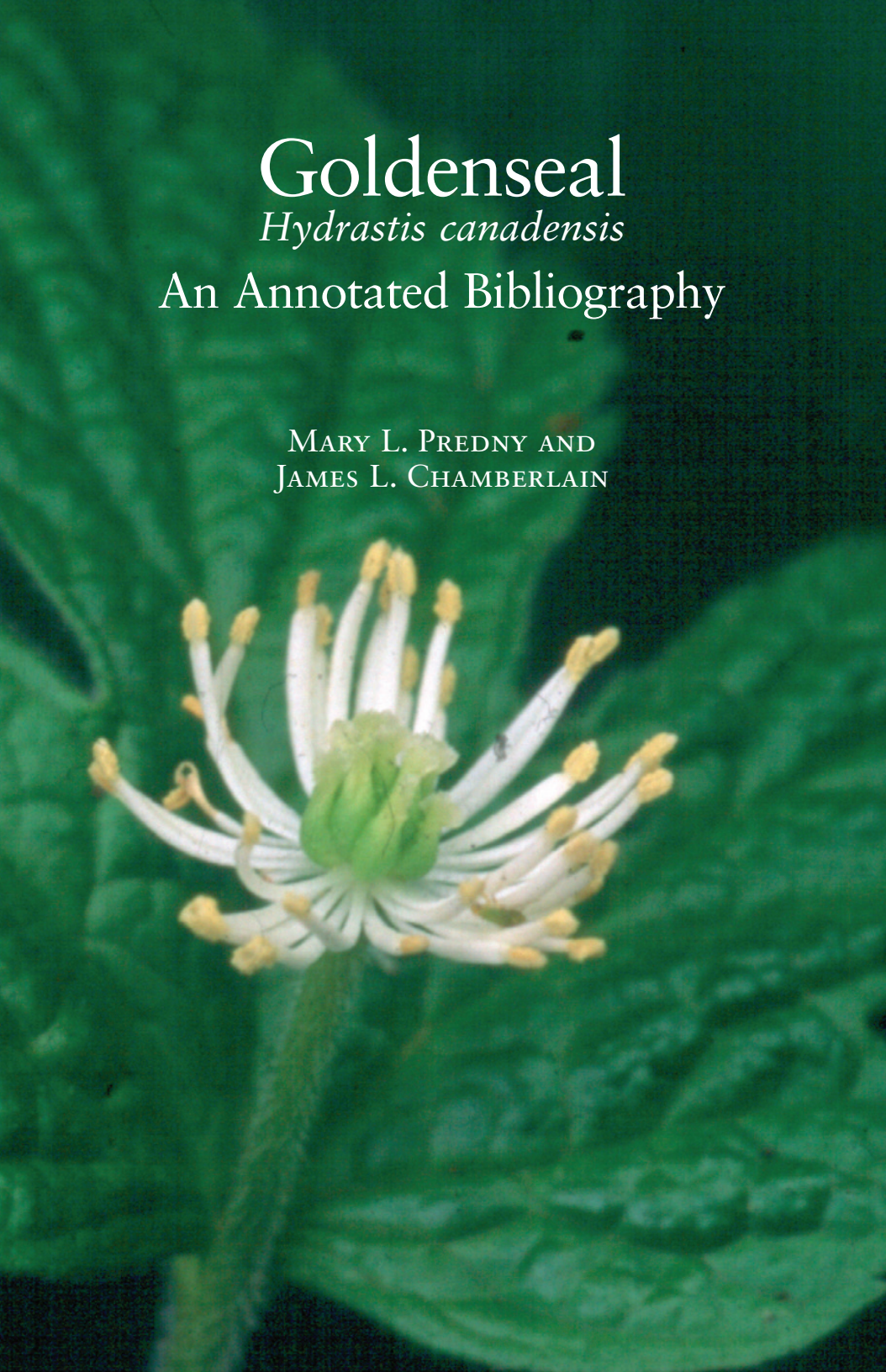
Goldenseal
Hydrastis canadensis
An Annotated Bibliography

Mary L. Predny and
James L. Chamberlain



Goldenseal *(Hydrastis canadensis)*

is a medicinal forest herb with antibiotic attributes.

THE AUTHORS:
Mary L. Predny, *Research Associate*, Virginia Polytechnic Institute and State University, Wood Science and Forest Products Department, Blacksburg, VA 24061.

James L. Chamberlain, *Research Scientist*, U.S. Department of Agriculture, Forest Service, Southern Research Station, Blacksburg, VA 24060.

Cover photograph by Thomas G. Barnes

Goldenseal (*Hydrastis canadensis*): An Annotated Bibliography

Mary L. Predny and James L. Chamberlain

Statements made by authors cited in this document concerning medicinal uses and properties may not have been evaluated by the Food and Drug Administration, and are included for educational purposes only. Discussion of medical uses is not intended for diagnoses, treatment, cure, nor prevention of disease. Goldenseal should not be used during pregnancy. Information in this publication about medicinal uses is intended for educational purposes only and is not a substitute for the advice of qualified healthcare professionals. Material presented in this document is for reader information only and does not imply endorsement by the U.S. Department of Agriculture.

Table of Contents

Goldenseal (*Hydrastis canadensis*): An Annotated Bibliography

Mary L. Predny and James L. Chamberlain

Abstract

Goldenseal (*Hydrastis canadensis*), a member of the buttercup family (Ranunculaceae), is an herbaceous perennial found in rich hardwood forests throughout the Northeastern United States and Canada. Originally used by Native Americans as both a medicine and a dye, the herb was eventually adopted by the settlers and eclectic physicians[1] in the 19th century. The alkaloids in goldenseal have been found to have antibiotic, anti-inflammatory, antispasmodic, and tonic effects. Scientists and physicians continue to expand on the knowledge of the clinical applications and disease-fighting potential of the plant. Growing awareness of possible medicinal benefits has increased worldwide consumption, which, combined with a continual loss of habitat, has greatly reduced wild populations. Goldenseal has been listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II protection since 1997. Demand for cultivated roots has increased as wild populations become scarce, motivating research into propagation and cultivation techniques. More attention should be focused on: educating consumers about the appropriate uses of the herb in order to reduce overconsumption; working with growers to increase the profitability of cultivation and reduce pressures on wild plants; and identifying and tracking wild populations to determine the most effective management and conservation practices.

Keywords: Conservation, goldenseal, *Hydrastis*, medicinal herbs, nontimber forest products, poaching.

Botany and Ecology

Goldenseal (*Hydrastis canadensis*) is an herbaceous perennial found in rich hardwood forests throughout the Northeastern United States and Canada (Small and Catling 1999). The herb's range encompasses the Ohio River Valley with Cincinnati serving as an important trade center (Grieve 1931) (fig. 1). Most wild-harvested goldenseal comes from the few surrounding States: Ohio, Kentucky, Indiana, West Virginia, and Virginia (Grieve 1931, Harding 1936). Although the range extends north into Ontario and Minnesota and south into Georgia and Missouri, overharvest and habitat loss have greatly reduced wild populations in most of these areas (NatureServe Explorer 2002, U.S. Department of Agriculture 2001).

[1] Eclectic physicians were doctors who treated patients with herbal medicines between the late 1800s and early 1900s.

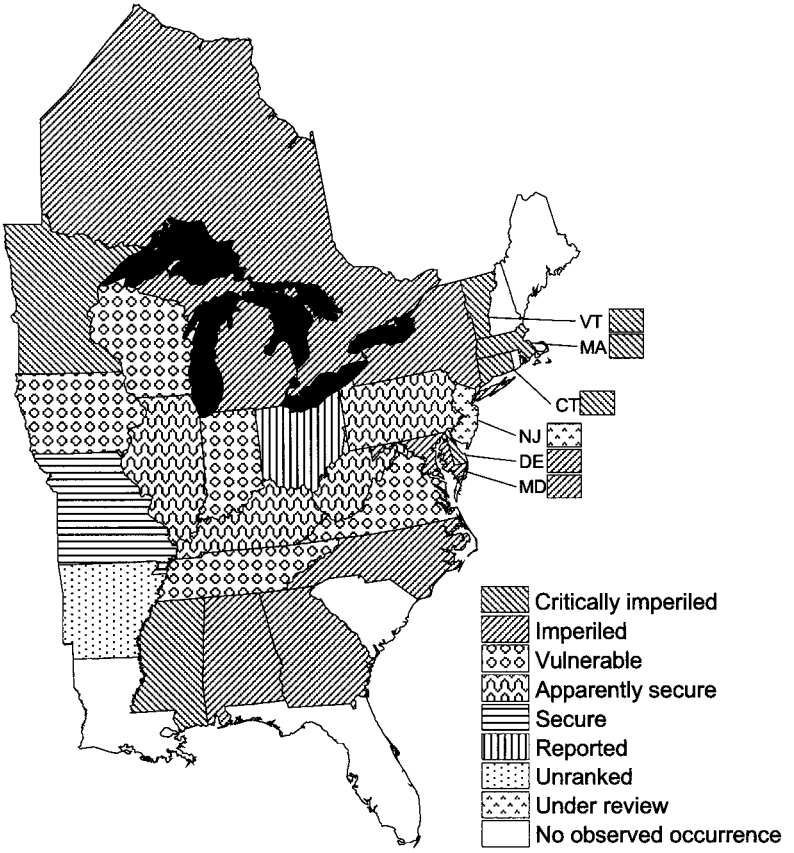


Figure 1—Goldenseal range and distribution (adapted from NatureServe Explorer Database 2002 and U.S. Department of Agriculture, Natural Resources Conservation Service 2001).

Mature goldenseal plants emerge in early spring with a pubescent, cylindrical stem that reaches 12 inches tall (Grieve 1931, Sievers 1930) (fig. 2). The stem is a bright yellow color below ground and purplish above, with several small scales at the base (Cech 2002, Miller 1988). Each stem is forked, with two terminal five- to seven-lobed palmate leaves (Foster and Duke 2000). One leaf is usually larger than the other; leaves range from 3 to 12 inches wide and 3 to 8 inches long (Harding 1936, Plyler 2001–02). Both leaves are dark green, prominently veined, and have serrate margins (Grieve 1931). Immature or weak plants form a stem with one leaf and no flower (Miller 1988, Sievers 1949).

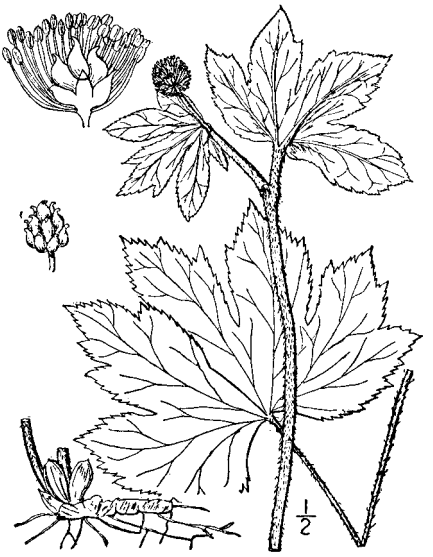


Figure 2—Goldenseal plant (Britton and Brown 1913).

Flowers appear in April and May when the leaves are only partially developed and typically last only 5 or 6 days (Foster and Duke 2000, Harding 1936). Individual blooms are only a half-inch in diameter, with three small petal-like sepals that fall away as the bud expands (Grieve 1931, Small and Catling 1999). Flowers are hermaphroditic (including both male and female organs) and greenish-white in color with white stamens in clusters (Fern 1997–2000, Foster and Duke 2000).

The fruit, which resembles a large raspberry (hence the common name "ground raspberry"), turns red and ripens in July and August (Grieve 1931, Harding 1936, Sievers 1930). Each berry contains 10 to 20 small, hard, shiny black seeds, which are dispersed by birds and other animals (Bowers 1891, Cech 2002, Eichenberger and Parker 1976, Harding 1936).

The root system consists of horizontal rhizomes, 1/2- to 3/4-inch thick, with numerous fibrous rootlets (Davis 1999, Harding 1936). The name "goldenseal" comes from the bright yellow color of the roots and from the circular scars from previous years' stems that resemble waxed seal imprints (Cech 2002, Grieve 1931, Harding 1936). Roots reach maturity after 4 to 5 years, then begin to die back at one end as quickly as they grow at the other (Davis and McCoy 2000).

Bowers (1891) thoroughly describes the various stages of the goldenseal life cycle. Seeds sown naturally after the fruit ripens in August germinate the following spring. In the first year of growth, two cotyledons and a small radicle are produced. During the second year, plants send up a stem with a single, palmate leaf. Plants reach maturity in their third or fourth year, sending up a forked stem with two leaves and a flower.

Wild populations of goldenseal primarily reproduce asexually. Several growing points form on the rhizome, and knotlike buds develop on the fibrous roots, which eventually develop into independent plants (Cech 2002). Natural populations tend to grow in dense clonal clumps, with less reproductive effort put into seed production (Gagnon 1999).

Roots are typically harvested in the fall. Lloyd and Lloyd (1884–1887) reported substantially more weight loss when drying roots that were harvested while still succulent and growing as opposed to roots harvested after the fruit ripened. Harvesting roots before the fruit ripens also prevents the maturation and dispersal of seeds and, therefore, is not recommended (Miller 1988). The fibrous rootlets become brittle and break off while drying; the bare, knotted rhizome is the part used in commercial trade (Harding 1936, Lloyd and Lloyd 1884–1887, Miller 1988).

Goldenseal is found on a variety of sites: in open woods; on hillsides, ridges and bluffs; and along streams and rivers where there is good drainage, a shady tree canopy, and plenty of leaf mold (Fern 1997–2000, Miller 1988, Sievers 1930, Small and Catling 1999). Mueller (2001) describes two populations of goldenseal growing on very different geological substrates. One population was found on calcareous, dolomitic limestone soils with a pH of 4.4 to 8.0, whereas the other was growing in a granitic terrain with a pH range of 5.5 to 6.0.

Penskar and others (2001) identified the plant species often associated with goldenseal in Michigan. Overstory species include *Acer saccharum* (sugar maple), *Fagus grandifolia* (American beech), *Quercus rubra* (red oak), *Betula allegraniensis* (yellow birch), *Acer saccharinum* (silver maple), *Tilia americana* (American basswood), *Juglans nigra* (black walnut), *Juglans cinerea* (butternut), *Celtis occidentalis* (hackberry), and *Fraxinus pennsylvanica* and *F. nigra* (green and black ash). Common herbs that are associated with goldenseal include *Arisaema triphyllum* (jack-in-the-pulpit), *Asarum canadense* (wild ginger), *Carex hirtifolia* (sedge), *Carex plantaginea* (plantain-leaved sedge), *Claytonia virginica* (spring beauty), *Erythronium americanum* (trout-lily), *Caulophyllum thalictroides* (blue cohosh), *Geranium maculatum* (wild geranium), *Uvularia perfoliata* (wild

oats), *Trillium grandiflorum* (common trillium), and *Hepatica acutiloba* (hepatica), among many others. Other associated herbs include valuable medicinals such as American ginseng (*Panax quinquefolius*), black cohosh (*Actaea racemosa*), bloodroot (*Sanguinaria canadensis*), mayapple (*Podophyllum peltatum*), and false unicorn root (*Chamaelirium luteum*) (Bannerman 1997).

Goldenseal is recognized as a member of the Ranunculaceae family, though several studies have suggested that the genus *Hydrastis* belongs in its own family (Hoot 1991, Tobe and Keating 1985).

Uses

Medicinal

The genus name *Hydrastis* is derived from two Greek words meaning "water" and "to accomplish," referring to the plant's effects on the mucus membranes (Nutriflip 1998).

Native Americans had numerous uses for goldenseal and taught its various properties to European settlers (Bergner 1997, Foster 2000, Moerman 1999). The Cherokee used it as a wash for inflammations and as a treatment for dyspepsia, cancer, poor appetite, and general debility (Foster 2000, Moerman 1999). The Iroquois used the root to treat whooping cough, diarrhea, tuberculosis, liver disease, fever, earaches, stomachache, flatulence, pneumonia, and heart trouble (Foster 2000, Moerman 1999). The Micmac used goldenseal to treat chapped and cut lips (McCaleb 1994).

The most common historical medicinal uses for goldenseal include an eye wash (hence the common names eye root and eye balm), a bitter tonic, a digestive aid and appetite stimulant, and a treatment for mucus membrane inflammation (Foster 2000, Lloyd and Lloyd 1884–1887, Miller 1988, Sievers 1930). Eclectic physicians experimented with various additional uses for the root, including treatments for nasal catarrh, sore throat, tonsillitis, ear diseases, diphtheria, scarlatina, gonorrhea, vaginal and uterine leucorrhea, ulcers, skin disorders, passive hemorrhage, breast cancer, dysmenorrhea, blood stasis, muscular debility, intestinal catarrh, constipation, hepatic congestion, gastritis, acne, scrofula, pitting caused by smallpox, lupus, boils, carbuncles, nervous prostration, night sweats, and more (Bergner 1997, Cook 1869, Felter 1922, Felter and Lloyd 1898, Grieve 1931, Lloyd and Lloyd 1884–1887, Petersen 1905, Potter 1902).

