American Herbal Pharmacopoeia®
and Therapeutic Compendium

Slippery Elm Inner Bark
Ulmus rubra Muhl.

Standards of Analysis, Quality Control, and Therapeutics

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ISBN: 1-929425-30-9 **ISSN:** 1538-0297

Literature retrieval provided by CCS Associates Inc, Mountain View, CA.

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Cover Photograph

Ulmus rubra tree with full foliage. Photograph © 2011 7Song. Sample of inner bark of *U. rubra*. Photograph courtesy of Silvester Ölzant, University of Vienna, Austria.

Nomenclature

Botanical Nomenclature

Ulmus rubra Muhl. syn. *Ulmus fulva* Michx.

Botanical Family

Ulmaceae

Pharmaceutical Nomenclature

Cortex Ulmi Fulvae, Cortex Ulmi Interior, Ulmi Fulvae Cortex, Ulmi Rubrae Cortex

Definition

Slippery elm inner bark consists of the whole, cut, or powdered dried inner bark (phloem) of sustainably harvested *Ulmus rubra* Muhl.

Common Names

English:	Slippery elm.
French:	Orme rouge, écorce de l'orme de l'Amérique, poudre d'écorce d'orme rouge.
Dutch:	Rode iep.
German:	Rotulme, Rotulmenrinde, Ulmus-rubra-Rinde.

History

Slippery elm inner bark is a highly respected botanical medicine among herbalists and is regarded both for its soothing anti-inflammatory mucilage and its use as a nourishing gruel. The primary tree species that it comes from, *Ulmus rubra*, is indigenous to North America, and the bark has been utilized extensively by Native Americans. Other, European species of elm were used medicinally for similar purposes.

The name *elm* or *ulm* is common in the Teutonic (Germanic) and nearly all Celtic dialects, and remains unchanged in English until today. In Teutonic mythology, elm formed the first woman, *Emla*, and ash the first man, *Aske* (Barton and Castle 1877). Today, in modern German, elm tree is called *die Ulme* (a feminine noun). In the Romance languages, the *u* changes to an *o*: *olmo* in Italian, *olme* in Old French (*orme* in modern French), *olm* in Dutch and Middle Low German. The botanical name *Ulmus* was assigned to the genus by Carolus Linnaeus in 1753. Earlier use of the Latin name is documented in writings of the Roman poet Virgil (Publius Vergilius Maro; 70–19 BCE). The Roman naturalist Pliny the Elder (Gaius Plinius Secundus; 23–79 CE) mentions *Ulmus* in his encyclopedic *Naturalis Historiae*, published in 77 CE (Marzell 1979).

In the United States, *Ulmus* was first characterized botanically in 1739 by John Clayton (1694–1773), a Colonial plant collector and author of *Flora Virginica*, one of the earliest botanical works in North America (Sargent 1895). The Scottish botanist William Aiton (1731–1793) added the variety *rubra* to *U. americana* in 1789 in the first edition of *Hortus Kewensis*. In 1793, the taxon was raised to the full species status, *U. rubra*, by a German-American botanist Gotthilf Heinrich Ernst Muhlenberg (1753–1815) (GRIN 2011). Ten years later, French botanist François André Michaux in his *Flora Boreali-Americana* named the same species *U. fulva* (Michaux 1803), with many subsequent botanical works and popular books following suit. However, in accordance with the general rules of botanical nomenclature (McNeill et al. 2006), the earlier species name is given priority. Thus, the most appropriate name for the species is *U. rubra* Muhl. The specific epithet *rubra* means "red," referring to the reddish color of the outer bark and to the rust color of the buds in spring prior to the emergence of leaves. The common attribute "slippery" refers to the mucilaginous nature of the inner bark.

Therapeutic uses of elm species have been documented since antiquity. The medical use of the inner bark ("liber") of the European species, common or English elm (*U. campestris*), as an astringent was described by the Greek physician Pedanius Dioscorides (40–90 CE) in his *De Materia Medica* (65 CE) (Barton and Castle 1877). The English herbalist John Parkinson (1567–1650) in his *Theater of Plants* (1640) recommended the use of an elm poultice for relieving gout. Parkinson cites Dioscorides and Columella (4–70 CE) in saying "the outer bark of the Elme drunk in wine hath a property to purge phlegm…a decoction of the leaves, barke or roote being bathed, healeth broken bones … the decoc-

Figure 1 Slippery elm: herbal drug of yesteryear and today

Photograph © 2011 Steven Foster.

