *B. tinctoria*, German researchers (Feldman, 2011) developed an alternative cultivation method. Meristem cultures were taken from week-old seedlings germinated from seed collected from wild populations in Ohio. The introduction of symbiotic microorganisms was crucial to commercial survival rates (Grotkass, Hutter & Feldman, 2000). Plants were transplanted to fields and cultivated for three years. Vibrating plows are used to loosen the roots which are then harvested.

Harvesting and drying

Roots are harvested in the fall during the second or third growing season as the plants begin to die back. Both hand tools and mechanical diggers are used (NCSU, 2003; Feldman, 2011). Roots should be kept shaded or otherwise protected until harvesting is complete. If the lateral roots are removed and the crowns divided, drying time will be improved. Once the roots are thoroughly washed, they are place in an herb dryer. If a dryer is not available, rooms in a barn can be modified for drying. The roots should be spread on non-aluminum screens and arranged so that air circulates freely. Dry the roots in normal seasonal temperatures by circulating air rather than adding heat to complete the drying process. If humidity levels are high, it may be necessary to introduce some heat while maintaining good air circulation. Store dried roots in lightproof sacks, burlap bags, or polybags in a cool, dry, dark location (Greenfield & Davis, 2004).

Insects and Disease

B. tinctoria is considered susceptible to the following diseases: powdery mildew, *Erysiphe polygoni*; rust, *Puccinia andropogonis*; stem diseases, *Diaporthe arctii*, *Mycosphaerella baptisiicola*, and *M. granulate*. Root rot may be a problem in poorly drained soils (Greenfield & Davis, 2004). Seeds gathered from the wild have a low germination rate because of weevil predation (Belt, n.d.)

7. Summary and moving forward

It is an intriguing fact that the majority of the analytical and experimental research conducted on this endemic species has been conducted in Europe, presumably reflecting higher demand and greater regard for its healing virtues in that continent. Unfortunately the European studies are more focused on *B. tinctoria* as an ingredient in polyformulae, and it would be advantageous for U.S. researchers to study the purported immunomodulatory effects of simple herb extracts as well as in selected combinations – both experimentally and clinically.

While *B. tinctoria* may not be considered endangered over much of its range, wild populations could become vulnerable should demand suddenly increase as sometimes happens. Sites where wild-harvesting occurs require careful monitoring, and cultivation programs should be initiated or extended in order to take pressure off the wild populations.

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Appendix-1

Endangered, threatened, rare status.

State or region	Status	Source
Global	G5 - Widespread, abundant & apparently secure globally	Maine Dept. of Conservation, 2008). According to (http://www.appalachianforest.org/ptw_wild_indigo.html)
Canada	considered at risk in Ontario, Canada.	Maine Dept. of Conservation, 2008). According to (http://www.appalachianforest.org/ptw_wild_indigo.html)
ME	S1, critically endangered	Maine Dept of Conservation, 2008. Maine is northern range limit, declining populations (one known population where it may be affected by road maintenance), vulnerable to human activity
IL	threatened	Nyboer & Ebinger, 2004
IA	special concern	Iowa Natural Resource Commission, Iowa Administartive Code, 1999 http://www.appalachianforest.org/ptw_wild_indigo.html

KY	threatened	Endangered. Kentucky Rare plant Report, 2010. accessed at http://naturepreserves.ky.gov/pubs/publications/KYRarePlantReport_2010.pdf
IN	watch list	Indiana Natural Heritage Data Center (2010) Indiana county endangered, threatened and rare species list. Indiana Dept of Natural Resources, Division of Nature Preserve, Indiana Natural Heritage Data Center.