In modern medicine, goldenseal has been used as an antibiotic, immunostimulatory, anticonvulsant, tonic, and sedative; it has been used particularly to treat infections of the eyes, ears, nose, throat, stomach, intestines, uterus, and vagina (Bergner 1997, Bradshaw 1997, Fern 1997–2000, Foster and Duke 2000). Goldenseal has been shown to have antibiotic properties against numerous bacteria, fungi, and parasites in laboratory tests and can prevent the overgrowth of yeast that often results from antibiotic use. Goldenseal shows particular promise as a treatment for infectious tuberculosis (Gentry and others 1998). In the intestines, it inhibits the adhesion of bacteria to host tissue and, therefore, prevents infections. Physiologically it increases blood supply to the spleen, activates macrophages and white blood cells, and stimulates secretion of bile and bilirubin (Anon. 2000). Foster (1989) suggests that goldenseal can aid in the elimination of toxins from the kidney, liver, and blood. Until the 1980s, goldenseal was a constituent in many eye washes due to its antiseptic effects and ability to constrict capillaries and reduce bloodshot eyes. Goldenseal is considered to be a synergistic or carrier herb (one that increases the effectiveness of other herbs) and is often used in combinations, particularly with *Echinacea* species. Current studies are looking at the ability of goldenseal to fight tumor cells (Bradshaw 1997; Foster and Duke 2000; Hoffman, n.d.; McCaleb 1994; NatureServe Explorer 2002).

Although goldenseal is reported to be an incredibly useful plant, the reputation of the herb as a heal-all is misleading and has contributed to excessive collection. The belief that goldenseal can mask illicit drugs in urine tests, particularly morphine, is a myth started by John Uri Lloyd in his 1900 novel "Stringtown on the Pike" (Foster 1989). Scientific research has disproved this belief (Combie and others 1982, Foster and Duke 2000, Mikkelsen and Ash 1988), but the myth persists.

Bergner, in his article "Goldenseal and the Common Cold: the Antibiotic Myth," covers the appropriate use and dosage of goldenseal to treat colds and flu symptoms. According to Bergner, many people take goldenseal thinking that it will treat any type of cold; however, goldenseal is only effective in fighting bacterial infections, not viral infections. It is also misleading to think that goldenseal can prevent colds. Taking the herb too early or in excessive doses can cause more harm than good, as its active ingredients can dry out mucus membranes, inhibit the healthy inflammatory reaction, and weaken the digestive system (Bergner 1996–97, Bergner 1997).

Goldenseal can cause mild toxicity if ingested in large doses, resulting in nausea, vomiting, diarrhea, nervousness, and depression (Russell 1997). The alkaloids are excreted slowly and can accumulate in the body, causing adverse effects on the mucus membranes and digestive system (Bergner 1997). It is therefore recommended that treatment be limited to 3 months. Goldenseal should not be used during pregnancy as it stimulates the uterus and can cause abortion or premature labor (Bradshaw 1997, Fern 1997–2000, McCaleb 1994).

Clinical Studies

The active constituents in goldenseal rhizomes are alkaloids, particularly berberine, canadine, and hydrastine (Foster and Duke 2000). Berberine contains the main antibacterial and anticonvulsive properties, increasing the secretion of bile, and lowering blood pressure (Foster and Duke 2000). It is believed that the other alkaloids act together synergistically to reduce muscle spasms. If any one of the main alkaloids is removed, the effectiveness is greatly reduced (Foster and Duke 2000). Other constituents include berberastine, meconin, chlorogenic acid, phytosterins, resins, albumin, starch, fatty matter, sugar, lignin, and a small quantity of volatile oil that contributes to the odor of the root (Bradshaw 1997).

Most of the scientific research on goldenseal has focused on identifying the medicinal alkaloids and understanding their mechanisms of action (Abdel-Haq and others 2000, Ckless and others 1995, Cometa and others 1996, Messana 1980, Palmery and others 1993, Periera da Silva and others 2000, Rehmann and others 1999, Scazzocchio and others 2001, Schmeller and others 1997, Sun and others 1988). Many of these studies have focused on the main alkaloid berberine, which is also found in Coptis or goldenthread (*Coptis chinensis)*, Oregon grape (*Berberis aquifolium)*, barberry (*Berberis vulgaris)*, and tree turmeric (*Berberis aristata)* (Anon. 2000, Bergner 1997, Bhide and others 1969, Birdsall and Kelly 1997, Lau and others 2001).

Other research has looked at the usefulness of goldenseal and/or berberine to treat specific diseases and disorders such as: recurrent otitis media in children (Aldous 2001); diarrhea (Bradshaw 1997, Khin-Maung and others 1985), particularly AIDS-related diarrhea (Anon. 1996); trachoma and eye disease caused by *Chlamydia trachomatis* (Babbar and others 1982, Bradshaw 1997); intestinal tract infections caused by *Escherichia coli* (Bradshaw 1997); tuberculosis (Gentry and others 1998); cholera (Bradshaw 1997, Khin-Maung and others 1987); chlorine-resistant malaria (Sheng and others 1997); and symptoms of streptozotocin diabetes (Swanston-Flatt and others 1989). In addition, recent studies have identified the potential use of

goldenseal to fight tumor cells (Kuo and others 1995, Nishino and others 1986). These studies suggest that goldenseal can cause apoptosis (preprogrammed early death) of abnormal cells and suppress the tumor-promoting activity of cancer cells.

Laboratory research has explored methods for identifying and quantifying the constituents of pharmaceutical goldenseal preparations (Abourashed and Khan 2001, Datta and others 1971, El-Masry and others 1980, Govindan and Govindan 2000, Li and Fitzloff 2002, Sturm and Stuppner 1998), and developing micropropagation techniques (Bedir and others 2003, Hall and Camper 2002).

A few studies have examined the safety and/or toxicity of goldenseal and its constituents. Inbaraj and others (2001) investigated the phototoxicity of berberine and concluded that the alkaloid does have toxic potential, particularly when applied topically. The authors suggest avoiding exposure to ultraviolet light when using goldenseal externally; however, they also assert that the interaction between the alkaloid and ultraviolet light may actually contribute to the drug's efficacy. Tice (1997) provides a thorough review of the literature on the toxic potential of both berberine and hydrastine.

Other Uses

Native Americans commonly used goldenseal to stain their faces and dye clothing (Fern 1997–2000, Grieve 1931, McCaleb 1994, Moerman 1999). Several common names for the species denote this use of the roots, such as yellow root, orange root, yellow puccoon, Indian paint, Indian dye, yellow paint, golden root, wild curcuma, jaundice root, and yellow eye (Lloyd and Lloyd 1884–1887, Sievers 1930). The Cherokee also mixed goldenseal root with bear grease to make an insect repellent (Fern 1997–2000, McCaleb 1994, Miller 1988; Small and Catling 1999).

Market Trends

According to Sievers (1949), before 1880 the price for goldenseal averaged 8 to 12 cents per pound. Decreasing supplies increased prices to 58 cents per pound in 1890. Prices fluctuated in the following decades, showing a general increase over time with several periods of low prices (Lloyd and Lloyd 1884–1887, Harding 1936, Sievers 1949).

Current prices for goldenseal roots range between $30 and $50 per pound (Davis 1999). Variations in price depend on the quality, cleanliness, and

alkaloid content of the roots. Wholesale prices of $100 per pound have been reported (Foster 2000). Decreasing supplies of wild roots have increased prices, which dropped as low as $8 to $11 per pound in the early 1990s (Foster 2000).

In 2002, retail prices from various goldenseal vendors ranged from $5.50 to $11 per ounce or $.80/g of cut whole roots, and $6.50 to $12 per ounce or $.90/g of powdered root (with the higher prices for certified organic roots or wild harvested roots); $11 per ounce or $.40/mL of liquid extract; $12 for 30 capsules; $3 per ounce of cut and sifted farm-grown leaf; and $.30/mL fluid leaf extract (Elixir Farm Botanicals, n.d.; Herb Trader, n.d.; Pacific Botanicals, n.d.; Richters Herbs, n.d.; Select Oils, n.d.; Viable Herbal Solutions, n.d.). For cultivation purposes, goldenseal is available at the following prices: $5 to $8 for a bare-root plant; $9.50 for a plant in a quart pot; $1.50 to $3 per live rootlet; and $11 per seed packet (number of seeds not given) (Elixir Farm Botanicals, n.d.; Garden Medicinals, n.d.; Gardens of the Blue Ridge, n.d.; Richters Herbs, n.d.).

Lloyd and Lloyd (1884–1887) estimate the total annual consumption of goldenseal roots in the late 1800s at 140,000 to 150,000 pounds. A total of 15,000 pounds of roots was exported to Europe in 1883, though the European market was considered at the time to be "spasmodic." Fifty years later, Grieve (1931) estimated the market for goldenseal roots to be 200,000 to 300,000 pounds, with one-tenth of that amount exported and the rest used domestically. The current annual consumption is estimated at more than 250,000 pounds of dried roots (Foster 2000). It takes approximately 200 to 250 rhizomes to make 1 pound dry weight (NatureServe Explorer 2002).

According to a market report by Bannerman (1997), the United Nations Food and Agriculture Organization (FAO) lists goldenseal as one of the best selling herbs internationally. The herb is listed in the official pharmacopoeias of Britain, France, Germany, and Italy and is a component in homeopathic remedies produced in Australia, France, Germany, Spain, Switzerland, and the United Kingdom. Most of the exported goldenseal goes to France, Germany, and Italy to make tinctures, extracts, dilutions, and other phyto-therapeutic products. Many of these finished products are then exported back to the United States.

The Tonnage Survey of North American Wild-Harvested Plants by the American Herbal Products Association (2003) shows a decrease in goldenseal consumption over the last 4 years with an increase in the amount of cultivated root supplying the market.

Cultivation

In the late 1800s, eclectic physicians began expressing concern about the sustainability of goldenseal, observing that overharvest and loss of habitat were quickly reducing the abundance of wild goldenseal (Harding 1936, Lloyd and Lloyd 1884–1887). Harding (1936) wrote extensively about propagating and cultivating goldenseal. His book "Ginseng and Other Medicinal Herbs" included methods of goldenseal propagation, markets, conservation, and stories of growers' experiences.

Numerous articles and books have been published detailing current research on goldenseal propagation and cultivation (Beyfuss 1998, Davis 1999, Davis and McCoy 2000, Haage and Ballard 1989, Konsler 1987, Sinclair and Catling 2001). Older articles on goldenseal cultivation (Harding 1936, Henkel and Klugh 1908, Lloyd 1912, Van Fleet 1914) are often referenced in current literature; many of the cultivation and propagation methods have not changed significantly in the last century.

Although information on cultivation is readily available, cultivation itself is not a fast or easy undertaking. Before the crop can be harvested, goldenseal must be grown for 3 to 5 years when propagated from rhizomes, or 5 to 7 years when propagated from seed (Davis and McCoy 2000, Sievers 1949). Plants can be grown for an additional year if market conditions are not optimal; however, the rhizomes begin to become overcrowded and deteriorate after reaching maturity. Leaves are occasionally used medicinally, so there is a small market for fresh or dried leaves (Davis 1999).

Germination rates for purchased seeds range from 10 to 90 percent (Davis 1999). Better results can be obtained by growers who collect their own seeds and sow them immediately. Seeds must be planted as soon as possible or by late autumn (Fern 1997–2000). Regardless, Davis (1999) states that "propagation of goldenseal from seed can be difficult and unpredictable."

A more reliable method of propagation involves dividing healthy rhizomes into 1/2-inch thick or larger pieces, each containing a bud and rootlets. The rhizomes are planted in the fall or early spring in the southern part of the plant's range (Cech 2002, Davis 1999, Fern 1997–2000). The National Center for the Preservation of Medicinal Herbs (1999) is conducting research on the various methods of propagating rhizomes and successive growth rates at various sites.

Once goldenseal plants are established, they can be transplanted to woods or cultivated beds. Wooded areas should be cleared of undergrowth that will compete with roots for nutrients (Davis 1999). The optimum sites for goldenseal are wooded areas that support several of the other plant species associated with the herb (Cech 2002). Plants grown in cultivated beds must be mulched to retain moisture, reduce weeds, and protect roots during cold weather (Davis 1999, Sievers 1949). Cultivated goldenseal requires a shade structure that provides 60 to 75 percent shade (Davis 1999, Grieve 1931, Sievers 1949).

According to Davis (1999), goldenseal has relatively few pest problems when grown in natural wooded settings; however, several pest and disease problems are known to occur in large cultivation operations. Some of the problems most often encountered by goldenseal growers include slugs, which can eat the entire crown of the plant; root knot nematodes, which reduce plant growth; moles and voles; and *Botrytis* leaf spot, which can be controlled by removing the affected foliage in mild infestations or by replacing mulch during the over-wintering period in more severe cases. Other diseases known to infect cultivated goldenseal include *Alternaria*, *Rhizoctonia*, and *Fusarium.*

Accurate yield estimates for goldenseal are not available due to variations in cultivation practices. An estimated average yield per acre is 1,000 to 2,000 pounds dry root, though lows of 800 pounds and highs of 3,000 pounds have also been reported (Davis 1999).

A national survey of goldenseal harvest conducted by the American Herbal Products Association reported a total of only 140 acres of goldenseal in cultivation in 1998. At that time, they estimated an annual harvest of 35,000 pounds of dried roots per year, projecting a future total of 82,000 pounds by the fall of 2000 (McGuffin 1999).

Conservation Issues

Like many other valuable medicinal herbs in the Appalachian region, wild goldenseal populations have substantially decreased and are more difficult to find than in the past. Many factors contribute to this decline: unsustainable collection of roots; loss of habitat due to the expansion of urban areas, agricultural lands, and roads; and increased fragmentation of remaining forested lands from timber harvest and recreational use. Goldenseal is particularly sensitive to soil disturbance and does not grow on land that has been cleared or plowed (Lloyd 1912).

It is estimated that there are 1,000 to 5,000 populations of goldenseal globally, each with approximately 70 to 500 individuals (NatureServe Explorer 2002); however, populations are not tracked or monitored, so the accuracy of these estimates is unknown. Goldenseal is listed as "endangered" by the States of Connecticut, Georgia, Massachusetts, Minnesota, North Carolina, and Vermont; "threatened" in Maryland, Tennessee, and New York; "vulnerable" in Pennsylvania; "fairly rare" in Oklahoma and Michigan; "historic" in New Jersey; and "of special concern" in Wisconsin. In addition, the plant is on the "rare plants" list in Alabama; the "to watch" list in Delaware, Virginia, and Indiana; and is reported but unprotected in Arkansas, Illinois, Iowa, Kentucky, Mississippi, Ohio, and West Virginia (Bannerman 1997, NatureServe Explorer 2002, U.S. Department of Agriculture 2001).

Goldenseal is on the United Plant Savers "At-Risk List," which includes native plant species widely used in commerce that have significantly declined throughout their range (United Plant Savers, n.d.). The global heritage status rank for goldenseal is G4, or "apparently secure." The national heritage status rank is N4, or "apparently secure" in the United States, and N2, or "imperiled" in Canada (NatureServe Explorer 2002).

Since 1997, goldenseal has been listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which monitors international trade in live plants, whole and sliced roots, and parts of roots—excluding manufactured parts or derivatives (i.e., powders, pills, extracts, tonics, teas, confectionery, etc.) (Robbins 2000; U.S. Fish and Wildlife Service, Office of Management Authority 1998; U.S. Fish and Wildlife Service, Department of the Interior 1999; U.S. Fish and Wildlife Service, International Affairs, Office of Management Authority 1999). The U.S. Fish and Wildlife Service (USFWS) is responsible for implementing CITES within the United States. The export of goldenseal requires an individual dealer to apply for an export permit. All dealers must keep documentation of their goldenseal transactions, with complete verifiable information from the point of harvest to sale (i.e., harvest permits, landowner permission, area and date of harvest, amount of harvest, individual contact information, etc.). Before a dealer can actually export goldenseal roots, these documents must be reviewed by the USFWS to ensure that the roots were legally collected and that the wild harvest of goldenseal was not detrimental to the species (Robbins 2000; U.S. Fish and Wildlife Service, Office of Management Authority 1998; U.S. Fish and Wildlife Service, Department of the Interior 1999; U.S. Fish and Wildlife Service, International Affairs, Office of Management Authority 1999).

Discussion

Sustainability of goldenseal has been a concern since the times of the first eclectic physicians who reported dwindling occurrences of wild populations as early as the 1800s. In the last few decades, conservation strategies have been implemented, such as listing goldenseal in Appendix II of CITES, which regulates export and ensures that harvest of roots stays within sustainable limits. However, goldenseal is not monitored or tracked in the States where it occurs, and there is insufficient information available on the abundance and distribution of the species. Furthermore, there is little information on the rate of regeneration and sustainable harvest amounts.

Future efforts should focus on collecting data, particularly the number of occurrences of wild populations and the rate of regeneration after root harvest, so that accurate sustainability levels can be determined. Cultivation can reduce pressure on wild populations; therefore, research into optimal production strategies is a key component in conservation. Finally, educating consumers about the inappropriate uses of goldenseal (i.e., cold prevention and drug masking) can reduce unnecessary overconsumption of goldenseal products.

Acknowledgments

This publication was produced in cooperation with Virginia Polytechnic Institute and State University (College of Natural Resources, Cheatham Hall, Blacksburg, VA 24060), under Cooperative Agreement SRS-01-CA-11330142-522; and the National Park Service (Shenandoah National Park, Luray, VA 22835), under Cooperative Agreement 02-IA-11330142-283. This research was supported by funds provided by the U.S. Department of Agriculture Forest Service, Southern Research Station, Asheville, NC.

The authors express their sincere appreciation to Pat Ford (Botanist, U.S. Fish and Wildlife Service, Division of Scientific Authority) and Wayne Owen (National Botany and Rare Plant Program Leader, U.S. Department of Agriculture Forest Service) for their diligence and hard work in reviewing this document, an effort that helped to ensure its quality of coverage.

Literature Cited

Abdel-Haq, H.; Cometa, M.F.; Palmery, M. [and others]. 2000. Relaxant effects of *Hydrastis canadensis* L. and its major alkaloids on guinea pig isolated trachea. Pharmacology and Toxicology. 87(5): 218-222.