Table 1 Historical timeline of the medical use of *U. rubra* inner bark

Native American use	Various tribes used slippery elm as a source of food and fiber and for its medicinal properties, predominantly as a demulcent.
65 CE	Inner bark of English elm (*U. campestris*) is described as an astringent by Dioscorides.
1749	Inner bark of elm (*Ulmi cortex media*) is listed by Linnaeus in his *Materia Medica* as an astringent and vulnerary.
1770	Elm bark reported as an effective demulcent in several case reports of inflammatory skin conditions submitted to London's College of Physicians.
Early 1800's	Slippery elm preparations become widely available and can be "found in every drug store."
1820 – 1936	Elm inner bark is included in the 1st-11th editions of the *United States Pharmacopoeia* (USP).
1833	Samuel Thomson, the originator of Thomsonian medicine, promotes slippery elm for "soreness in the throat, stomach, and bowels."
1834 – 1960	Slippery elm is listed in *The Dispensatory of the United States of America*.
1859	Wooster Beach, the founder of the Eclectic medical movement, highly praises slippery elm inner bark, recommending it for a variety of conditions and initiating its broad use by Eclectics.
1988	Slippery elm (as Elm) is approved as a Generally Recognized As Safe and Effective (GRASE) demulcent active ingredient in over-the-counter (OTC) drugs.
1995	Elm reappears in the 23rd edition of the *United States Pharmacopeia*.

tion of the barke of the roote fomented, mollyfieth hard tumours, and the shrinking of the sinews…the barke ground with brine or pickle until it come to the forme of a pultis and laid on the place pained with the gout, giveth a great deale of ease."

Linnaeus, in addition to naming the genus, included the inner bark of elm (*Ulmi cortex media*) in his *Materia Medica* of 1749, classifying it as an astringent and a vulnerary (wound healer) and indicated its use for ascites. The astringent quality of the barks from European species may be due to the higher concentration of tannins, compared to slippery elm, which also impart a darker color to the powdered material (Sayre 1906). Historically, American elm (*U. americana*) was also used for the mucilaginous properties (Moerman 1998). This species is highly susceptible to Dutch elm disease, although it is reported to still exist in substantial numbers both as cultivated shade trees and in its native range (Sherman-Broyles 1997). *U. rubra* is the preferred species of commerce.

Physician, botanist, and zoologist Johann David Schöpf (1752-1800) of Erlangen, Bavaria, who served as chief surgeon of Hessian troops fighting for King George III in the Revolutionary War referred to elm bark under the name of "*Cortex unguentarius*" (salve bark) in his book *Materia Medica Americana Potissimum Regni Vegetabilis* (Schöpf 1787). Peter Good, in *The Family Flora and Materia Medica Botanica* (1845), reported that surgeons of the Revolutionary Army of 1776 prepared poultices from the flour of elm bark for external application to gunshot wounds, observing that elm poultice brought rapid suppuration and wound healing. Other uses reported by Good include "to moisten the parched mouth, to correct irritation of the throat, lungs, stomach and bowels, to nourish weak stomachs, to relieve thirst, to give constant moisture and softness to a cataplasm, to roll up pills in, to aid in the action of enemas, and combined with charcoal and gum myrrh (*Commiphora* spp.) to prevent mortification."

Historical and contemporary uses of slippery elm inner bark find their origin in Native American medical traditions. The transfer of this knowledge was from aboriginal healers to early European settlers of America and from them introduced to the medical profession (Lloyd 1911). Native Americans of different tribal nations used slippery elm as a source of fiber, food, as well as for its medicinal and other properties. A boiling water decoction of the fresh inner bark was drunk as a laxative by the Menominee of Wisconsin and Native Americans of the Missouri River region (Gilmore 1919). The Menominee also used the bark to draw pus out of wounds by forcing a small sliver into the sore and then binding it with a poultice made with bark to reduce swelling. After the pus has been initially drawn out, the sliver was removed, taking the pus with it, and the wound was reported to heal readily (Smith 1923). Samuel Stearns, a New England physician and author of one of the earliest herbals of North America, *The American Herbal* (1801), noted that slippery elm was used for leprous conditions among "Indians" and was good for chronic cutaneous eruptions, "suppression of urine," dropsy, inflammations, and hard tumors.

Good (1845) reported that Native American women (tribal nation not specificed) drank slippery elm tea during the last two months of pregnancy as a specific to ensure easy parturition. To ease labor, Cherokee women of the southern Appalachian Mountains drank a boiling water decoction of slippery elm bark combined with jewel weed stem (*Impatiens biflora*) and speedwell root (*Veronica officinalis*). The Cherokee also treated dysentery with a decoction of the inner barks of slippery elm, American basswood (*Tilia*

americana), and American sycamore (*Platanus occidentalis*), boiled with excrescences of *Quercus calis* var. *maxima* and buds or suckers of post oak (*Quercus stellata*) (Taylor 1940). The Alabama also prepared a decoction of elm bark mixed with gunpowder for prolonged labor (Swanton 1928). What role the gunpowder played in this is unknown. The Iroquois of northeastern North America chewed the bark for sore throat and to facilitate childbirth, placed elm bark poultices on swollen glands, applied infusions of the bark as a wash for sore eyes, drank a decoction of elm bark for sleepiness and weakness and as an emetic to clean the stomach, and used the bark for infected kidneys (Herrick 1995). The Ojibwa of north-central United States and southern Canada prepared a decoction of elm bark as a gargle for sore throat or chewed the dried bark (Moerman 1998).