Abourashed, E.A.; Khan, I.A. 2001. High-performance liquid chromatography determination of hydrastine and berberine in dietary supplements containing goldenseal. Journal of Pharmaceutical Science. 90(7): 817-822.

Aldous, M. 2001. A randomized controlled trial of the use of craniosacral osteopathic manipulative treatment and of botanical treatment in recurrent otitis media in children. Study ID Numbers: 1 P50 AT00008-01P1; 1 P50 AT00008-01. National Library of Medicine Identifier NCT00010465. [Location of publisher unknown]: National Center for Complementary and Alternative Medicine. http://clinicaltrials.gov/ct/gui/c/w2b/screen/ResultScreen/action/GetStudy?order=1&xml_file_id=xmlfiles%2FNCT00010465.xml%40csdb&JServSessionIdzone_ct=06q3djbel1. [Date accessed: April 26, 2004].

American Herbal Products Association. 2003. Tonnage survey of North American wild-harvested plants. Washington, DC: American Herbal Products Association. 19 p.

Anon. 1996. Berberine may ease AIDS related diarrhea. AIDS Weekly Plus. October: 12.

Anon. 2000. Berberine. Alternative Medicine Review. 5(2): 175-177.

Babbar, O.P.; Chatwal, V.K.; Ray, I.B.; Mehra, M.K. 1982. Effect of berberine chloride eye drops on clinically positive trachoma patients. Indian Journal of Medical Research. 76: 83-88.

Bannerman, J.E. 1997. Goldenseal in world trade: pressures and potentials. HerbalGram. 41: 51-52.

Bedir, E.; Lata, H.; Schaneberg, B. [and others]. 2003. Micropropagation of *Hydrastis canadensis*: goldenseal, a North American endangered species. Planta Medica. 69(1): 86-88.

Bergner, P. 1996/1997. Goldenseal and the common cold: the antibiotic myth. Medical Herbalism. 8(4): 1-6, 10. http://www.medherb.com/84.HTM. [Date accessed: April 26, 2004].

Bergner, P. 1997. The healing power of *Echinacea*, goldenseal, and other immune system herbs. Rocklin, CA: Prima. 322 p.

Beyfuss, R.L. 1998. Growing ginseng and goldenseal in your forest. In: Kays, J.S., ed. Natural resources income opportunities on private lands conference: proceedings and invited papers. Hagerstown, MD: University of Maryland Cooperative Extension Service: 148-155.

Bhide, M.B.; Chavan, S.R.; Dutta, N.K. 1969. Absorption, distribution, and excretion of berberine. Indian Journal of Medical Research. 57: 2128-2131.

Birdsall, T.C.; Kelly, G.S. 1997. Berberine: therapeutic potential of an alkaloid found in several medicinal plants. Alternative Medicine Review. 2(2): 94-103.

Bowers, H. 1891. A contribution to the life history of *Hydrastis canadensis.* Botanical Gazette. 16: 73-82.

Bradshaw, C., comp. 1997. Goldenseal: *Hydrastis canadensis*. In: Complimentary and alternative medicine: a scientific reference for health care professionals. http://www.geocities.com/chadrx/goldenseal.html. [Date accessed: April 26, 2004].

Cech, R. 2002. Growing at-risk medicinal herbs: cultivation, conservation, and ecology. Williams, OR: Horizon Herbs. 323 p.

Ckless, K.; Schlottfeldt, J.L.; Pasqual, M. [and others]. 1995. Inhibition of in vitro lymphocyte transformation by the isoquinoline alkaloid berberine. Journal of Pharmacy and Pharmacology. 47(12A): 1029-1031.

Combie, J.; Nugent, T.E.; Tobin, T. 1982. Inability of goldenseal to interfere with the detection of morphine in urine. Journal of Equine Veterinary Science. 2: 16-21.

Cometa, M.F.; Galeffi, C.; Palmery, M. 1996. Acute effect of alkaloids from *Hydrastis canadensis* L. on guinea pig ileum: structure-activity relationships. Phytotherapy Research. 10(suppl. 1): S56-S58.

Cook, W. 1869. The physiomedical dispensatory. Scanned version by Journal of Medical Herbalism, 2001. http://www.ibiblio.org/herbmed/eclectic/cook/HYDRASTIS_CANADENSIS.htm [Date accessed: April 26, 2004].

Datta, D.D.; Bose, P.C.; Ghosh, D. 1971. Thin layer chromatography and U.V. spectrophotometry of alcoholic extracts of *Hydrastis canadensis*. Planta Medica. 19(3): 258-263.

Davis, J.M. 1999. Forest production of goldenseal. Agroforestry Note 16. Forest Farming - 5. In cooperation with the U.S. Department of Agriculture, Forest Service, and the U.S. Department of Agriculture, Natural Resources Conservation Service. Lincoln, NE: U.S. Department of Agriculture, National Agroforestry Center. 6 p.

Davis, J.M.; McCoy, J. 2000. Commercial goldenseal cultivation. North Carolina State University Horticulture Inf. Leafl. 131. Raleigh, NC: North Carolina Cooperative Extension Service. http://www.ces.ncsu.edu/depts/hort/hil/hil-131.html. [Date accessed: April 26, 2004].

Eichenberger, M.D.; Parker, G.R. 1976. Goldenseal (*Hydrastis canadensis* L.) distribution, phenology, and biomass in an oak hickory forest. Ohio Journal of Science. 76(5): 204-210.

Elixir Farm Botanicals. [N.d.]. Goldenseal product. http://www.elixirfarm.com/. [Date accessed: April 26, 2004].

El-Masry, S.; Korany, M.A.; Abou-Donia, A.H. 1980. Colorimetric and spectrophotometric determinations of *Hydrastis* alkaloids in pharmaceutical preparations. Journal of Pharmaceutical Science. 69(5): 597-598.

Felter, H.W. 1922. The eclectic Materia Medica, pharmacology and therapeutics. Scanned version by M. Moore, 2001-2002. http://www.ibiblio.org/herbmed/eclectic/felter/hydrastis.html. [Date accessed: April 26, 2004].

Felter, H.W.; Lloyd, J.U. 1898. King's American dispensatory. 18th ed., 3rd rev. Scanned version by H. Kress, 2000-2001. http://www.ibiblio.org/herbmed/eclectic/kings/hydrastis.html. [Date accessed: April 26, 2004].

Fern, K. 1997-2000. Plants for a future: the species database. http://www.ibiblio.org/pfaf/cgi-bin/arr_html?Hydrastis+canadensis. [Date accessed: April 26, 2004].

Foster, S. 1989. Goldenseal masking of drug tests: from fiction to fallacy. HerbalGram. 21: 7.

Foster, S. 2000. Goldenseal (*Hydrastis canadensis*). Steven Foster group herb monographs. http://www.stevenfoster.com/education/monograph/goldenseal.html. [Date accessed: April 26, 2004].

Foster, S.; Duke, J.A. 2000. A field guide to medicinal plants and herbs of Eastern and Central North America. 2nd ed. National Audubon Society, National Wildlife Federation, and the Roger Tory Peterson Institute. New York: Houghton Mifflin Co. 411 p.

Gagnon, D. 1999. A review of the ecology and population biology of goldenseal, and protocols for monitoring its populations. Final report to the Office of Scientific Authority of the U.S. Fish and Wildlife Service. http://www.nps.gov/plants/medicinal/pubs/goldenseal.htm [Date accessed: April 26, 2004].

Garden Medicinals. [N.d.]. Goldenseal product. http://www.gardenmedicinals.com/. [Date accessed: April 26, 2004].

Gardens of the Blue Ridge. [N.d.]. Goldenseal product. http://www.gardensoftheblueridge.com/. [Date accessed: April 26, 2004].

Gentry, E.J.; Jampani, H.B.; Keshavarz-Shokri, A. [and others]. 1998. Antitubercular natural products: berberine from the roots of commercial *Hydrastis canadensis* powder. Isolation of inactive 8-oxotetrahydrothalifendine, canadine, beta-hydrastine, and two new quinic acid esters, hycandinic acid esters-1 and -2. Journal of Natural Products. 61(10): 1187-1193.

Govindan, M.; Govindan, G. 2000. A convenient method for the determination of the quality of goldenseal. Fitoterapia. 71(3): 232-235.

Grieve, M. 1931. A modern herbal. Hypertext version by Botanical.com. 1995-2002. http://www.botanical.com/botanical/mgmh/g/golsea27.html. [Date accessed: April 26, 2004].

Haage, L.J.; Ballard, J.L. 1989. A grower's guide to goldenseal. Norway, IA: Nature's Cathedral. [Not paged].

Hall, K.C.; Camper, N.D. 2002. Tissue culture of goldenseal. Journal of the Tissue Culture Association. 38(3): 293-295.

Harding, A.R. 1936. Ginseng and other medicinal plants. Scanned version by M. Moore, 2002. http://www.ibiblio.org/herbmed/eclectic/harding/main.html. [Date accessed: April 26, 2004].

Henkel, A.; Klugh, G.F. 1908. The cultivation and handling of goldenseal. Bureau of Plant Industry - Circ. 6. Washington, DC: U.S. Department of Agriculture. 19 p.

Herb Trader. [N.d.]. Goldenseal product. http://www.herbtrader.com/. [Date accessed: April 26, 2004].

Hoffman, D.L. [N.d.]. Goldenseal. Herbal Materia Medica. Health World Online. http://www.healthy.net/asp/templates/article.asp?PageType=article&ID=1906. [Date accessed: April 26, 2004].

Hoot, S.B. 1991. The phylogeny of the Ranunculaceae based on epidermal microcharacters and macromorphology. Systemic Botany. 16: 741-755.

Inbaraj, J.J.; Kukielczak, B.M.; Bilski, P. [and others]. 2001. Photochemistry and photocytotoxicity of alkaloids from Goldenseal (*Hydrastis canadensis* L.) 1. Berberine. Chemical Research in Toxicology. 14(11): 1529-1534.

Khin-Maung U.; Myo-Khin; Nyunt-Nyunt-Wai [and others]. 1985. Clinical trial of berberine in acute watery diarrhea. British Medical Journal. 291: 1601-1604.

Konsler, T.R. 1987. Woodland production of ginseng and goldenseal. In: Proceedings of the First National Herb Growing and Marketing Conference. Stn. Bull. West Lafayette, IN: Purdue University Agricultural Experiment Station: 175-178.

Kuo, C.L.; Chou, C.C.; Yungk, B.Y.M. 1995. Berberine complexes with DNA in the berberine-induced apoptosis in human leukemic HL-60 cells. Cancer Letters. 93(2): 193-200.

Lau, C.W.; Yao, X.Q.; Chen, Z.Y. [and others]. 2001. Cardiovascular actions of berberine. Cardiovascular Drug Review. 19(3): 234-244.

Li, W.; Fitzloff, J.F. 2002. A validated high performance liquid chromatographic method for the analysis of goldenseal. Journal of Pharmacy and Pharmacology. 54(3): 435-439.

Lloyd, J.U. 1912. The cultivation of *Hydrastis*. Journal of the American Pharmaceutical Association. 1: 5-12.

Lloyd, J.U; Lloyd, C.G. 1884-1887. Drugs and medicines of North America. Scanned version by H Kress, ©2001-2003. http://www.ibiblio.org/herbmed/eclectic/dmna/hydrastis-cana.html. [Date accessed: April 26, 2004].

McCaleb, R. 1994. Unearthing the health care of goldenseal. Better Nutrition for Today's Living. 56(9): 58.

McGuffin, M. 1999. AHPA goldenseal survey measures increased agricultural production. HerbalGram. 46: 66-67.

Messana, I. 1980. The alkaloids of *Hydrastis canadensis*. Two new alkaloids: hydrastidine and isohydrastidine. Gazetta Chimica Italiana. 110(9/10): 539-543.

Mikkelsen, S.L.; Ash, K.O. 1988. Adulterants causing false negatives in illicit drug testing. Clinical Chemistry. 34(11): 2333-2336.

Miller, R.A. 1988. Native plants of commercial importance. Grants Pass, OR: OAK, Inc. 343 p.

Moerman, D. 1999. Native American ethnobotany database: foods, drugs, dyes, and fibers of native North American peoples. The University of Michigan-Dearborn. http://herb.umd.umich.edu/. [Date accessed: April 26, 2004].

Mueller, R.F. 2001. *Hydrastis canadensis* L.: two Appalachian occurrences. Forests of the Central Appalachians project. http://www.spies.com/~gus/forests/hydrastis.htm. [Date accessed: April 26, 2004].

National Center for the Preservation of Medicinal Herbs. 1999. Summary of goldenseal research projects for 1998 and 1999. http://home.frognet.net/~rural8/frames2.html. [Date accessed: May 12, 2004].

NatureServe Explorer. 2002. An online encyclopedia of life [web application]. Version 1.6. Arlington, VA: NatureServe http://www.natureserve.org/explorer. [Date accessed: April 26, 2004].

Nishino, H.; Kitagawa, K.; Fujiki, H.; Iwashima, A. 1986. Berberine sulfate inhibits tumor-promoting activity of teleocidin in two-stage carcinogenesis on mouse skin. Oncology. 43(2): 131-134.

Nutriflip. 1998. Naturopathy: herbs and other plant products. Nutrition for a living planet - food, nutrition, diet, and health. http://www.geocities.com/nutriflip/Naturopathy/. [Date accessed: April 26, 2004].

Pacific Botanicals. [N.d.]. Goldenseal product. http://www.pacificbotanicals.com/. [Date accessed: April 26, 2004].

Palmery, M.; Leone, M.G.; Pimpinella, G.; Romanelli, L. 1993. Effects of *Hydrastis canadensis* L. and the two major alkaloids, berberine and hydrastine, on rabbit aorta. Pharmacology Research. 27(suppl.1): 73-74.

Penskar, M.R.; Choberka, E.G.; Higman, P.J. 2001. Special plant abstract for *Hydrastis canadensis* (goldenseal). Lansing, MI: Michigan Natural Features Inventory. 3 p.

Periera da Silva, A.; Rocha, R.; Silva, C.M. [and others]. 2000. Antioxidants in medicinal plant extracts. A research study of the antioxidant capacity of *Crataegus*, *Hamamelis,* and *Hydrastis*. Phytotherapy Research. 14(8): 612-616.

Petersen, F. 1905. Materia Medica and clinical therapeutics. Scanned version by M. Moore, 2002. http://www.ibiblio.org/herbmed/eclectic/petersen/hydrastis.html. [Date accessed: April 26, 2004].

Plyler, S.C. 2001-2002. Indian spring herbal encyclopedia. http://www.indianspringherbs.com/Goldenseal.htm. [Date accessed: April 26, 2004].

Potter, S.O.L. 1902. A compend of Materia Medica, therapeutics, and prescription writing. Scanned version by H. Kress, 2000-2002. http://www.ibiblio.org/herbmed/eclectic/potter-comp/hydrastis.html. [Date accessed: April 26, 2004].

Rehman, J.; Dillow, J.M.; Carter, S.M. [and others]. 1999. Increased production of antigen-specific immunoglobulins G and M following in vivo treatment with the medicinal plants *Echinacea angustifolia* and *Hydrastis canadensis*. Immunology Letters. 68(2-3): 391-395.

Richters Herbs. [N.d.]. Goldenseal product. http://www.richters.com. [Date accessed: April 26, 2004].

Robbins, C.S. 2000. Comparative analysis of management regimes and medicinal plant trade monitoring mechanisms for American ginseng and goldenseal. Conservation Biology. 14(5): 1422-1434.

Russell, A.B. 1997. Poisonous plants of North Carolina. North Carolina State University Department of Horticultural Science. http://www.ces.ncsu.edu/depts/hort/consumer/poison/Hydraca.htm. [Date accessed: April 26, 2004].

Scazzocchio, F.; Cometa, M.F.; Tomassini, L.; Palmery, M. 2001. Antibacterial activity of *Hydrastis canadensis* extract and its major isolated alkaloids. Planta Medica. 67(6): 561-564.

Schmeller, T.; Latz-Bruning, B.; Wink, M. 1997. Biochemical activities of berberine, palmatine, and sanguinarine mediating chemical defense against microorganisms and herbivores. Phytochemistry. 44(2): 257-266.

Select Oils. [N.d.]. Goldenseal product. http://www.selectoils.com/. [Date accessed: April 26, 2004].

Sheng, W.D.; Jiddawi, M.S.; Hong, X.Q.; Abdulla, S.M. 1997. Treatment of chloroquine-resistant malaria using pyrimethanine in combination with berberine, tetracycline, or cotrimoxazole. East African Medical Journal. 74(5): 283-284.

Sievers, A.F. 1930. The herb hunters guide. Misc. Publ. 77. Washington, DC: U.S. Department of Agriculture. Hypertext version April 8, 1998. http://www.hort.purdue.edu/newcrop/herbhunters/goldenseal.html. [Date accessed: April 26, 2004].

Sievers, A.F. 1949. Goldenseal under cultivation. Farmer's Bull. 613. Washington, DC: U.S. Department of Agriculture. 14 p.

Sinclair, A.; Catling, P.M. 2001. Cultivating the increasingly popular medicinal plant, goldenseal: review and update. American Journal of Alternative Agriculture. 16(3): 131-140.

Small, E.; Catling, P.M. 1999. Canadian medicinal crops. Canada: NRC Press. 240 p.

Sturm, S.; Stuppner, H. 1998. Analysis of isoquinoline alkaloids in medicinal plants by capillary electrophoresis-mass spectrometry. Electrophoresis. 19(16-17): 3026-3032.

Sun, D.; Courtney, H.S.; Beachey, E.H. 1988. Berberine sulfate blocks adherence of *Streptococcus pyogenes* to epithelial cells, fibronectin, and hexadecane. Antimicrobial Agents and Chemotherapy. 32(9): 1370-1374.

Swanston-Flatt, S.K.; Day, C.; Bailey, C.J.; Flatt, P.R. 1989. Evaluation of traditional plant treatments for diabetes: studies in streptozotocin diabetic mice. Acta Diabetol Lat. 26(1): 51-55.

Tice, R. 1997. Goldenseal (*Hydrastis canadensis* L.) and two of its constituent alkaloids: berberine and hydrastine. Review of toxicological literature. Research Triangle Park, NC: Integrated Laboratory Systems. Prepared for the National Institute of Environmental Health Sciences, Research Triangle Park, NC. http://ntp-server.niehs.nih.gov/htdocs/Chem_Background/ExSumPdf/GoldenSeal.pdf. [Date accessed: April 26, 2004].

Tobe, H.; Keating, R.C. 1985. The morphology and anatomy of *Hydrastis* (Ranunculales): systematic re-evaluation of the genus. Botany Magazine (Tokyo). 98: 291-316.

United Plant Savers. [N.d.]. At risk plants. http://www.plantsavers.org/. [Date accessed: April 26, 2004].

U.S. Department of Agriculture, Natural Resources Conservation Service. 2001. The PLANTS database. Version 3.1. Baton Rouge, LA: Plant Data Center. http://plants.usda.gov. [Date accessed: January 29, 2004].

U.S. Fish and Wildlife Service, Department of the Interior. 1999. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): listing of goldenseal (*Hydrastis canadensis*) in Appendix II and its implementation by the United States. Public meeting. Federal Register. April 26, 1999: 64(79). http://policy.fws.gov/library/99fr20320.html. [Date accessed: April 26, 2004].

U.S. Fish and Wildlife Service, International Affairs, Office of Management Authority. 1999. Exporting goldenseal. http://international.fws.gov/pdf/go.pdf. [Date accessed: April 26, 2004].

U.S. Fish and Wildlife Service, Office of Management Authority. 1998. Export of goldenseal. Arlington, VA. 2 p. http://international.fws.gov/pdf/export.pdf. [Date accessed: April 26, 2004].

Van Fleet, W. 1914. Goldenseal under cultivation. Farmer's Bull. 613. Revised 1949. [Place of publication unknown]: U.S. Department of Agriculture. [Number of pages unknown].

Viable Herbal Solutions. [N.d.]. Goldenseal product. http://www.viable-herbal.com/. [Date accessed: April 26, 2004].

Annotated Bibliography

Research Literature

Anon. 1996. Berberine may ease AIDS related diarrhea. AIDS Weekly Plus. October: 12.

Discusses the effectiveness of berberine for treating diarrhea. Berberine, which has antimicrobial, antisecretory, and antimotility properties, may be effective in fighting gastrointestinal infections caused by various pathogens and relieving chronic diarrhea, particularly as it relates to AIDS. Clinical trials have shown that berberine is safe and has few side effects.

Keywords: Berberine, medicinal uses.

Anon. 2000. Berberine. Alternative Medicine Review. 5(2): 175-177.

Provides details on the structure, properties, and actions of berberine. The plant alkaloid berberine is a constituent in the roots, rhizomes, and stems of several plant species. Berberine has been used medicinally throughout history, showing significant antimicrobial properties against bacteria, viruses, fungi, protozoans, and other infectious organisms. In modern medicine, berberine is most commonly used to treat infections such as bacterial diarrhea, intestinal parasites, and ocular trachoma. The various pharmacological actions include inhibition of metabolism and enterotoxin production for certain pathogens, inhibition of smooth muscle contraction and fluid accumulation in intestines, inflammation reduction, and stimulation of bile and bilirubin production, among others. The specific physiological actions against these organisms are discussed. Berberine is not considered toxic in moderate doses, though high dosages can result in gastrointestinal problems, low blood pressure, and heart damage. The alkaloid can also cause uterine contractions and should not be used during pregnancy.

Keywords: Alkaloids, berberine, medicinal actions, medicinal uses, toxicity.

Abdel-Haq, H.; Cometa, M.F.; Palmery, M. [and others]. 2000. Relaxant effects of *Hydrastis canadensis* L. and its major alkaloids on guinea pig isolated trachea. Pharmacology and Toxicology. 87(5): 218-222.

Investigates the individual contribution of several of the major alkaloids in goldenseal to the overall relaxant effect on guinea pig trachea and attempts to determine the exact mechanism of action. It is believed that the alkaloids interact with adrenergetic and adenosinic receptors. Definite conclusions were not reached, though several hypotheses are suggested based on the results.

Keywords: Alkaloids, clinical studies, medicinal uses.

Abourashed, E.A.; Khan, I.A. 2001. High-performance liquid chromatography determination of hydrastine and berberine in dietary supplements containing goldenseal. Journal of Pharmaceutical Science. 90(7): 817-822.

Examines a high-performance liquid chromatography (HPLC) method to detect and quantify hydrastine and berberine in several products containing both goldenseal and echinacea. Alkaloid levels varied widely among the samples. The Dietary Supplement Health and Education Act does not require alkaloid content to be included on a product label. Because of this, content uniformity varies widely among products. HPLC is a valid method for determining product quality.

Keywords: Alkaloids, berberine, product quality.

Aldous, M. 2001. A randomized controlled trial of the use of craniosacral osteopathic manipulative treatment and of botanical treatment in recurrent otitis media in children. Study ID Numbers: 1 P50 AT00008-01P1; 1 P50 AT00008-01. National Library of Medicine Identifier NCT00010465. [Location of publisher unknown]: National Center for Complementary and Alternative Medicine. http://clinicaltrials.gov/ct/gui/c/w2b/screen/ResultScreen/action/GetStudy?order=1&xml_file_id=xmlfiles%2FNCT00010465.xml% 40csdb&JServSessionIdzone_ct=06q3djbel1. [Date accessed: April 26, 2004].

Outlines ongoing research to evaluate treatment for recurrent otitis media in children; goldenseal is listed as one of the herbs to be included in the study.

Keywords: Clinical studies, medicinal uses.

Babbar, O.P.; Chatwal, V.K.; Ray, I.B.; Mehra, M.K. 1982. Effect of berberine chloride eye drops on clinically positive trachoma patients. Indian Journal of Medical Research. 76: 83-88.

[No abstract].

Keywords: Berberine, clinical studies, medicinal uses.

Bedir, E.; Lata, H.; Schaneberg, B. [and others]. 2003. Micropropagation of *Hydrastis canadensis*: goldenseal, a North American endangered species. Planta Medica. 69(1): 86-88.

Provides a detailed investigation into techniques and successful results for an in vitro propagation protocol for goldenseal.

Keywords: Micropropagation, research.

Beyfuss, R.L. 1998. Growing ginseng and goldenseal in your forest. In: Kays, J.S., ed. Natural resources income opportunities on private lands conference: proceedings and invited papers. Hagerstown, MD: University of Maryland Cooperative Extension Service: 148-155.

Reports observations of sites containing wild populations of goldenseal and American ginseng (*Panax quinquefolius*) in New York, Massachusetts, North Carolina, and Tennessee. Summarizes the ecological growing conditions for potential growers to reproduce for successful wild-simulated cultivation. A brief history of goldenseal collection and markets is provided. It is noted that Native Americans used goldenseal more than American ginseng in their remedies. Goldenseal grows in a rich, moist, shady forest environment with other herbs such as maidenhair fern (*Adiantum pedatum*), jack-in-the-pulpit (*Arisaema triphyllum*), and blue cohosh (*Caulophyllum thalictroides*). Site preparation can range from simply raking back leaves and broadcasting seeds to removing small trees and other understory plants, tilling soil, and arranging raised beds. Some details are provided on planting and fertilization. The worst problems encountered in cultivating goldenseal include slugs, poachers, *Alternaria*, *Phytophthora*, and *Botrytis.* Plants are harvested 3 to 4 years after planting. Roots start to die off if they are left for longer periods of time. Cleaned roots are dried on screens in the shade or in air driers. When drying, roots lose approximately 70 percent of their weight. Total yields per acre are estimated at 1,000 to 2,000 pounds. Prices fluctuate, making it difficult to predict the costs and returns of cultivation.

Keywords: Associated herbs, cultivation, drying, habitat, Native American uses, pests and diseases, site preparation, yield estimates.

Bhide, M.B.; Chavan, S.R.; Dutta, N.K. 1969. Absorption, distribution, and excretion of berberine. Indian Journal of Medical Research. 57: 2128-2131.

Describes the actions of the alkaloid berberine in healthy and choleric infant rabbits. Berberine was absorbed through the gastrointestinal tract; was found in high levels in the heart, pancreas, and liver; and was excreted through stools and urine.

Keyword: Berberine.

Birdsall, T.C.; Kelly, G.S. 1997. Berberine: therapeutic potential of an alkaloid found in several medicinal plants. Alternative Medicine Review. 2(2): 94-103.

Summarizes the actions and uses of berberine, describing numerous clinical studies that support medicinal claims. Berberine has antimicrobial properties that make it an effective treatment for cholera and *Escherichia coli* infections. The alkaloid prevents smooth muscle contraction, reduces inflammation, and stimulates increased production of bile and bilirubin. The most common clinical applications are for bacterial diarrhea, intestinal parasites, ocular trachoma, and ventricular tacharrhythmias. Berberine is directly antibacterial to *Vibrio cholerae*; inhibits intestinal secretion caused by enterotoxins; prevents the adhesion of *E. coli* and *Streptomyces pyogenes* to epithelial cells; inhibits growth of *Giardia lamblia*, *Trichomonas vaginalis*, *Entamoeba histolytica*, and *Chlamydia trachomatis*; and inhibits metabolic functions and toxin formation in certain organisms. In normal clinical doses, berberine is nontoxic, though high doses can cause low blood pressure, dyspnea, gastrointestinal problems, heart damage, and flu-like symptoms. Berberine causes uterine contractions and should not be used by pregnant women.

Keywords: Berberine, medicinal uses, toxicity.

Budzinski, J.W.; Foster, B.C.; Vandenhoek, S.; Arnason, J.T. 2000. An in vitro evaluation of human cytochrome P450 3A4 inhibition by selected commercial herbal extracts and tinctures. Phytomedicine. 7(4): 273-282.

Examines the metabolism of several herbal extracts to determine areas of potential drug interactions within the body.

Keywords: Drug interactions, research.

Carlquist, S. 1995. Wood and bark anatomy of Ranunculaceae (including *Hydrastis*) and Glaucidiaceae. Aliso. 14(2): 65-84.

[No abstract].

Keywords: Ranunculaceae family, research.

Ckless, K.; Schlottfeldt, J.L.; Pasqual, M. [and others]. 1995. Inhibition of in vitro lymphocyte transformation by the isoquinoline alkaloid berberine. Journal of Pharmacy and Pharmacology. 47(12A): 1029-1031.

Evaluates berberine's interaction with lymphocytes. No proliferative effects were observed; it is speculated that the anti-inflammatory action of goldenseal is partly due to its inhibition of DNA synthesis in activated lymphocytes.

Keywords: Berberine, research.

Combie, J.; Nugent, T.E.; Tobin, T. 1982. Inability of goldenseal to interfere with the detection of morphine in urine. Journal of Equine Veterinary Science. 2: 16-21.

Evaluates the ability of goldenseal to interfere with detection of morphine in urine tests of racing horses. Results showed that goldenseal was not able to mask the presence of the drug in urine samples.

Keyword: Drug masking.

Cometa, M.F.; Galeffi, C.; Palmery, M. 1996. Acute effect of alkaloids from *Hydrastis canadensis* L. on guinea pig ileum: structure-activity relationships. Phytotherapy Research. 10(suppl. 1): S56-S58.

Identifies the chemical structures of berberine, ß-hydrastine, canadine, and canadaline, the four major alkaloids isolated from rhizomes and roots of goldenseal. The different chemical structures are connected with varying contractile potencies on guinea pig ileum. The mechanism of action is described.

Keywords: Alkaloids, berberine, research.

Creasy, W.A. 1979. Biochemical effects of berberine. Biochemical Pharmacology. 28: 1081-1084.

[No abstract].

Keyword: Berberine.

Datta, D.D.; Bose, P.C.; Ghosh, D. 1971. Thin layer chromatography and U.V. spectrophotometry of alcoholic extracts of *Hydrastis canadensis*. Planta Medica. 19(3): 258-263.

[No abstract].

Keywords: Alkaloids, product quality.

Dyke, S.F.; Tiley, E.P. 1975. The synthesis of berberastine. Tetrahedron. 31: 561-568.

[No abstract].

Keyword: Alkaloids.

Eichenberger, M.D.; Parker, G.R. 1976. Goldenseal (*Hydrastis canadensis* L.) distribution, phenology, and biomass in an oak hickory forest. Ohio Journal of Science. 76(5): 204-210.

Describes the growth of several individual clumps of goldenseal found in a nature preserve in Indiana. The greatest concentration of plants was found in the northeast sections of the preserve. The seasonal life cycle is described, and both above- and below-ground biomass are calculated and compared throughout the growing season.

Keywords: Habitat, life cycle.

El-Masry, S.; Korany, M.A.; Abou-Donia, A.H. 1980. Colorimetric and spectrophotometric determinations of *Hydrastis* alkaloids in pharmaceutical preparations. Journal of Pharmaceutical Science. 69(5): 597-598.

Describes the use of an acid-dye technique to determine and attempt to extract the alkaloids hydrastine, canadine, and berberine from goldenseal roots.

Keywords: Alkaloids, berberine, product quality, research.

Gagnon, D. 1999. A review of the ecology and population biology of goldenseal, and protocols for monitoring its populations. Final report to the Office of Scientific Authority of the U.S. Fish and Wildlife Service. http://www.nps.gov/plants/medicinal/pubs/goldenseal.htm [Date accessed: April 26, 2004].

Provides a detailed protocol for field-monitoring studies of goldenseal populations with a brief literature review on the botany and ecology of the species.

Keywords: Conservation, monitoring.

Galeffi, C.; Cometa, M.F.; Tomassini, L.; Nicoletti, M. 1997. Canadinic acid: an alkaloid from *Hydrastis canadensis.* Planta Medica. 63: 194.

Describes the chemical structure and known properties of an alkaloid found in the roots of goldenseal.

Keyword: Alkaloids.

Gentry, E.J.; Jampani, H.B.; Keshavarz-Shokri, A. [and others]. 1998. Antitubercular natural products: berberine from the roots of commercial *Hydrastis canadensis* powder. Isolation of inactive 8-oxotetrahydrothalifendine, canadine, beta-hydrastine, and two new quinic acid esters, hycandinic acid esters-1 and -2. Journal of Natural Products. 61(10): 1187-1193.

Evaluates the chemical compounds in goldenseal and their medicinal uses. Berberine is the active constituent in goldenseal roots that is effective against *Mycobacterium tuberculosis*. Several new inactive compounds are isolated from goldenseal roots, and their chemical structures are identified.

Keywords: Berberine, chemical constituents, medicinal uses, research.

Govindan, M.; Govindan, G. 2000. A convenient method for the determination of the quality of goldenseal. Fitoterapia. 71(3): 232-235.

Investigates methods to evaluate goldenseal products. Two methods of thin-layer chromatography were used to determine the quality and possible adulteration of 10 goldenseal products. Five samples contained hydrastine and berberine, four contained berberine, and one did not contain either alkaloid. Results were verified by high-performance liquid chromatography analysis.

Keywords: Alkaloids, product quality, research.

Hall, K.C.; Camper, N.D. 2002. Tissue culture of goldenseal. Journal of the Tissue Culture Association. 38(3): 293-295.

Examines methods of tissue culture on various media to determine the most efficient method for in vitro propagation for goldenseal. Includes description of materials, methods, results, and discussion.

Keywords: Micropropagation, tissue culture.

Hoot, S.B. 1991. The phylogeny of the Ranunculaceae based on epidermal microcharacters and macromorphology. Systemic Botany. 16: 741-755.

Analyzes epidermal microcharacters such as type of trichome and stomatal length to assess phylogeny in the family Ranunculaceae. The results of this study suggest that *Hydrastis* belongs in a separate family, Hydrastidaceae.

Keywords: Classification, Ranunculaceae family.

Hung, O.L.; Shih, R.D.; Chiang, W.K. [and others]. 1997. Herbal preparation use among urban emergency department patients. Academy of Emergency Medicine. 4(3): 209-213.

Describes a survey of emergency room patients, showing that a significant number use herbal preparations. Physicians should be aware of the potential for drug interactions or possible herbal-induced toxicity.

Keyword: Toxicity.

Inbaraj, J.J.; Kukielczak, B.M.; Bilski, P. [and others]. 2001. Photochemistry and photocytotoxicity of alkaloids from goldenseal (*Hydrastis canadensis* L.) 1. Berberine. Chemical Research in Toxicology. 14(11): 1529-1534.

Evaluates the toxic potential of berberine. The alkaloid berberine may have phototoxic effects when exposed to light. The photochemistry of berberine is examined in several solvents. Results show that berberine can cause cell damage in the presence of ultraviolet light; therefore, persons using topical preparations of berberine should avoid exposure to light. However, the authors also speculate that exposure to sun possibly enhances the antiseptic effects of goldenseal.

Keywords: Berberine, phototoxicity, toxicity.

Johannesen, S.J. 2001. An assessment of the threat to survival of six medicinal plants native to the U.S.A. [Place of publication unknown]: University of Wales, College of Phytotherapy. [Not paged]. Bachelor of Science dissertation.