The use of slippery elm as a mucilaginous tea was common in the homes of early Americans (Sumner 2004). Mixed with meal, slippery elm was reportedly used as bread by settlers when food was scarce. In the Thomsonian system of herbal medicine, popular during the early 1800's, the recipe for oral use of slippery elm inner bark was to mix a teaspoonful of the powder with an equal part of sugar, then add cold water, stir until it formed a thick jelly, and take the mucilage directly. Additionally, hot water could be added to the leftover bark and drunk freely. A teaspoonful was considerd an "excellent medicine to heal soreness in the throat, stomach and bowels, caused by canker." Thomson (1833) also recommended elm bark for making poultices mixed with pounded cracker and ginger (*Zingiber officinale*). Medical writers throughout North America considered slippery elm to be one of the most efficacious and valuable demulcents for inflammatory conditions of the skin and alimentary tract. According to Gunn (1863), various forms of slippery elm could be "found in every drug store." The demand was so great that in Massachusetts, slippery elm became threatened due to over and improper harvesting (Emerson 1875).

Lozenges with slippery elm as the primary ingredient have remained a very popular staple among health food enthusiasts almost exclusively due to the Henry Thayer Company (THAYERS® Natural Remedies), whose lozenges have dominated in the market. Dr. Henry Thayer (1823-1902) was the son of a physician from Milford, Massachusetts. Dr. Thayer opened a retail apothecary in 1842 and by 1847 was manufacturing pharmaceutical preparations, specializing in the manufacture of herbal fluidextracts. THAYERS® Company published a book of their medicines in 1866; however, lozenges were not included among the offerings (Thayer 1874).

There are reports from the Civil War period (1861-1865) of Confederate battlefield surgeons applying slippery elm bark with wahoo (*Euonymus atropurpurea*) root bark, perhaps due to its resinous properties, in a solution of common salt, when emollients were indicated. The slippery elm was also used by druggists and physicians as a substitute for some normally imported articles or drugs that were in short supply during the war, e.g., wax bougies and gum arabic (*Acacia senegal*) (Jacobs 1898). Slippery elm figured widely in the practices of American Eclectics and Physiomedicalists, predominantly for easing inflammations of various tissues due to its demulcent properties. Wooster Beach, the founder of the Eclectic medical movement, wrote of slippery elm: "In point of utility it is of far more value than its weight in gold" (Beach 1859) (also see Traditional Indications). In the late 19th century, Eclectic physicians classified elm bark as nutritive, expectorant, diuretic, demulcent, and emollient with the aqueous infusion of the bark being the most common form of administration. The mucilaginous drink was prescribed for treating mucous inflammations of the lungs, bowels, stomach, bladder, or kidneys, as well as for treatment of diarrhea, dysentery, coughs, pleurisy, strangury, and sore throat (Felter and Lloyd 1898). Tinctures were considered ineffective for delivering any significant amount of mucilage (Lloyd 1889).

The Dispensatory of the United States of America (Wood and Bache 1870) included the use of slippery elm as a demulcent, especially recommended for dysentery, diarrhea, and diseases of the urinary passages. The bark was commonly prepared as an aqueous infusion, taken ad libitum as a soothing and nutritious drink in catarrhal and nephritic diseases, and in inflammatory affections of the intestinal mucous membrane.

Less widespread than its use in inflammatory conditions was the employment of elm sticks (bougies) to facilitate dilation of the *os uteri* and anus for various reasons including strictures and physical abnormalities. The branches or pieces of bark were whittled into a long conical shape, dipped in water, allowed to hydrate, and inserted when lubrication was sufficient (Byford 1902; Griffith 1847). This practice proved troublesome, however, in urethral structures, with parts of the bark or branch breaking off while attempting to withdraw it, and entering the bladder (Farncombe 1935; Felter and Lloyd 1905; Williams 1954). Knowledge of these uses allegedly led to use of lengths of the branches to terminate pregnancy, reportedly resulting in deaths from hemorrhage (Hanson 2003) and bacterial infection (Romalis 2008).

The late 19th and early 20th century psychic Edgar Cayce (1877-1945) often prescribed slippery elm bark dissolved in water for gastrointestinal disorders. Between 1911 and 1944 elm was prescribed in 170 Cayce readings (McGarey 1968; Meridian Institute 2006). In the 1920's, Rene Caisse, head nurse at the Sisters of Providence Hospital in northern Ontario, Canada, began to experiment with cancer patients using an eight-herb tea formula reported to be a traditional medicine of the Ojibwa tribe. Caisse named the formula Essiac™, her name spelled backwards, and reduced the formula to the four herbs she considered to be the active components: slippery elm bark, sheep sorrel (*Rumex acetosella*), turkey rhubarb (*Rheum palmatum*) root, and burdock (*Arctium lappa*) root. This formula and other variations of it (e.g., Flor-Essence®) remain among the most widely used herbal products by cancer patients today in Canada, and have been subject to laboratory and clinical research (Leonard et al. 2006; Tamayo et al. 2000).

In 1974, American herbalist Rosemary Gladstar formulated a demulcent herbal tea, Throat Coat® (Traditional

Medicinals, Sebastopol, CA), with slippery elm bark, marshmallow (*Althaea officinalis*) root, licorice (*Glycyrrhiza glabra*) root, and wild cherry (*Prunus serotina*) bark, among other ingredients. The product is available today in several countries and has been the subject of clinical research (Brinckmann et al. 2003). Slippery elm has also been used by organic farmers who are not allowed to utilize allopathic drugs under certified organic programs for livestock for the treatment of diarrhea and scours (Lans et al. 2007).

Ulmus inner bark was included in the *Pharmacopoeia of Massachusetts* in its only edition of 1808. It appeared in the list of materia medica in the 1st edition of the *Pharmacopoeia of the United States of America* (USP 1820) and remained official until its removal from USP XI in 1936. Immediately following its removal from the USP XI in 1936, slippery elm bark became an official monograph in the 6th edition of the *National Formulary* (1936) until its elimination from the 11th edition in 1960. Elm appeared in the 2nd edition of *The Dispensatory of the United States of America* (Wood and Bache 1834) and was last included in the 25th edition (Osol and Farrar 1955).

In 1982, elm bark appeared in a Food and Drug Administration (FDA) Advance Notice of Proposed Rulemaking (ANPR) for the establishment of a therapeutic monograph for oral health care drug products for over-the-counter (OTC) human use (FDA 1982). In the ANPR as well as in the subsequent tentative final monograph of 1988 and in the amendment to the monograph of 1991, elm bark was classified as a Category I Generally Recognized as Safe and Effective (GRASE) OTC oral demulcent active ingredient.

Subsequent to its OTC approval, monograph standards were developed and slippery elm once again became official in the USP as Elm on November 15, 1995 (USP 23-NF 18 1995) and remains official in the current edition (USP 34-NF 29 2010). The *European Pharmacopoeia* does not currently list slippery elm.

The use of slippery elm remains popular mainly in the countries where it was originally found, Canada and the United States, but also in Australia, the United Kingdom, and some others. The primary form used is powdered inner bark as an active ingredient in demulcent lozenges, sometimes in combination with fenugreek seed (*Trigonella foenum-graecum*), and also in capsules and tablets, often with other demulcents such as marshmallow (*Althaea officinalis*) root and/or licorice (*Glycyrrhiza* spp.) root, for treating inflammations and ulcerations of the gastrointestinal tract such as esophagitis, gastritis, colitis, gastric or duodenal ulcers, and diarrhea. Other forms include granulated powder as part of herbal tea formulas for soothing coughs and sore throats and an extractive component in lozenges and syrups.

Aside from the medicinal uses of slippery elm, the famous pitcher and baseball Hall of Fame inductee Gaylord Perry was notorious for the long-prohibited spitball. Perry used mud, K-Y® jelly, Vaseline, sweat, and chewing gum to make the pitch roll, bounce, and jump. However, chewing on slippery elm lozenges or slivers of slippery elm bark that Perry harvested from his father's farm was reportedly among his favorites.

Identification

Botanical Identification

Ulmus rubra Muhl. Tree to 35 m high, with spreading branches and open flat crown. **Bark:** Dark brown to reddish-brown, deeply furrowed. **Leaves**: Alternate; simple; petiolate with petiole (3-)5-7(-9) mm long; 7-18(-23) cm long, 5-10(-15) cm broad; elliptical to ovate, oblong, or obovate with oblique base and acuminate apex; margins serrate towards base, elsewhere doubly serrate; upper surface scabrous; lower surface tomentose; secondary veins parallel, slightly curved, running to tips of marginal teeth. **Inflorescence**: Axillary fascicles, roughly hemispherical, 8-20 flowered; 1.5(-2.5) cm in diameter. **Flowers**: Small, perfect; pedicels 1-2(-3) mm long; calyx campanulate, 5-9-lobed at apex, ca. 2.6-3.5 mm in diameter, reddish-pubescent; petals absent; stamens 5-9, exserted at flowering; styles 2. **Fruit**: Winged samara, yellowish, irregularly suborbicular or occasionally broadly elliptical or obovate, 10-20 mm in diameter, reddish-pubescent over seed; wing papery-textured.