Summarizes trends in goldenseal markets such as changes in demand for, and supply sources of, the herb, (i.e., wild-crafted vs. cultivated).

Keyword: Market demand.

Khin-Maung U.; Myo-Khin; Nyunt-Nyunt-Wai [and others]. 1985. Clinical trial of berberine in acute watery diarrhea. British Medical Journal. 291: 1601-1604.

[No abstract].

Keywords: Berberine, clinical studies, medicinal uses.

Khin-Maung U.; Myo-Khin; Nyunt-Nyunt-Wai [and others]. 1987. Clinical trial of high-dose berberine and tetracycline in cholera. Journal of Diarrheal Diseases Research. 5(3): 184-187.

[No abstract].

Keywords: Berberine, clinical studies, medicinal uses.

Kuo, C.L.; Chou, C.C.; Yungk, B.Y.M. 1995. Berberine complexes with DNA in the berberine-induced apoptosis in human leukemic HL-60 cells. Cancer Letters. 93(2): 193-200.

Discusses the cancer-fighting potential of berberine. Berberine has demonstrated the ability to cause apoptosis (preprogrammed early cell death) in leukemia cells, particularly in cells at a certain stage of growth. Effectiveness was determined for berberine treatment in cells in various phases by attempting to isolate berberine DNA-complexes. Although berberine interacts with DNA in vitro, the results of this study suggest that cellular processes other than DNA-interaction may be the cause of berberine-induced apoptosis of leukemia cells. The process between DNA binding and early cell death by apoptosis is not yet understood.

Keywords: Berberine, cancer, clinical studies, medicinal uses.

Lau, C.W.; Yao, X.Q.; Chen, Z.Y. [and others]. 2001. Cardiovascular actions of berberine. Cardiovascular Drug Review. 19(3): 234-244.

Describes the cardiovascular effects of berberine and two of its derivatives. Berberine, which is often used in Chinese medicine, is an antimicrobial agent used to treat dysentery and infectious diarrhea. Some of these effects are due to the ability of these alkaloids to block potassium channels and stimulate cation exchange. The beneficial cardiovascular actions of berberine suggest usefulness in treating arrhythmias or heart failure. Various studies supporting these observations are presented.

Keywords: Berberine, clinical studies, medicinal uses.

Li, W.; Fitzloff, J.F. 2002. A validated high performance liquid chromatographic method for the analysis of goldenseal. Journal of Pharmacy and Pharmacology. 54(3): 435-439.

Describes the development of a fast and simple high performance liquid chromatographic method to analyze the active constituents in commercial goldenseal products.

Keywords: Chemical constituents, product quality, research.

Messana, I. 1980. The alkaloids of *Hydrastis canadensis*. Two new alkaloids: hydrastidine and isohydrastidine. Gazetta Chimica Italiana. 110(9/10): 539-543.

Describes the chemistry and characteristics of two new alkaloids and eight previously identified alkaloids isolated from goldenseal roots.

Keyword: Alkaloids.

Mikkelsen, S.L.; Ash, K.O. 1988. Adulterants causing false negatives in illicit drug testing. Clinical Chemistry. 34(11): 2333-2336.

Tests eight additives commonly used to provide false negative results on enzyme immunoassay drug assays. Relative density, pH, color, and turbidity of the urine were examined to detect the presence of these adulterants.

Keywords: Drug masking, research.

Mueller, R.F. 2001. *Hydrastis canadensis* L.: two Appalachian occurrences. Forests of the Central Appalachians project. http://www.spies.com/~gus/forests/hydrastis.htm. [Date accessed: April 26, 2004].

Describes the ecological preferences of goldenseal in two locations with different soil conditions. Geology, topography, soil characteristics and pH, microclimate, and associated plant species are identified.

Keywords: Ecology, habitat, research.

National Center for the Preservation of Medicinal Herbs. 1999. Summary of goldenseal research projects for 1998 and 1999. http://home.frognet.net/~rural8/frames2.html. [Date accessed: May 12, 2004].

Provides a summary of a field trial for goldenseal cultivation. Variables that were investigated included the use of mushroom compost, prepared beds vs. woods grown, and various sizes of root propagules. Results showed that larger roots initially showed the best growth, though smaller roots did eventually reach comparable size. Rootlets alone had very poor growth rates. Plants cultivated in beds were more vigorous. Compost warmed the soil and provided for earlier growth, though plants in uncomposted soil eventually reached the same size. Weeds were more prolific in composted soil. Additional studies in progress include solar direction of plantings, water requirements, wildlife damage, and rootstock quality vs. performance.

Keywords: Cultivation, research.

National Toxicology Program. [N.d.]. Developmental toxicity evaluation for goldenseal (*Hydrastis canadensis*) root powder administered in the feed to Swiss (CD-1®) mice on gestational days 6-17. NTP Study: TER99004. http://ntp-server.niehs.nih.gov/htdocs/TT-studies/TER99004.html [Date accessed: April 26, 2004].

Determines toxicity levels and potential side effects for gestational mice ingesting goldenseal.

Keywords: Research, toxicity.

Nishino, H.; Kitagawa, K.; Fujiki, H.; Iwashima, A. 1986. Berberine sulfate inhibits tumor-promoting activity of teleocidin in two-stage carcinogenesis on mouse skin. Oncology. 43(2): 131-134.

Investigates the cancer-fighting actions of berberine. Berberine inhibits the effects of the tumor-promoting chemicals of cancer cells. Berberine sulfate suppressed the tumor-promoting ability of teleocidin on skin tumor formation in mice.

Keywords: Berberine, cancer, clinical studies, medicinal uses.

O'Hara, M.A.; Keifer, D.; Farrell, K.; Kemper, K. 1998. A review of 12 commonly used medicinal herbs. Archives of Family Medicine. 7: 523-536.

Reviews 12 of the most commonly used herbs in the United States, focusing on guidelines for appropriate use, drug interactions, and possible side effects. Goldenseal is mainly used as an antidiarrheal and antiseptic. Large doses can lead to gastrointestinal tract and mucus membrane irritation, uterine and cardiac contractions, vasoconstriction, and stimulation of the central nervous system. Goldenseal should not be taken by pregnant women, lactating women, neonates, cardiovascular patients, or epileptics.

Keywords: Medicinal uses, toxicity.

Palmery, M.; Leone, M.G.; Pimpinella, G.; Romanelli, L. 1993. Effects of *Hydrastis canadensis* L. and the two major alkaloids, berberine and hydrastine, on rabbit aorta. Pharmacology Research. 27(suppl.1): 73-74.

Describes the medicinal actions of goldenseal. Alcohol extracts produce both a vasoconstrictive effect and an inhibitory action on the contraction of rabbit aorta induced by adrenaline, serotonin, and histamine. Berberine and hydrastine tested alone did not produce the same results as the combined alcohol extract. The authors concluded that several other constituents besides berberine and hydrastine contribute to this effect.

Keywords: Berberine, chemical constituents, medicinal uses, research.

Periera da Silva, A.; Rocha, R.; Silva, C.M. [and others]. 2000. Antioxidants in medicinal plant extracts. A research study of the antioxidant capacity of *Crataegus*, *Hamamelis,* and *Hydrastis*. Phytotherapy Research. 14(8): 612-616.

Evaluates and quantifies the antioxidant capacity of *Crataegus oxyacantha*, *Hamamelis virginiana*, and *Hydrastis canadensis* extracts.

Keywords: Medicinal uses, research.

Rehman, J.; Dillow, J.M.; Carter, S.M. [and others]. 1999. Increased production of antigen-specific immunoglobulins G and M following in vivo treatment with the medicinal plants *Echinacea angustifolia* and *Hydrastis canadensis*. Immunology Letters. 68(2-3): 391-395.

Investigates the effects of goldenseal and echinacea (*Echinacea* spp.) on the immune system. Groups of rats treated with either echinacea or goldenseal

were observed for 6 weeks to determine the effectiveness of each herb on antigen-specific immunity. Results showed that both echinacea and goldenseal enhance the immune system's ability to fight infections by increasing antigen-specific immunoglobulin production.

Keywords: Medicinal uses, research.

Robbins, C. 1999. Medicine from U.S. wildlands: an assessment of native plant species harvested in the United States for medicinal use and trade and evaluation of the conservation and management implications. Prepared by TRAFFIC North America for the Nature Conservancy. http://www.nps.gov/plants/medicinal/pubs/traffic.htm. [Date accessed: April 26, 2004].

Discusses the trade and use of selected medicinal herbs with implications for conservation. In 1995, 254 permits were sold for goldenseal collection in the Hoosier National Forest in Indiana. In 1996, 505 permits were sold in Hoosier, 274 in the Wayne National Forest in Ohio, and 2 in the Daniel Boone National Forest in Kentucky. In 1997, 317 permits were sold in the Hoosier, 193 in the Wayne, and 2 in the Daniel Boone. The Hoosier National Forest no longer sells permits for goldenseal collection.

Keywords: Conservation, permits.

Robbins, C.S. 2000. Comparative analysis of management regimes and medicinal plant trade monitoring mechanisms for American ginseng and goldenseal. Conservation Biology. 14(5): 1422-1434.

Outlines, compares, and critiques the management programs for American ginseng (*Panax quinquefolius*) and goldenseal. Trade in both American ginseng and goldenseal is regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The goldenseal management program relies on assistance from the industry. Both dealers and growers of goldenseal keep records of their transactions with the place of harvest, date, and name of the harvester to verify legal acquisition. This system relies on accurate and truthful reporting from the dealers. Documentation of the place and amount of harvest supplements U.S. Fish and Wildlife Service field studies on ecology and biology to track populations and determine sustainable harvest levels. Limited knowledge of the life cycle and habitat of goldenseal is an obstacle to ensuring proper management strategies. The amount of goldenseal in cultivation is small but increasing.

Keywords: CITES, dealers, regulations.

Sack, R.B.; Froehlich, J.L. 1982. Berberine inhibits intestinal secretory response of *Vibrio cholerae* toxins and *E. coli* enterotoxins. Infection and Immunology. 35: 471-475.

Investigates the clinical usefulness of the alkaloid berberine in treating acute diarrheal disease.

Keywords: Berberine, clinical research, medicinal uses.

Scazzocchio, F.; Cometa, M.F.; Tomassini, L.; Palmery, M. 2001. Antibacterial activity of *Hydrastis canadensis* extract and its major isolated alkaloids. Planta Medica. 67(6): 561-564.

Evaluates the antibacterial actions of the major alkaloids of goldenseal for the microorganisms *Staphylococcus aureus*, *Streptococcus sanguis*, *Escherichia coli*, and *Pseudomonas aeruginosa*. The "killing time" recorded for each organism validated the use of goldenseal as an antibiotic.

Keywords: Alkaloids, medicinal uses, research.

Schmeller, T.; Latz-Bruning, B.; Wink, M. 1997. Biochemical activities of berberine, palmatine, and sanguinarine mediating chemical defense against microorganisms and herbivores. Phytochemistry. 44(2): 257-266.

Analyzes the biochemical properties of berberine, palmatine, and sanguinarine to determine the mechanisms for their toxicity to insects, vertebrates, bacteria, fungi, and viruses. For each alkaloid, various actions are identified that mediate goldenseal's chemical defense against microorganisms and herbivores. Most of these actions include interference with DNA, protein synthesis, and neuron receptors; enzyme inhibition; and increased membrane permeability.

Keywords: Berberine, chemical defenses, research, toxicity.

Sheng, W.D.; Jiddawi, M.S.; Hong, X.Q.; Abdulla, S.M. 1997. Treatment of chlorine-resistant malaria using pyrimethanine in combination with berberine, tetracycline, or cotrimoxazole. East African Medical Journal. 74(5): 283-284.

Describes a study where patients with chloroquine-resistant malaria were treated with pyrimethamine and berberine, pyrimethamine and tetracycline, or pyrimethamine and cotrimoxazole. The group taking the berberine mixture had a 74.4-percent clearance rate after treatment; the tetracycline group had 67.2 percent; and the cotrimoxazole group had 47.8 percent.

These results show that berberine is more effective in treating the parasite than both tetracycline and cotrimoxazole.

Keywords: Berberine, medicinal uses, research.

Shideman, F.E. 1950. A review of the pharmacology and therapeutics of *Hydrastis* and its alkaloids hydrastine, berberine, and canadine. Bulletin of the National Formulary Committee [United Kingdom]. 18(102): 3-19.

Reviews clinical studies on the effects of the alkaloids hydrastine, berberine, and canadine. Summarizes the state of knowledge of goldenseal in 1950.

Keywords: Alkaloids, clinical studies, history.

Sinclair, A.; Catling, P.M. 2001. Cultivating the increasingly popular medicinal plant, goldenseal: review and update. American Journal of Alternative Agriculture. 16(3): 131-140.

Interviews goldenseal growers and provides a summary of cultivation knowledge and experience. Includes a botanical description, prices and market trends, associated species, propagation methods, current research, and environmental conditions needed for healthy crops.

Keyword: Cultivation.

Sturm, S.; Stuppner, H. 1998. Analysis of isoquinoline alkaloids in medicinal plants by capillary electrophoresis-mass spectrometry. Electrophoresis. 19(16-17): 3026-3032.

Describes the use of capillary electrophoresis mass-spectrometry to identify the isoquinoline alkaloids contained in crude methanolic extracts of medicinal herbs, including goldenseal.

Keywords: Alkaloids, product quality, research.

Sun, D.; Courtney, H.S.; Beachey, E.H. 1988. Berberine sulfate blocks adherence of *Streptococcus pyogenes* to epithelial cells, fibronectin, and hexadecane. Antimicrobial Agents and Chemotherapy. 32(9): 1370-1374.

Describes the mechanisms by which berberine sulfate prevents infections by streptococci.

Keywords: Berberine, medicinal uses.

Swanston-Flatt, S.K.; Day, C.; Bailey, C.J.; Flatt, P.R. 1989. Evaluation of traditional plant treatments for diabetes: studies in streptozotocin diabetic mice. Acta Diabetol. Lat. 26(1): 51-55.

Studies seven herbs used to treat diabetes in mice with streptozotocin diabetes. Goldenseal was one of the herbs that significantly reduced hyperphagia and polydipsia. Of the herbs studied, bearberry (*Arctostaphylos uva-ursi*), goldenseal, mistletoe (*Viscum album*) and tarragon (*Artemesia dracunculus*) significantly reduced symptoms of streptozotocin diabetes but did not affect glycemic control.

Keywords: Clinical studies, medicinal uses.

Tice, R. 1997. Goldenseal (*Hydrastis canadensis* L.) and two of its constituent alkaloids: berberine and hydrastine. Review of toxicological literature. Research Triangle Park, NC: Integrated Laboratory Systems. Prepared for the National Institute of Environmental Health Sciences, Research Triangle Park, NC. http://ntp-server.niehs.nih.gov/htdocs/Chem_Background/ExSumPdf/GoldenSeal.pdf. [Date accessed: April 26, 2004].

Examines the two major chemical constituents of goldenseal and the literature on their toxicology. Includes the chemical structure, properties, actions, and thorough review of technical and clinical literature on the toxicity, side effects, and other safety issues of the constituents and various compounds in varying dosages and exposures.

Keywords: Berberine, chemical constituents, research, toxicity.

Tobe, H.; Keating, R.C. 1985. The morphology and anatomy of *Hydrastis* (Ranunculales): systematic re-evaluation of the genus. Botany Magazine (Tokyo). 98: 291-316.

Suggests that the genus *Hydrastis* should be moved from Ranunculaceae to its own family, based on differing plant characteristics.

Keywords: Classification, Ranunculaceae family.

Van Der Voort, M.; Bailey, B.; Samuel, D.E.; McGraw, J. 2003. Recovery of populations of goldenseal (*Hydrastis canadensis* (L.)) and American ginseng (*Panax quinquefolius* (L.)) following human harvest. The American Midland Naturalist. 149 (2): 282–292.

Describes observations on the recovery of wild populations of goldenseal and American ginseng (*Panax quinquefolius)* after natural and simulated harvest.

Keywords: Conservation, harvest, research.

Whetzel, H.H. 1918. The *Botrytis* blight of golden seal. Phytopathology. 8: 73-76.

Describes the most common disease of cultivated goldenseal. Botrytis can affect seedlings, leaves, leaf petioles, flowers, and seed heads. The disease is present in most gardens, though it is usually observed only in the wet season. Spraying crops with Bordeaux mixture can reduce damage.

Keywords: Cultivation, pests, disease.

Wu, A.H.; Forte, E.; Casella, G. [and others]. 1995. CEDIA for screening drugs of abuse in urine and the effect of adulterants. Journal of Forensic Science. 40(4): 614-618.

Studies several adulterants for potential ability to alter the results of urinalysis for the screening of various drugs. Goldenseal showed only selective or minimal interference.

Keywords: Drug masking, research.

Popular Press

The following articles and websites have not been peer reviewed, but are included to indicate popular views and perceptions.

Adam, K.L. 2002. Ginseng, goldenseal, and other native roots. Hort. Tech. Note. Fayetteville, AR: Appropriate Technology Transfer for Rural Areas. 12 p. http://attra.ncat.org/attra-pub/ginsgold.html. [Date accessed: April 26, 2004].

Provides a well-documented overview for American ginseng (*Panax quinquefolius)*, goldenseal, black cohosh (*Actaea racemosa)*, and blue cohosh (*Caulophyllum thalictroides*); covers cultivation, regulations, and production. Goldenseal has a similar range and habitat requirement to ginseng. Research is being conducted on propagation and cultivation methods to alleviate the demand on wild resources, though most of the current methods are similar to those described in publications written at the turn of the century. Reliable data on yields are not available, but estimates

range from 1,000 to 2,500 pounds per acre after 3 to 5 years of growth from seed.