Distribution: Mostly moist lowland woods, flood plains, along waterways, but can also be found on poor, dry sites. Normally flowers in late winter to spring before leaves appear, with most flowering early in the season, and fruits in spring; rarely flowers in fall but does not then produce fruit. Occurs across almost all of the eastern half of the United States, extending into southern Quebec and Ontario, and at its southern extreme into eastern Texas and the Florida Panhandle. *Ulmus rubra* appears to be more closely related to the introduced Asian species *U. pumila* L. than to other native American species of *Ulmus*. Where the two co-occur, interbreeding is common (Sherman-Broyles 1997; Wiegrefe et al. 1994).

Differentiation from other Ulmus species

The bark of mature *U. rubra* trees is darker than that of most other elms and often reddish. Slippery elm produces fruit (samaras) early in the spring. The fruit is pubescent on the body, but not ciliate along the margin. The leaves are larger than those of most other species (at least 8 cm long at maturity). The margins of the leaf are ciliate and the upper surface is scabrous (scratchy), particularly when rubbed from apex to base, a key characteristic of *U. rubra* (Sherman-Broyles 1997). For more details on botanical differentiation see Table 2.

Table 2 **Botanical comparison of *Ulmus* spp.**

Species	Common name	Bark	Samara (fruit)	Leaves	Flowering season	Distribution
U. rubra	Slippery elm	Reddish-brown, irregularly furrowed with age	Yellow-beige, nearly round, 1.2-1.8 cm, with broad wings, reddish hairs only over seed body	8-20 × 5-7.5 cm; bristle-like and scratchy on the upper surface, especially when rubbed from the tip	Late winter – early spring	**Canada:** ON, QC, NB; **USA:** AL, AR, CT, DE, DC, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, NE, NH, NJ, NY, NC, ND, OH, OK, PA, SC, SD, TN, TX, VT, VA, WV, WI
U. americana	American elm	Brownish or gray, with cracks forming fragmented appearance	Yellow-beige, egg-shaped, about 1 cm, wings narrow, hairy along the edge	7-14 × 3-7 cm; not very scratchy on the upper side	Winter – early spring	**Canada:** MB, NB, NS, ON, PE, QC, SK; **USA:** AL, AR, CT, DE, DC, FL, GA, IL, IN, IA, KS, KY, LA, ME, MD, MA, MI, MN, MS, MO, MT, NE, NH, NJ, NY, NC, ND, OH, OK, PA, RI, SC, SD, TN, TX, VT, VA, WV, WI, WY
U. pumila	Siberian elm	Grayish-brown, with deep interconnecting furrows	Yellowish, round, 1-1.4 cm, with broad hairless wings, notched on the tip up to 1/2 its length	Small, 2-6.5 × 2-3.5 cm; not harsh on either surfaces	Late winter – early spring	**Canada:** NB, ON, QC; **USA:** AL, AZ, AR, CA, CO, CT, DC, FL, GA, ID, IL, IN, IA, KS, KY, LA, MD, MA, MI, MN, MO, MT, NE, NV, NJ, NM, NY, ND, OH, OK, PA, SD, TN, TX, UT, VA, WI, WY; Asia.
U. serotina	September elm, red elm	Brownish or reddish; slightly cracked	Brownish, oval to egg-shaped, 1-1.5 cm, wings narrow, hairy along the edges, tip with a deep notch	7-10 × 3-4.5 cm; yellowish-hairy on the lower surface; not scratchy above	Late summer – fall	**USA:** AL, AR, GA, IL, MS, OK, TN, TX
U. thomasii	Rock elm	Gray and deeply furrowed	Large, 1.5-2.2 cm, ovaloid, with narrow wings, soft-hairy, with a shallow notch on the tip	2.5-16 × 2.5-5 cm; soft-hairy underneath, bare on the upper surface	Spring	**Canada:** ON; **USA:** AR, IL, IN, IA, KS, KY, MI, MN, MS, NE, NH, NJ, NY, OH, SD, TN, VT, WV, WI
U. alata	Winged elm, wahoo	Lightly brown or gray, shallowly ridged; distinguished by wing-like outgrowths on twigs and branches	Grayish-beige, often with a reddish tint, narrow, with long, 1-2 mm, hairs along the edges	3-6.9 × 0.6-3.2 cm; sometimes scratchy on the upper surface	Late winter – early spring	**USA:** AL, AR, FL, GA, IL, IN, KS, KY, LA, MS, MO, NC, OH, OK, SC, TN, TX, VA
U. procera	English (cork) elm	Gray or brown, with deep ridges, separating in flakes	Light to dark brown, almost red over seed, round, 0.9-1.8 cm, wings broad, with a slight notch, soft hairs near the tip	3-10 × 3-10 cm; lower surface woolly, pale; upper surface dark green	Early – late spring	**Canada:** ON; **USA:** CA, CT, IL, MA, MO, NY, RI; native to Europe.
U. glabra	Scotch elm, wych elm, broad-leaved elm	Gray, unwrinkled, furrowed when old	Somewhat green or brown, oval to egg-shaped with a dull tip, 1.5-2.5 × 1-1.8 cm, wings broad, very small notch	4-16 × 3-10 cm; pale on the lower surface, dark green and may be scratchy above	Spring – early summer	**USA:** CT, ME, MA, NY, RI, VT; native to Europe and Asia.