Keywords: Cultivation, propagation, yield estimates.

Bergner, P. 1996/1997. Goldenseal and the common cold: the antibiotic myth. Medical Herbalism. 8(4): 1-6, 10. http://www.medherb.com/84.HTM. [Date accessed: April 26, 2004].

Discusses the increasing use of goldenseal to prevent or treat colds with an emphasis on the inappropriate vs. appropriate uses of the herb. Although goldenseal can treat bacterial infections, it has no effect on viral infections. Taking excessive doses of goldenseal can do more harm than good, drying out mucus membranes and killing beneficial flora in the intestines. Using goldenseal to prevent colds before infection has started can also interfere with the natural defenses of the body, leaving the system too weak to react when infection does set in.

Keywords: Dosage, medicinal uses.

Hoffman, D.L. [N.d.]. Goldenseal. Herbal Materia Medica. Health World Online. http://www.healthy.net/asp/templates/article.asp?PageType=article&ID=1906. [Date accessed: April 26, 2004].

Provides a short summary of the medicinal actions and benefits of goldenseal. The chemical constituents and their associated action on the body are discussed. Preparations, dosages, and combinations with other herbs are presented.

Keywords: Chemical constituents, medicinal uses.

Liebmann, R.; Cech, R.; Goodman, S. [and others]. 1998. Industry and organizations form partnership for goldenseal conservation. United Plant Savers Newsletter. Spring: 1-3.

Reports on the March 12, 1998, meeting in Anaheim, CA, where goldenseal dealers, manufacturers, and representatives from government and non-government organizations discussed goldenseal conservation issues. Issues included the paperwork tracking system from collection to final sale of roots, progress and research in cultivation, public education about proper uses and misuses of the herb, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) listing regulating export of the roots.

Keywords: CITES, conservation, regulations.

McCaleb, R. 1994. Unearthing the health care of goldenseal. Better Nutrition for Today's Living. 56(9): 58.

Reviews goldenseal history, conservation, medicinal uses, and safety. Goldenseal is commonly combined with echinacea (*Echinacea* spp.) for cold and flu remedies, or used alone for sore throats, wound healing, or digestive aid. The bright yellow color of the roots has also made it a useful dye. Medicinal use by Native Americans and early settlers is discussed. In modern medicine, goldenseal has similar uses as a tonic, laxative, digestive, antiseptic, mouthwash, mucus membrane stimulant, hemorrhoid treatment, and douche for vaginal infections. Goldenseal was used in pharmaceutical preparations to relieve eye irritations until the 1970s. The medicinal properties of goldenseal come from the alkaloids berberine, hydrastine, and canadine. The specific action for each of these alkaloids is discussed.

Keywords: Alkaloids, conservation, dye uses, history, medicinal uses.

McGuffin, M. 1999. AHPA goldenseal survey measures increased agricultural production. HerbalGram. 46: 66-67.

Summarizes the results of a survey designed to quantify the harvests of goldenseal from both wild and cultivated sources for the year 1998. The survey was sponsored by the Botanical Raw Materials Committee of the American Herbal Products Association. Survey respondents reported a total of 265,000 pounds of dried root harvested in the year 1998. An additional 62,000 pounds were harvested for use as planting stock. Cultivated roots are supplied from a total of 140 acres. The amount of goldenseal in cultivation is expected to increase over the next few years.

Keywords: Cultivation, harvest, market demand.

Nutriflip. 1998. Naturopathy: herbs and other plant products. Nutrition for a living planet - food, nutrition, diet, and health. http://www.geocities.com/nutriflip/Naturopathy/. [Date accessed: April 26, 2004].

Provides a general overview of goldenseal with nomenclature, distribution, ecological parameters, uses, preparations, and toxicity.

Keyword: Medicinal uses.

Silva, B. 2000. Commercial production of goldenseal: with wild populations endangered in some areas, this herb is in demand! AgVentures. 3(6): 24-27, 29.

Summarizes research on cultivation methods, production considerations for farmers, and markets for goldenseal roots. Goldenseal is endangered; wild harvest is illegal in North Carolina. There is a high demand for cultivated roots, and limitations on supply have increased prices. Obtaining rhizomes for propagation can be difficult and costly. When cultivated, goldenseal is often rotated with American ginseng (*Panax quinquefolius)*, as the two plants require similar conditions. Yields ranging from 800 to 3,000 pounds per acre have been reported. Prices fluctuate, making profits difficult to predict.

Keywords: Cultivation, market demand.

Other Information Sources

The following are general materials that provide background and reference information. Included are encyclopedias, fact sheets, historical documents, planting guides, herbal manuals, and other miscellaneous information.

Ahluwalia, S.S. 1977. Goldenseal – American gold. Bronx, NY: Walden House. 22 p.

Provides information on cultivating goldenseal, with a botanical description, medicinal uses, history, propagation, market trends, and a list of suppliers.

Keyword: Cultivation.

American Herbal Products Association. 2003. Tonnage survey of North American wild-harvested plants. Washington, DC: American Herbal Products Association. 19 p.

Summarizes recent market trends for several medicinal herbs. Results of the survey show a decrease in goldenseal consumption over the last 4 years with an increase in the proportion of cultivated root supplying the market.

Keywords: Annual consumption, market.

Bannerman, J.E. 1997. Goldenseal in world trade: pressures and potentials. HerbalGram. 41: 51-52.

Discusses various factors that influence conservation—markets, ecology, harvest, medicinal uses, cultivation, and more. Goldenseal is only found in North America, growing in moist shady hardwood forests with other herbs such as American ginseng (*Panax quinquefolius*), black cohosh (*Actaea racemosa*), bloodroot (*Sanguinaria canadensis*), mayapple (*Podophyllum peltatum*), and false unicorn root (*Chamaelirium luteum*). Various factors such as overharvest, timber harvesting, agriculture expansion, road expansion, and increased urbanization have contributed to the decreasing numbers of wild populations. The Network of National Heritage Programs has assigned goldenseal a "fragile" ranking. Trade is regulated in 7 of the 26 States where goldenseal is found; wild harvest is prohibited in North Carolina, Vermont, Connecticut, Georgia, Massachusetts, and Minnesota. Goldenseal is reported, but unprotected, in Arkansas, Illinois, Iowa, Kentucky, Mississippi, Ohio, and West Virginia. It is on the "rare plant" list in Alabama; the "watch" list in Delaware, Virginia, and Indiana; "threatened" in Maryland, Tennessee, and New York; "fairly rare" in Oklahoma and Michigan; "historic" in New Jersey; "vulnerable" in Pennsylvania; and "of special concern" in Wisconsin. The United Nations Food and Agriculture Organization lists goldenseal as one of the top selling herbs worldwide. It is listed in the official pharmacopoeias of France, Britain, Germany, and Italy. A large proportion of the goldenseal exported to Italy and France is used to make tinctures, dilutions, extracts, and other products. Export amounts imply an enormous harvest of roots; but, without knowledge about sustainable harvest levels, the impact on the species is unknown. Because of concern over the conservation of resources, goldenseal was included in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II in 1997. Research into cultivation methods and practices has increased in an effort to reduce the demand on wild plants.

Keywords: Associated herbs, CITES, conservation, habitat, export, regulations.

Bergner, P. 1997. The healing power of *Echinacea*, goldenseal, and other immune system herbs. Rocklin, CA: Prima. 322 p.

Provides a synopsis of the medicinal applications of goldenseal and echinacea (*Echinacea* spp.). A detailed history of goldenseal's medicinal use is provided, including Native American, colonial, and homeopathic remedies. Most clinical research related to the chemical constituents of goldenseal and their medicinal properties has focused on the alkaloid berberine, which is found in several other plants. Modern medicinal applications and dosage are discussed in detail with a thorough discussion on the appropriate and inappropriate indications for the herb.

Keywords: Alkaloids, chemical constituents, history, medicinal uses.

Bowers, H. 1891. A contribution to the life history of *Hydrastis canadensis.* Botanical Gazette. 16: 73-82.

Describes the various stages of the goldenseal life cycle. Seeds naturally sown after the fruit ripens in August will germinate the following spring. The first year of growth produces two cotyledons and a small radicle. In the second year of growth, the plant sends up a single, palmately-lobed leaf. The plant reaches maturity in the third or fourth year, having a stem 15 to 30 centimeters tall with two alternate palmate leaves. The lower leaf is larger and has a petiole; the smaller upper leaf supports a peduncle with the flower. Plants can propagate by adventitious buds on the rhizomes and rootlets. Illustrations and detailed descriptions are provided for all stages of growth and all plant parts.

Keywords: Botanical description, life cycle.

Bradshaw, C., comp. 1997. Goldenseal: *Hydrastis canadensis*. In: Complimentary and alternative medicine: a scientific reference for health care professionals. http://www.geocities.com/chadrx/goldenseal.html. [Date accessed: April 26, 2004].

Provides an overview of chemical composition and constituents, with reviews of several clinical studies. The main active alkaloid in goldenseal roots is berberine. Other constituents include berberastine, canadine, hydrastine, meconin, chlorogenic acid, phytosterins, and resin. Berberine is antibiotic, immuno-stimulatory, anticonvulsant, sedative, and potentially anticancer. It is effective in inhibiting numerous bacteria, fungi, and protozoans. Berberine's effect is tied to either inhibiting growth or preventing the adhesion of pathogens to host cells. Dosage and toxicity information is included. Several clinical trials are outlined, including the effectiveness of using berberine in treating watery diarrhea associated with cholera; using high-dose berberine in treating cholera; using berberine sulfate to treat diarrhea caused by *Escherichia coli* or *Vibrio cholerae*; and using berberine chloride eye drops to treat trachoma. Conclusions from these studies show that berberine is effective for treating intestinal infections caused by *E. coli* but not *V. cholerae*, and that berberine is useful for treating trachoma.

Keywords: Berberine, chemical constituents, medicinal actions, medicinal uses, research reviews.

Britton, N.L.; Brown, A. 1913. An illustrated flora of the Northern United States, Canada, and the British Possessions. Vol. 2. New York: Charles Scribner's Sons. In: U.S. Department of Agriculture, Natural Resources Conservation Service. 2001. The PLANTS database. Version 3.1. National Plant Data Center, Baton Rouge, LA 70874-4490 U.S.A. Available at: http://plants.usda.gov. [Date accessed: April 26, 2004].

Provides a botanical illustration of goldenseal.

Keyword: Botanical description.

Catling, P.M.; Sinclair, A. 1998. The history of the golden seal. Recovery – an Endangered Species Newsletter (Canadian Wildlife Service). 1998 (Spring): 12.

Summarizes conservation concerns for goldenseal in Canada.

Keyword: Conservation.

Cech, R. 2002. Growing at-risk medicinal herbs: cultivation, conservation, and ecology. Williams, OR: Horizon Herbs. 323 p.

Provides a thorough discussion of goldenseal botany, ecology, and cultivation. Goldenseal is a long-lived perennial, growing in communal patches on northern or northeastern hillsides of hardwood forests. Plants reproduce asexually through knot-like buds that form on the roots and from various growing points that form along the main rhizome. Details are provided on the range and hardiness, life cycle, cultivation from seed and rhizome, optimal growing conditions, harvest, storage, seed collection, and conservation status.

Keywords: Conservation, cultivation.

Cook, W. 1869. The physiomedical dispensatory. Scanned version by Journal of Medical Herbalism, 2001. http://www.ibiblio.org/herbmed/eclectic/cook/HYDRASTIS_CANADENSIS.htm [Date accessed: April 26, 2004].

Provides historical information on goldenseal, with a detailed botanical description, medicinal properties and uses, and pharmaceutical preparations. Goldenseal acts upon the whole physical system but mainly benefits the mucus membranes, digestive tract, and uterus. The herb has been shown to stimulate the involuntary muscles but does not increase the pulse.

Descriptions of internal and external therapeutic actions are provided. Instructions for the pharmaceutical preparation of extracts, tinctures, fluid extracts, and hydrastin are included.

Keywords: History, medicinal uses, preparations.

Davis, J.M. 1998. Goldenseal. In: Berzins, R.; Snell, H.; Richter, C., eds. Richters second commercial herb growing conference – transcripts. Goodwood, Ontario, Canada: Richters: 133-143.

Summarizes results of goldenseal cultivation research in North Carolina. Discusses factors that affect plant growth rates such as soil pH, nitrogen, phosphorus, mulch, and shade. Methods of storing and planting seeds are evaluated.

Keywords: Cultivation, research.

Davis, J.M. 1999. Forest production of goldenseal. Agroforestry Note 16. Forest Farming - 5. In cooperation with the U.S. Department of Agriculture, Forest Service, and the U.S. Department of Agriculture, Natural Resources Conservation Service. Lincoln, NE: U.S. Department of Agriculture, National Agroforestry Center. 6 p. http://www.unl.edu/nac/afnotes/ff-5/index.html. [Date accessed: April 26, 2004].

Provides details for cultivating goldenseal. Overharvesting has led to declines in native populations, increasing the need to meet consumer demand for the herb with cultivated sources. The plant is an herbaceous perennial with a stem reaching up to 14 inches tall that ends in a fork with two 3- to 12-inch wide, 5- to 7-lobed leaves. The plants spread naturally by means of the bright yellow horizontal rhizomes and fibrous roots. Goldenseal grows best in moist, well-drained, shady sites under mixed hardwoods. Guidelines are provided for preparing soil and removing roots, weeds, and other plants. Details are given for soil amendments and fertilizers. Propagation is most commonly done by dividing rhizomes. Propagation by seed is unpredictable and can be difficult. More details on seed collection, planting times, and planting methods are provided. Prevention and treatment methods for pests and disease are discussed. Information is provided for harvesting, cleaning, drying, and packaging roots.

Keywords: Botanical description, cultivation, habitat, propagation, site preparation.

Davis, J.M. 2000. Sources of goldenseal seeds, plants, or roots. North Carolina State University Horticulture Inf. Leafl. 123. Raleigh, NC: North Carolina Cooperative Extension Service. http://www.ces.ncsu.edu/hil/hil-123.html. [Date accessed: April 26, 2004].

Provides a list of sources of goldenseal seed, plants, and growing stock.

Keywords: Cultivation, vendors.

Davis, J.M.; McCoy, J. 2000. Commercial goldenseal cultivation. North Carolina State University Horticulture Inf. Leafl. 131. Raleigh, NC: North Carolina Cooperative Extension Service. http://www.ces.ncsu.edu/depts/hort/hil/hil-131.html. [Date accessed: April 26, 2004].

Offers comprehensive information on cultivation, with propagation methods, site selection and preparation, pests and diseases, harvest, and more. Although the native range for the plant extends from Vermont and Wisconsin south to Georgia and west to Kansas, overcollection has reduced native populations. Most of the remaining patches are found in hardwood forests of Illinois, Ohio, Indiana, and western Kentucky. Goldenseal is protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II, and is an endangered species in North Carolina. Contact information is included for individuals to obtain the necessary permits.

Success with goldenseal cultivation depends on the grower's ability to reproduce the native habitat. Research is being conducted on ideal shade conditions; preliminary results indicate that a range of 63- to 80-percent shade is optimal. In woodlands, understory plants that indicate good habitat for planting include mayapple (*Podophyllum peltatum*), trillium (*Trillium* spp.), bloodroot (*Sanguinaria canadensis)*, or black cohosh (*Actaea racemosa*). Good overstory trees include oak (*Quercus* spp.), poplar (*Populus* spp.), walnut (*Juglans nigra*), and basswood (*Tilia americana*). Instructions are given for preparing and amending the soil. Details are provided on propagation procedures, seed stratification, soil preparation, and plant spacing. Methods to prevent and treat disease and pest problems are presented. Roots should be harvested before they get overcrowded and die back. Instructions are given for cleaning, drying, and storing roots.

Keywords: Associated herbs, CITES, cultivation, habitat, harvest, overstory species, permits, regulations, sun requirements.

Ellingwood, F. 1919. The American Materia Medica, therapeutics and pharmacognosy. Scanned version by M. Moore, 2001-2002. http://www.ibiblio.org/herbmed/eclectic/ellingwood/hydrastis.html. [Date accessed: April 26, 2004].

Provides a historical account of goldenseal, with descriptions of various preparations and doses, chemical constituents, physiological actions, and medicinal uses.

Keywords: History, medicinal uses.

Felter, H.W. 1922. The eclectic Materia Medica, pharmacology and therapeutics. Scanned version by M. Moore, 2001-2002. http://www.ibiblio.org/herbmed/eclectic/felter/hydrastis.html. [Date accessed: April 26, 2004].

Covers historical knowledge of goldenseal, including principal constituents, preparations, specific indications, actions, and therapy. Various preparations and dosages are given. Indications for use are catarrh, diarrhea, dysentery, gonorrhea, hemorrhage, ulcers, gas, irritations of the mucus membranes, throat and mouth problems, muscle soreness, and skin diseases. Goldenseal is poisonous to some animals, but safe for humans in moderate doses. Both the internal and external therapeutic actions of goldenseal are described in detail.

Keywords: History, medicinal uses.

Felter, H.W.; Lloyd, J.U. 1898. King's American dispensatory. 18th ed., 3rd rev. Scanned version by H. Kress, 2000-2001. http://www.ibiblio.org/herbmed/eclectic/kings/hydrastis.html. [Date accessed: April 26, 2004].