Source: Sherman-Broyles (1997).

2a.

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2c.

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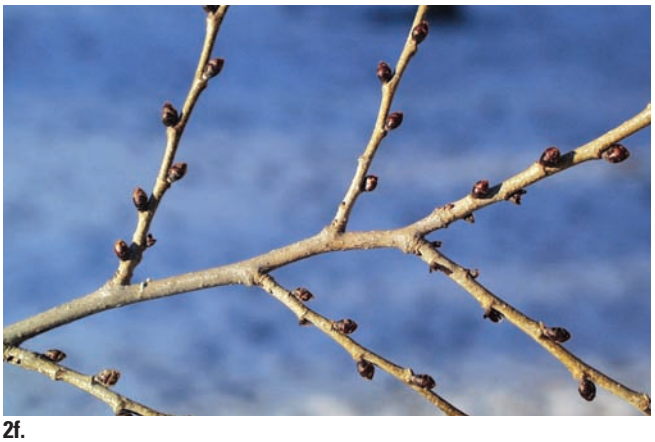
2e.



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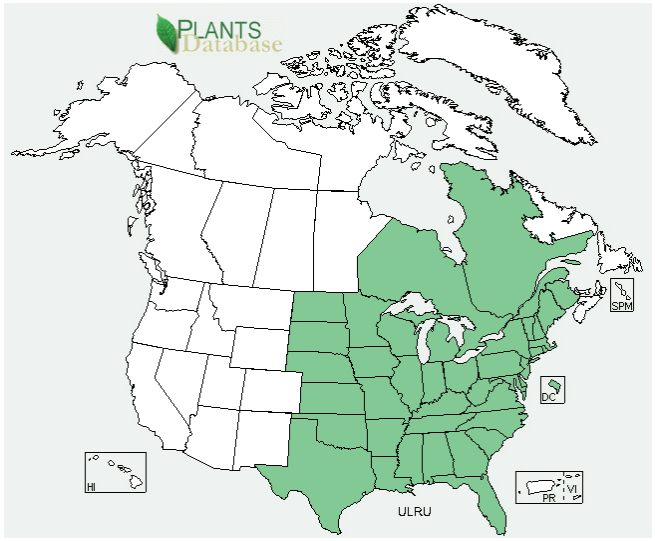


2l.

Figures 2a-l Botanical characteristics of *U. rubra*

2a. *U. rubra* tree.
2b. Bark of a mature *U. rubra* tree.
2c, d. *U. rubra* leaves with doubly serrated edges.
2e. *U. rubra* leaf showing the typical oblique base and an acuminate apex.
2f. *U. rubra* branch with buds.
2g. Close-up of a young, densely pubescent branch with a bud. Pubescence disappears with age.
2h. *U. rubra* leaves and buds together on a branch showing alternate leaf arrangement.
2i. *U. rubra* flowers.
2j, k. Fruit (samaras) of *U. rubra*, somewhat round, broadly winged, and with glabrous margins.
2l. Geographic range of *U. rubra.*

Photographs courtesy of: (2a,b, h) © 2011 7Song; (2c,d, g, j, k) © 2011 Steven Foster; (2e,f) Paul Wray, Iowa State University, Bugwood.org; (2i) Indiana University - Purdue University, Fort Wayne, IN; (2l) USDA Plants database.

3a.

3b.

3c.

Figure 3a-c Comparative morphology of the bark of *U. rubra* and *U. americana*

3a. Bark of a mature *U. rubra* tree; note the ridged, deeply furrowed look.

3b. Bark of *U. americana*; note the fragmented look and shallow grooves compared to the more furrowed bark of *U. rubra*.

3c. An example of co-occurring *U. rubra* (larger, left) and *U. americana* (smaller, right).

Photographs courtesy of: (3a,c) © 2011 7Song; (3b) Paul Wray, Iowa State University, Bugwood.org.

Macroscopic Identification

Slippery elm inner bark is found in commerce in the following forms: whole, cut and sifted (C/S), granulated, and powdered. Other forms of slippery elm bark that are traded include: unrossed, also referred to as "natural" or "thick," which includes both outer and inner bark and occurs in the same forms as the inner bark; and "cotton cut." "Cotton cut" is a by-product of the grinding of the inner bark. Both unrossed bark and "cotton cut" are considered inferior materials because they consistently yield low amounts of mucilage (see Qualitative Differentiation).