Reviews the botany, chemical composition, and medicinal uses of goldenseal in the late 1800s. Includes a thorough description of the herb's botany, growth habit, roots, and nomenclature. Conservation issues are presented with the comment that goldenseal does not grow well in disturbed soil and, therefore, is more susceptible to loss of habitat. The chemistry, medicinal actions, and extractions are discussed for berberine, hydrastine, and canadine. The alkaloids are more effective in combination than in isolated extracts. Medicinal actions are discussed in detail, along with descriptions of pharmaceutical preparations and dosages.

Keywords: Alkaloids, conservation.

Fern, K. 1997-2000. Plants for a future: the species database. http://www.ibiblio.org/pfaf/cgi-bin/arr_html?Hydrastis+canadensis. [Date accessed: April 26, 2004].

Provides details on the various uses of goldenseal, the environment in which the plant is found, and methods of cultivation. Goldenseal grows in various soil types but prefers moist, shaded areas. Medicinal actions are antibacterial, antiperiodic, antiseptic, antispasmodic, astringent, cholagogue, diuretic, laxative, sedative, stomachic, and tonic. Goldenseal is particularly valuable for treating disorders of the mucus membranes and digestion and is also used to treat irritations and other problems with the ears, eyes, throat, nose, stomach, intestines, and vagina. Because it destroys beneficial organisms along with pathogens, goldenseal should only be used for short durations. The roots are also used as an insect repellent and dye. Plants can be propagated by seed or by division of rhizomes.

Keywords: Habitat, medicinal actions, medicinal uses, other uses.

Ford, B.A. 1997. *Hydrastis.* In*:* Flora of North America Editorial Committee, ed. Flora of North America north of Mexico. New York: Oxford University Press: 87-88. Vol. 3.

Summarizes the botany, ecology, and nomenclature of goldenseal; includes illustrations.

Keywords: Botanical description.

Foster, S. 1989. Goldenseal masking of drug tests: from fiction to fallacy. HerbalGram. 21: 7.

Discusses the myth that goldenseal can mask drugs in urine tests. Eclectic physicians recommended goldenseal combined with cayenne to cleanse the liver in alcoholic patients. The idea that goldenseal can mask drugs in urinalysis is a myth that originated from “Stringtown on the Pike,” a novel written by John Uri Lloyd in 1900. Scientific research has proven that goldenseal is, in fact, incapable of masking various drugs in urine tests of humans or racehorses.

Keyword: Drug masking.

Foster, S. 2000. Goldenseal (*Hydrastis canadensis*). Steven Foster group herb monographs. http://www.stevenfoster.com/education/monograph/goldenseal.html. [Date accessed: April 26, 2004].

Provides general information on goldenseal history, medicinal use, and conservation. Goldenseal has been included in books on medicinal plants since the late 1700s. Native Americans used the herb to treat general debility, dyspepsia, poor appetite, diarrhea, whooping cough, liver disease, fever, stomach problems, flatulence, pneumonia, inflammation, heart trouble, and cancer. It was used by early European settlers to relieve skin and eye irritations, inflammation of the mucus membranes, and indigestion. Goldenseal is one of the most popular herbs on the market with an estimated 250,000 pounds of root sold every year. Prices in the early 1990s ranged from $8 to $11 per pound, then rose to $30 per pound, and upwards of $100 per pound in 2000. Prices continue to fluctuate with variations in supply or demand. With wild resources decreasing due to over-harvest and habitat loss, cultivation is encouraged. Goldenseal is included in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II, and international trade is monitored and regulated by the U.S. Fish and Wildlife Service.

Keywords: CITES, conservation, history, market prices, medicinal uses, Native American uses, U.S. Fish and Wildlife Service.

Foster, S.; Duke, J.A. 2000. A field guide to medicinal plants and herbs of Eastern and Central North America. 2nd ed. National Audubon Society, National Wildlife Federation, and the Roger Tory Peterson Institute. New York: Houghton Mifflin Co. 411 p.

Provides details on the botany, ecology, and medicinal uses of goldenseal. Each plant consists of a forked stem with two double-toothed leaves. Single flowers with numerous stamens appear in April and May; the berry resembles a raspberry. Plants are found from Vermont to Georgia, west to Arkansas and Minnesota. The main medicinal uses of the herb are for inflammation of the mucus membranes in the mouth, throat, digestive tract, or uterus. Goldenseal has also been used to treat jaundice, bronchitis, pharyngitis, and gonorrhea and was an ingredient in commercial eyewash formulas until the 1980s. The main active alkaloid is berberine, which lowers blood pressure, increases bile secretion, and reduces convulsions. Studies have shown that the alkaloids in goldenseal act synergistically and are more effective in combination than when used alone.

Keywords: Alkaloids, berberine, botanical description, medicinal uses, range.

Grieve, M. 1931. A modern herbal. Hypertext version by Botanical.com. 1995-2002. http://www.botanical.com/botanical/mgmh/g/golsea27.html. [Date accessed: April 26, 2004].

Summarizes information on goldenseal botany, ecology, medicinal uses, cultivation, and preparations. Other common names for goldenseal include yellow root, orange root, yellow puccoon, ground raspberry, wild curcuma, turmeric root, Indian dye, eye root, eye balm, Indian paint, jaundice root, and warnera. Goldenseal is found in rich soils in shady forests throughout the Eastern United States and is primarily collected in the Ohio Valley and sold from Cincinnati. Goldenseal is a perennial herb with a horizontal, knotted, bright yellow 1/4- to 3/4-inch-thick rhizome. The rhizome is covered with numerous rootlets and marks left by stems from previous years. Stems are 6 to 12 inches tall, rounded with small hairs, and have scales at the base. Each stem has two dark green, wrinkled, and veined leaves, palmately arranged with five to seven lobes, and irregularly toothed margins. Flowers have only three small greenish-white sepals that fall away soon after opening, leaving no petals and numerous stamens. Characteristics of dried roots are provided. The medicinal properties of the root are discussed along with the chemical constituents. Native Americans used the roots as a tonic, a treatment for sore eyes and ulcers, and as a yellow dye. Goldenseal is most commonly used to treat digestive disorders, catarrh, appetite loss, nausea, hemorrhoids, and constipation. The herb can be used in powdered form or as a fluid extract, tincture, solid extract, infusion, or lotion.

Keywords: Botanical description, common names, flowers, habitat, medicinal uses, Native American uses, preparations, range.

Haage, L.J.; Ballard, J.L. 1989. A grower's guide to goldenseal. Norway, IA: Nature's Cathedral. [Not paged].

[No abstract].

Keyword: Cultivation.

Hamon, N.W. 1990. Herbal medicine: goldenseal. Canadian Pharmaceutical Journal. 123: 508-510.

Summarizes goldenseal's botanical characteristics, medicinal uses, history, phytochemistry, phytopharmacology, and phytotoxicity.

Keyword: Medicinal uses.

Hardacre, J.V.; Henderson, G.; Collins, F.B. [and others]. 1962. The wildcrafters goldenseal manual. Rockville, IN: Wildcrafters Publications. [Not paged].

[No abstract].

Keyword: Harvest.

Harding, A.R. 1936. Ginseng and other medicinal plants. Scanned version by M. Moore, 2002. http://www.ibiblio.org/herbmed/eclectic/harding/main.html. [Date accessed: April 26, 2004].

Provides a historical perspective on the plant description and cultivation. A list of other common names is included. In the 1930s, most of the commercial supply was collected in Ohio, Indiana, Kentucky, and West Virginia. Goldenseal is a perennial, growing to a foot in height, and consisting of a single stem with two leaves. Leaves are wrinkled and only partially developed at the time of flowering, but continue to expand as the plant matures. Flowers open in April and May, but only last 5 or 6 days. The fruit appears in July or August, is shaped like a raspberry, and contains 10 to 20 hard black seeds. The rhizomes are bright yellow and contain raised cup-like scars left by the previous years' stems. The scars resemble waxed seals, hence the common name goldenseal. Dried roots are crooked, wrinkled, and knotty, 1/8 to 1/3 inch in diameter, dull brown externally, and bright yellow internally. Rootlets break off easily, leaving the rhizome almost bare. Roots are collected in autumn after the seeds mature. Scarcity of native plants from overcollection and habitat loss has increased the need for cultivated resources. Cultivation is done in areas that are similar to the native habitat with moist, rich soil and shade.

A chapter entitled "Golden Seal Cultivation," is included, with propagation methods for seeds and root division, site selection, soil requirements, shade requirements, planting, harvest, drying, root classifications and prices, diseases, other concerns, risks, and profits. Much of the information contained in this chapter is similar to recent publications based on current scientific research.

Another chapter, "Golden Seal History, Etc.," written by Alice Henkel and G. Fred Flume of the U.S. Department of Agriculture, includes an additional detailed botanical description, habitat description, common names, root description, collection and preparation, and trade. Concerns are raised about the diminishing numbers of plants in the wild due to overcollection and habitat loss.

Keywords: Botanical description, cultivation, flowers, fruit, harvest, history, rhizomes, seeds.

Haughton, C. 2001. Purple sage herb profiles. http://www.purplesage.org.uk/profiles/goldenseal.htm. [Date accessed: April 26, 2004].

Provides a general overview of goldenseal, including constituents, therapies, dosages, and other medicinal matters. A list of other common names is included with a brief botanical description. Rhizomes are harvested from 3-year-old plants in autumn after the seeds ripen. The roots are 5 percent isoquinoline alkaloids (hydrastine, berberine, and canadine); the remaining 95 percent consists of chlorogenic acid, essential oil, resin, fatty oil, starch, and sugar. Some of the medicinal actions listed are tonic, astringent, antimicrobial, laxative, stimulant, and anti-inflammatory. The indications for use are included. Because of its strong effects on the mucus membranes, goldenseal is often used for digestive disorders, liver disorders, and catarrh. The tonic and astringent properties of the herb make it useful for uterine and menstrual disorders, eczema, ringworm, and as a wash for eye and ear problems. Goldenseal also has strong antibacterial properties. Useful combinations with other medicinal herbs are listed. Because goldenseal stimulates involuntary muscles, it should be avoided during pregnancy.

Keywords: Alkaloids, harvest, medicinal uses.

Henkel, A.; Klugh, G.F. 1908. The cultivation and handling of goldenseal. Bureau of Plant Industry - Circ. 6. Washington, DC: U.S. Department of Agriculture. 19 p.

Summarizes early information on cultivating goldenseal. Includes habitat and range, a botanical description, medicinal uses, root harvest, soil and shade requirements, propagation methods, crop maintenance, and market conditions.

Keywords: Cultivation, history.

Hobbs, C. 1990. Goldenseal in early American medical botany. Pharmacy in History. 32(2): 79-82.

Provides an overview of the history of goldenseal usage in the United States.

Keyword: History.

Jackson, D.; Shelton, K. 1997-2001. Alternative nature online herbal. http://altnature.com/gallery/goldenseal.htm. [Date accessed: April 26, 2004].

Provides photographs and general information about medicinal uses. A short botanical description is included. Roots are used medicinally, for short durations of 3 months or less, as an antiseptic, antibacterial, antispasmodic, laxative, and astringent. Native Americans used goldenseal medicinally and as a dye to paint their faces, horses, and weapons. The common name goldenseal comes from the raised scars on the rhizomes, which resemble a waxed seal.

Keywords: Dye uses, medicinal uses, Native American uses.

Kelly, J. 1977. Herb collector's manual and marketing guide: ginseng growers and collectors handbook: a valuable guide for growers of ginseng and golden seal, medicinal herb and root collectors, containing old tyme herbe recipes and outdoor money-making ideas. 5th ed. Looneyville, WV: Wildcrafters. 97 p.

Provides essays and summaries on various aspects of wildcrafting such as plant identification, methods and seasons for harvesting plants, drying and storage, cultivation, propagation, and medicinal preparations.

Keyword: Harvest.

Konsler, T.R. 1987. Woodland production of ginseng and goldenseal. In: Proceedings of the First National Herb Growing and Marketing Conference. Stn. Bull. West Lafayette, IN: Purdue University Agricultural Experiment Station: 175-178.

[No abstract].

Keyword: Cultivation.

Lloyd, J.U. 1912. The cultivation of *Hydrastis*. Journal of the American Pharmaceutical Association. 1: 5-12.

Presents information on cultivating goldenseal. Includes common and scientific names, plant distribution, history of commerce, a root description, and propagation methods. Conservation issues are discussed.

Keywords: Conservation, cultivation.

Lloyd, J.U.; Lloyd, C.G. 1884-1887. Drugs and medicines of North America. Scanned version by H Kress, ©2001-2003. http://www.ibiblio.org/herbmed/eclectic/dmna/hydrastis-cana.html. [Date accessed: April 26, 2004].

Offers a comprehensive review of medicinal efficacies of goldenseal, a history of trade, and botanical references. This text includes thorough, detailed knowledge of all aspects of goldenseal from the eclectic physicians in 1887 and is referenced in numerous other articles presented in this bibliography. The plant nomenclature includes the history of various common names. A thorough botanical description of all plant structures and geographical range distribution with maps are included. The commercial history covers Native American uses through the modern trade center in Cincinnati. The market is evaluated, specifically the fluctuations in supply and demand that cause variations in price. Concerns are raised over the loss of native habitat and overcollection that are causing the plant to become more and more scarce. Substances used to adulterate supplies are presented. The discovery, chemistry, extraction, preparations, and properties of each of the main alkaloids are discussed. The medicinal uses and actions are described, supported with specific case studies and method of administration.

Keywords: Conservation, history, market, medicinal uses.

Miller, R.A. 1988. Native plants of commercial importance. Grants Pass, OR: OAK, Inc. 343 p.

Provides general information on goldenseal ecology, medicinal uses, history, markets, and conservation. A thorough botanical description is included. Goldenseal was used by various Native American tribes, including the Crow, Cherokee, Iroquois, Meskwaki, Seminole, and Blackfeet. The roots were used medicinally as an eyewash, topical cleanser, and skin treatment or to restore normal function to the mucus membranes, nutritive system, or circulatory system. Although it is mainly used externally, goldenseal has also been ingested to treat dyspepsia, anorexia, gastritis, menorrhagia, or dysmenorrhea. The yellow juice of the roots was used as a dye or mixed with bear grease for an insect repellent. Leaves can also be used medicinally, particularly in teas. The chemistry of goldenseal roots is presented. Details are provided for harvesting, sorting, drying, and storing roots. Goldenseal is popular worldwide and exported to European pharmaceutical companies. It should not be used in large doses or over long periods of time as it can damage the circulatory and digestive systems.

Keywords: Dye uses, export, insect repellent uses, medicinal uses, Native American uses.

Missouri Botanical Garden. 2002. Plant finder. http://ridgwaydb.mobot.org/kemperweb/plantfinder/Plant.asp?code=K570. [Date accessed: April 26, 2004].

Summarizes goldenseal cultivation information useful to the gardener. A brief botanical description is provided. Cultivated plants in the landscape have no serious pest or disease problems and are useful in woodland gardens and other shaded naturalized or wild gardens.

Keywords: Cultivation, landscape uses.

Moerman, D. 1999. Native American ethnobotany database: foods, drugs, dyes, and fibers of native North American peoples. The University of Michigan-Dearborn. http://herb.umd.umich.edu/. [Date accessed: April 26, 2004].

Details Native American uses for goldenseal. The Cherokee Indians used goldenseal to treat cancer, general debility, dyspepsia, poor appetite, and as a wash for local inflammation. The Iroquois Indians used goldenseal for whooping cough, diarrhea, liver trouble, fever, stomachache, gas, earaches, and as an emetic for biliousness.

Keywords: Medicinal uses, Native American uses.

NatureServe Explorer. 2002. An online encyclopedia of life [web application]. Version 1.6. Arlington, VA: NatureServe http://www.natureserve.org/explorer. [Date accessed: April 26, 2004].

Provides details on goldenseal ecology, conservation status, market demand, and distribution. Goldenseal has a global heritage status rank of G4, a national heritage status rank of N4 (apparently secure) in the United States, and a national heritage status rank of N2 (imperiled) in Canada. State heritage status ranks are provided for all States reporting goldenseal. Populations are not tracked or monitored throughout the range, so most information is based on estimates. It is believed that goldenseal populations are declining, mostly due to overharvest, development, and logging. Plants within the Great Smoky Mountains National Park have been diagnosed with leaf blight. Overstory species and associated understory herbs are listed.

Keywords: Conservation, global heritage status rank, market, national heritage status rank.

Penskar, M.R.; Choberka, E.G.; Higman, P.J. 2001. Special plant abstract for *Hydrastis canadensis* (goldenseal). Lansing, MI: Michigan Natural Features Inventory. 3 p.

Provides information on goldenseal specific to Michigan. A detailed botanical description with seasonal identifying characteristics is included. Overstory species include sugar maple *(Acer saccharum*), American beech *(Fagus grandifolia*), red oak *(Quercus rubra*), yellow birch *(Betula alleghaniensis*), silver maple *(Acer saccharinum*), American basswood *(Tilia americana*), black walnut (*Juglans nigra*), butternut *(Juglans cinerea*), hackberry *(Celtis occidentalis*), and green and black ash *(Fraxinus pennsylvanica* and *F. nigra*). Associated understory herbs include jack-in-the-pulpit *(Arisaema triphyllum*), wild ginger *(Asarum canadense*), sedge *(Carex hirtifolia*), plantain-leaved sedge *(Carex plantaginea*), spring beauty *(Claytonia virginica*), trout-lily *(Erythronium americanum*), blue cohosh *(Caulophyllum thalictroides*), wild geranium *(Geranium maculatum*), bellwort *(Uvularia perfoliata*), common trillium *(Trillium grandiflorum*), and hepatica *(Hepatica acutiloba*), among many others. Conservation issues are discussed, research needs are outlined, and references are provided.

Keywords: Associated herbs, overstory species.