Whole inner bark (rossed): Occurs in long, flexible strips, typically (25)50-70(100) cm long, 2-8(10) cm wide, 1-3 mm thick, often shredding longitudinally along the bast fibers; inner and outer surfaces longitudinally striated; outer surface rough, wooly from numerous partially detached small bast fibers, beige to light orange-brown, reddish-brown patches indicate adhering cork; inner surface smoother, yellowish-white to orange-brown. Fracture short, fibrous, incomplete; surface mealy (granular) between the fibers. The transverse section (cut by a knife or a blade), when examined under magnification (10x), reveals a delicately checkered pattern of tangentially arranged bast fibers traversed by medullary rays. If the section is moistened and allowed to soak for 1-2 minutes, swollen mucilage-containing cells can be detected.

Chopped, cut & sifted, and shredded inner bark: These intermediate forms occur as small pieces of the same color and texture as inner bark or as a mixture of matted fibers, powder, and occasional small pieces of the bark. Due to different equipment used by manufacturers, there can be variability in sizes of the bark fragments and different suppliers can refer to their materials using any of these terms, almost interchangeably.

Unrossed bark: Can occur in similar forms to those described above with the outer bark (cork) still present. The powder of unrossed bark will have darker reddish-brown hues to it (see Figure 10).

"**Cotton cut:**" Occurs as a tan or whitish- to yellowish-brown matted mass of small fibers, punctuated with thin slivers of outer bark; fibrous and pliable. This material often lacks the mucilage containing cells, which can be detected microscopically or macroscopically by powdery appearance.

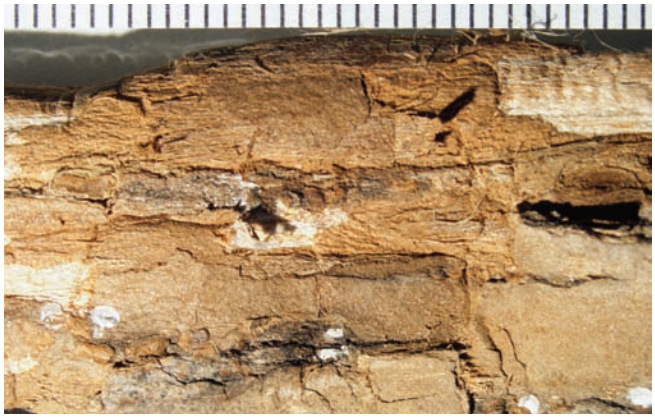
Granules: Light grayish-brown 2 mm x 1 mm pieces prepared from the bark.

Powder: Pale beige to light brown, with numerous visible bast fibers 2-3 mm long; soft to touch, mealy (lumps together when pressed between fingers, then falls apart easily).

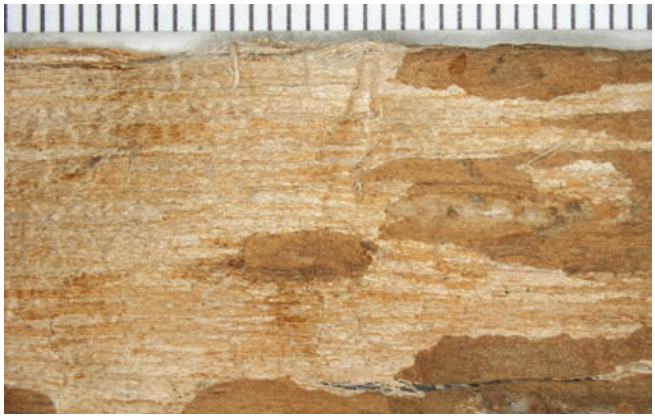
Organoleptic Characterization

Aroma: Characteristic, sweet and faintly aromatic, reminiscent of fenugreek, woody, distinct.

Taste: Bland; initially starchy then mucilaginous.



4a.



4b.

4c.

4d.

4e.

4f.

4g.