Petersen, F. 1905. Materia Medica and clinical therapeutics. Scanned version by M. Moore, 2002. http://www.ibiblio.org/herbmed/eclectic/petersen/hydrastis.html. [Date accessed: April 26, 2004].

Summarizes historical medicinal uses of goldenseal. The root is tonic, alterative, and laxative. It stimulates the nervous system, circulatory system, and mucus membranes and is particularly useful in stomach disorders, digestive disorders, catarrh, and cancers.

Keywords: History, medicinal uses.

Plyler, S.C. 2001-2002. Indian spring herbal encyclopedia. http://www.indianspringherbs.com/Goldenseal.htm. [Date accessed: April 26, 2004].

Provides general information on goldenseal cultivation and medicinal uses. A botanical description is included. Goldenseal was used by Native Americans as an antiseptic, tonic, and treatment for snakebite, whooping cough, pneumonia, and digestive problems. Early settlers used the roots as an eyewash and treatment for sore throat, mouth sores, and digestive problems. Commercial demand for the plant began around 1860; by the late

1800s, serious declines in native populations were reported. Medicinal actions reported for goldenseal include antiseptic, astringent, antibacterial, diuretic, laxative, and tonic. The main modern medicinal application of the herb is in treatments for bacterial and fungal infections, particularly in cases with diarrhea and cholera. Goldenseal roots also help to boost the immune system by increasing white blood cell counts. Various preparations and dosages are described. Specifics are given for cultivation and propagation with instructions for collecting and stratifying seeds.

Keywords: Cultivation, market demand, medicinal actions, medicinal uses, Native American uses.

Potter, S.O.L. 1902. A compend of Materia Medica, therapeutics, and prescription writing. Scanned version by H. Kress, 2000-2002. http://www.ibiblio.org/herbmed/eclectic/potter-comp/hydrastis.html. [Date accessed: April 26, 2004].

Covers the historical uses and preparations. Goldenseal is mainly used as a stomach tonic, antiperiodic, astringent, and antiseptic; particularly in afflictions of catarrh, syphilis, ulcers and sores, stomatitis, constipation, rectal fissure and hemorrhage, and malaria.

Keywords: History, medicinal uses.

Reed, D. 1999-2002. Wildflowers of the Southeastern United States. http://2bnthewild.com. [Date accessed: April 26, 2004].

Provides general ecological descriptions with accompanying photos and sketches. Goldenseal is also known as yellowroot or orangeroot. It is an herbaceous perennial with two alternate, coarse-textured leaves, each toothed, with five lobes and deep clefts. At times, one smaller basal leaf is present on a stem almost as tall as the main plant. Flowers are white and have no petals, but three small inconspicuous sepals are present. The fruit is a red berry. Plants prefer well-drained rich woods and are found throughout the Southeastern United States. Goldenseal was used by Native Americans as a dye and medicine. Concerns are raised about the sustainability of wild harvest.

Keywords: Botanical description, habitat, flowers, fruit.

Russell, A.B. 1997. Poisonous plants of North Carolina. North Carolina State University Department of Horticultural Science. http://www.ces.ncsu.edu/depts/hort/consumer/poison/Hydraca.htm. [Date accessed: April 26, 2004].

Summarizes the potential toxicity of goldenseal. Plants are found in rich woods and cultivated in medicinal plant gardens and in small-scale commercial operations. All parts of the plant contain the isoquinoline alkaloids, which are mildly poisonous, and can cause nausea, vomiting, diarrhea, nervousness, and depression if ingested in large doses.

Keywords: Alkaloids, toxicity.

Sievers, A.F. 1930. The herb hunters guide. Misc. Publ. 77. Washington, DC: U.S. Department of Agriculture. Hypertext version April 8, 1998. http://www.hort.purdue.edu/newcrop/herbhunters/goldenseal.html. [Date accessed: April 26, 2004].

Includes a botanical and ecological description from 1930. Other common names for goldenseal include yellowroot, yellow puccoon, orange root, yellow Indian paint, tumeric root, Indian tumeric, Ohio curcuma, ground raspberry, eye root, eye balm, yellow eye, jaundice root, and Indian dye. Though the plant is now becoming scarce throughout its range, it grows from western New England to western Ontario, and south to Georgia and Missouri. Plants arise from a yellow rhizome with a stem reaching about a foot in height. The top of the stem branches in two, one branch with a large leaf and the other branch with a smaller leaf and flower. Small, inconspicuous flowers appear in April and May, turning to a fleshy red berry with 10 to 20 small seeds in autumn. Roots are bright yellow, with many fibrous rootlets that break off when dried. Leaves are harvested in late summer, and roots are harvested in autumn after the fruit is ripe.

Keywords: Botanical description, common names, flowers, habitat, harvest, history, range.

Sievers, A.F. 1949. Goldenseal under cultivation. Farmer's Bull. 613. Washington, DC: U.S. Department of Agriculture. 14 p.

Summarizes all aspects of goldenseal cultivation. This bulletin is a revision of the original U.S. Department of Agriculture document published in 1914 by Van Fleet (Van Fleet 1914). Includes a botanical description of the plant, habitat and range, commercial history, soil preparation, propagation by seed and rhizomes, shade requirements, mulch, maintenance, pests and disease, harvest, yield, and costs. The cultivation techniques discussed in this bulletin are similar to recommendations found in current literature on goldenseal.

Keywords: Cultivation, history.

Simon, J.E.; Chadwick, A.F.; Craker, L.E. 1984. Herbs: an indexed bibliography. 1971-1980. The scientific literature on selected herbs, and aromatic and medicinal plants of the temperate zone. Hamden, CT: Archon Books. 770 p.

Presents a general overview of current goldenseal knowledge, including common names, habitat, a botanical description, cultivation and propagation, chemical constituents, and historical and modern medicinal applications.

Keywords: Botanical description, medicinal uses.

Small, E.; Catling, P.M. 1999. Canadian medicinal crops. Canada: NRC Press. 240 p.

Summarizes information on goldenseal nomenclature, morphology, classification, range, ecology, medicinal uses, toxicity, chemistry, nonmedicinal uses, agriculture, and folklore.

Keywords: Botanical description, medicinal uses.

Tyler, V. 1999. Goldenseal. In: The honest herbal. 4th ed. Binghamton, NY: Haworth Press: 159-161.

Provides a brief summary of the historical uses of goldenseal with accompanying references. Discusses Native American uses, turn-of-the-century medicines, and folk uses. Also covers modern pharmacology, disputes of the herb's effectiveness, and a discussion of the erroneous belief that goldenseal can mask drugs in urinalysis.

Keywords: History, medicinal uses.

U.S. Department of Agriculture, Forest Service. 1993. Income opportunities in special forest products: self-help suggestions for rural enterprises. Agric. Inf. Bull. 666. Washington, DC: U. S. Department of Agriculture, Forest Service. 206 p.

Provides an overview of forest botanicals used medicinally. Products are listed with information on gathering plants, selling to buyers, equipment needs and costs, harvesting, drying and storage, plant distribution, and conservation considerations.

Keywords: Harvest, market.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2001. The PLANTS database. Version 3.1. Baton Rouge, LA: Plant Data Center. http://plants.usda.gov. [Date accessed: January 29, 2004].

Provides photos of species and information on ecology, distribution and range, and conservation. Goldenseal is a member of the Ranunculaceae family. The natural range includes Alabama, Arkansas, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. Goldenseal is on the threatened plant list in Maryland, Michigan, and New York; the endangered list in Connecticut, Georgia, Massachusetts, Minnesota, New Jersey, and Vermont; is considered vulnerable in Pennsylvania; and of special concern in North Carolina and Tennessee.

Keywords: Conservation, range, Ranunculaceae family.

U.S. Fish and Wildlife Service, Department of the Interior. 1999. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): listing of goldenseal (*Hydrastis canadensis*) in Appendix II and its implementation by the United States. Public meeting. Federal Register. April 26, 1999: 64(79). http://policy.fws.gov/library/99fr20320.html. [Date accessed: April 26, 2004].

Announces a public meeting to discuss the listing of goldenseal under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II protection, which covers international trade in live plants, whole and sliced roots, or root parts. Manufactured products such as powders, pills, extracts, tonics, and teas are not included. Goldenseal is found in 27 States and 1 Canadian province, but due to overharvest in the late 19th century, the plant is considered to be "very threatened" by the Nature Conservancy throughout its range. Current management plans for goldenseal are not well developed, and knowledge of plant ecology and sustainable harvest levels is lacking. Under the CITES protection, all goldenseal must have an export permit, be exported through ports designated by the U.S. Department of Agriculture, and be inspected by a U.S. Department of Agriculture Animal and Plant Health Inspection Service, Division of Plant Protection and Quarantine inspector.

Keywords: CITES, conservation, permits, regulations.

U.S. Fish and Wildlife Service, International Affairs, Office of Management Authority. 1999. Exporting goldenseal. http://international.fws.gov/pdf/go.pdf. [Date accessed: April 26, 2004].

Discusses the export policies and regulations for goldenseal under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). A permit is required to export goldenseal plants, roots, or parts of roots. Although goldenseal is not presently threatened with extinction, high demand for the herb and decreases in wild populations make it susceptible to overuse. Permits can be obtained from the U.S. Fish and Wildlife Service Office of Management Authority for a small fee. Information is required to show that the roots were legally collected or cultivated. Specific instructions and contact information are provided.

Keywords: CITES, export, permits, U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service, Office of Management Authority. 1998. Export of goldenseal. Arlington, VA. 2 p. http://international.fws.gov/pdf/export.pdf. [Date accessed: April 26, 2004].

Provides basic guidelines for exporting goldenseal under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulations. Goldenseal was included in CITES Appendix II on September 18, 1997. To export goldenseal, a permit is required stating that the roots were legally acquired and that their export will not be detrimental to the survival of the species. Ecological field studies by the U.S. Fish and Wildlife Service provide information on species survival and sustainable harvest, whereas the individual exporting the roots provides proof of the legal collection or cultivation. Proof of legal collection for wild harvested roots requires the specific date and location of collection, the name and address of the collector, and copies of collection permits, licenses, or landowner permission. For cultivated goldenseal, the name and address of the cultivator and the purchase invoice are required. Individual exporters provide this information with each export. Dealers, cultivators, and collectors take part in a voluntary record-keeping system. Specific information for obtaining a permit is included.

Keywords: CITES, conservation, export, regulations.

United Plant Savers. [N.d.]. At risk plants. http://www.plantsavers.org/. [Date accessed: April 26, 2004].

Provides information on efforts to conserve goldenseal. Goldenseal is on the "At Risk Plants" list. Plants on this list are considered to be significantly declining in number due to overharvest, loss of habitat, or innate sensitivity and rareness.

Keywords: Conservation, United Plant Savers**.**

Upton, R., ed. 2001. Goldenseal root: standards of analysis, quality control, and therapeutics. Santa Cruz, CA: American Herbal Pharmacopoeia. 36 p.

Provides a detailed, thorough overview of goldenseal. Includes nomenclature, history, botany, macroscopic and microscopic identification, harvest, cultivation, preparations, chemical constituents, chemical analysis methods, medicinal uses, physiological actions, clinical research reviews, dosage, side effects, precautions, toxicity, and regulatory status.

Keywords: Chemical constituents, harvest, identification, medicinal uses, physiological actions, research reviews, side effects, toxicity.

Van Fleet, W. 1914. Goldenseal under cultivation. Farmer's Bull. 613. Revised 1949. [Place of publication unknown]: U.S. Department of Agriculture. [Number of pages unknown].

[No abstract].

Keywords: Cultivation, history.

Veninga, L.; Zaricor, B. 1976. Goldenseal/etc.: a pharmacognosy of wild herbs. Santa Cruz, CA: Ruka Publications. 193 p.

Provides details on goldenseal botany, wildcrafting, range and distribution, history, medicinal uses, preparations and dosage, combinations, contraindications, and cultivation. A historical background offers information on the medicinal uses of goldenseal by Native Americans, early pioneers, and eclectic physicians with references to several early medical and botanical books. Goldenseal grows in rich coves and on north-facing slopes in hardwood forests from the Ozarks and Appalachian Mountains to southern Ontario. Naturalized populations of goldenseal from previous cultivation can occasionally be found in Oregon and Washington. Preparations and formulas are provided. Indications and contraindications are discussed in detail with supporting case studies described. Large quantities of goldenseal can overstimulate the nervous system and cause tremors. Goldenseal should not be taken for extended periods of time as the

alkaloids in the plant are excreted slowly and may accumulate in the body. The chemical constituents and medicinal actions of the main alkaloids are discussed. Hints and tips for wildcrafting are included.

Keywords: Cultivation, harvest, history, medicinal uses, toxicity.

Wright, R. 1996. Ginseng and goldenseal. Countryside & Small Stock Journal. 80(2): 28-29.

Provides general information about cultivating goldenseal.

Keyword: Cultivation.

Commercial Vendors

Note: The following list of vendors is included to provide access to current information about availability and prices. The authors do not intend to recommend these vendors over any others not listed.

Elixir Farm Botanicals. [N.d.]. Goldenseal product. http://www.elixirfarm.com/. [Date accessed: April 26, 2004].

Vendor of goldenseal seed for propagation.

Keywords: Cultivation, vendors.

Garden Medicinals. [N.d.]. Goldenseal product. http://www.gardenmedicinals.com/. [Date accessed: April 26, 2004].

Vendor of goldenseal seed and roots for propagation.

Keywords: Cultivation, vendors.

Gardens of the Blue Ridge. [N.d.]. Goldenseal product. http://www.gardensoftheblueridge.com/. [Date accessed: April 26, 2004].

Vendor of goldenseal bare-root stock and potted plants for cultivation.

Keywords: Cultivation, vendors.

Herb Trader. [N.d.]. Goldenseal product. http://www.herbtrader.com/. [Date accessed: April 26, 2004].

Vendor of bulk goldenseal root, whole or powder, for medicinal use.

Keywords: Medicinal uses, vendors.

North Carolina Ginseng & Goldenseal Company. [N.d.]. Goldenseal product. http://www.ncgoldenseal.com/index.html. [Date accessed: April 26, 2004].

Vendor of goldenseal growing stock for propagation.

Keywords: Cultivation, vendors.

Pacific Botanicals. [N.d.]. Goldenseal product. http://www.pacificbotanicals.com/. [Date accessed: April 26, 2004].

Vendor of certified organic goldenseal rhizomes (whole, cut, or powdered) for medicinal uses.

Keywords: Medicinal uses, vendors.

Richters Herbs. [N.d.]. Goldenseal product. http://www.richters.com. [Date accessed: April 26, 2004].

Vendor of goldenseal growing stock (seed, roots, etc.) and bulk processed materials for propagation and medicinal uses.

Keywords: Medicinal uses, propagation, vendors.

Select Oils. [N.d.]. Goldenseal product. http://www.selectoils.com/. [Date accessed: April 26, 2004].

Vendor of dried goldenseal root powder for medicinal uses.

Keywords: Medicinal uses, vendors.

Viable Herbal Solutions. [N.d.]. Goldenseal product. http://www.viable-herbal.com/. [Date accessed: April 26, 2004].

Vendor of goldenseal capsules for medicinal uses.

Keywords: Medicinal uses, vendors.

Author Index

Subject Index

Disclaimers

This annotated bibliography represents a comprehensive, but not exhaustive, review of the literature on goldenseal. The references included were identified through a detailed search of academic library-based databases, regional literature, government documents, Internet databases, as well as commercial Internet sites. Bibliographic references are organized into sections—Research Literature, Popular Press, Other Information Sources—to indicate their origins. Research Literature includes references to peer reviewed articles published in scientific journals, while the references in Popular Press are not scientifically reviewed, but are included to indicate popular knowledge and perceptions. Other Information Sources include technical bulletins, horticultural lists, historical documents, and Web sites.

This document is available from the Non-Timber Forest Products Web site of the U.S. Department of Agriculture, Forest Service, Southern Research Station at http://www.sfp.forprod.vt.edu/.

Web sites listed in the bibliography were active at the time this document was prepared, but Web addresses may change or disappear over time. The date accessed indicates the last time the Web sites were checked.

The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Predny, Mary L.; Chamberlain, James L. 2005. Goldenseal (*Hydrastis canadensis*): an annotated bibliography. Gen. Tech. Rep. SRS-88. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 67 p.

Goldenseal (*Hydrastis canadensis*), a member of the buttercup family (Ranunculaceae), is an herbaceous perennial found in rich hardwood forests throughout the Northeastern United States and Canada. Originally used by Native Americans as both a medicine and a dye, the herb was eventually adopted by the settlers and eclectic physicians in the 19th century. The alkaloids in goldenseal have been found to have antibiotic, anti-inflammatory, antispasmodic, and tonic effects. Scientists and physicians continue to expand on the knowledge of the clinical applications and disease-fighting potential of the plant. Growing awareness of possible medicinal benefits has increased worldwide consumption, which, combined with a continual loss of habitat, has greatly reduced wild populations. Goldenseal has been listed under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II protection since 1997. Demand for cultivated roots has increased as wild populations become scarce, motivating research into propagation and cultivation techniques. More attention should be focused on: educating consumers about the appropriate uses of the herb in order to reduce overconsumption; working with growers to increase the profitability of cultivation and reduce pressures on wild plants; and identifying and tracking wild populations to determine the most effective management and conservation practices.

Keywords: Conservation, goldenseal, *Hydrastis*, medicinal herbs, nontimber forest products, poaching.

The Forest Service, United States Department of Agriculture (USDA), is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

United States
Department
of Agriculture

Forest Service

**Southern
Research
Station**

General
Technical
Report
SRS–88

United States
Department
of the Interior

National
Park Service