Figures 4a-i Macroscopic characteristics of *U. rubra* inner bark

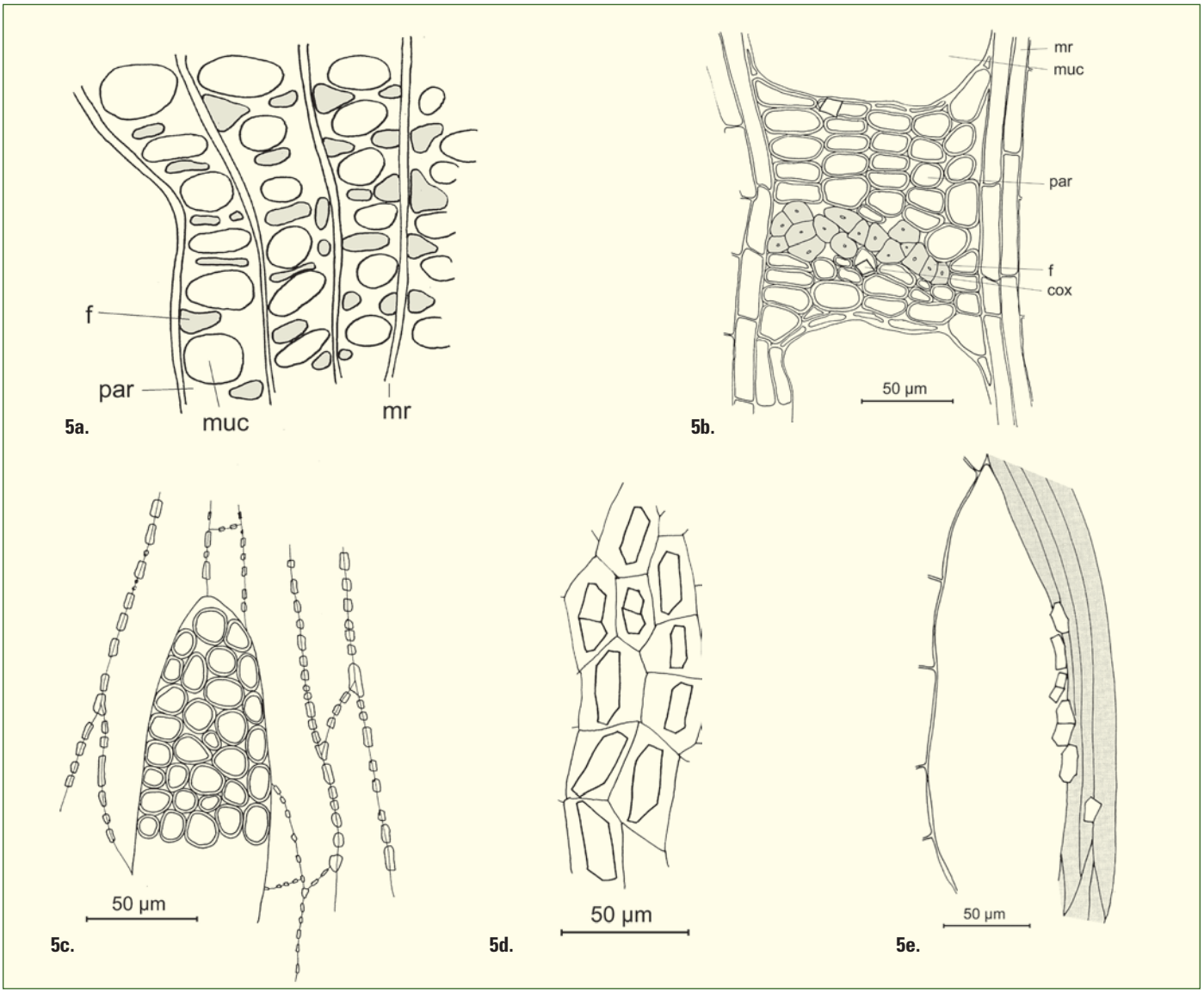
4a. Whole unrossed bark of *U. rubra*.
4b. Rossed bark of *U. rubra*.
4c. A quilled strip of *U. rubra* inner bark.
4d. *U. rubra* cut and sifted inner bark.
4e. *U. rubra* inner bark granules.
4f. Powdered *U. rubra* inner bark.
4g. "Cotton cut", a by-product of the bark-milling process.
Photographs: (3a-c, e-g) Silvester Ölzant, University of Vienna, Austria; (3d) AHP, Scotts Valley, CA.

Microscopic Identification

Transverse section: Parenchyma cells of secondary phloem roundish in outline alternating with regularly arranged narrow medullary rays 1-6 cells broad; ray cells radially elongated; narrow groups of bast fibers with small lumens are arranged tangentially between rays; large mucilage-containing cells, 50-160 µm diameter, alternate with parenchyma and fiber groups; calcium oxalate prisms 10-25 µm long are abundant along fibers and within the parenchyma cells; starch granules may be found in medullary ray and parenchyma cells.

Tangential longitudinal section (tls): Medullary rays elliptical in outline; fibers arranged in a network that follows the outlines of the medullary rays; mucilage-containing idioblasts; parenchyma cells appear elongated with beaded cell walls.

Powder: Long, thick-walled fibers, usually broken, up to 25 µm in diameter with non-lignified or only slightly lignified walls, often in twisted bundles; mucilage-containing idioblasts; monoclinic calcium oxalate prisms up to 25 µm in length, usually accompanying the idioblasts; parenchyma with beaded cell walls; mucilage; starch grains absent or rarely present. The presence of a large quantity of starch cells is indicative of adulteration.



Figures 5a-e Microscopic characteristics of *U. rubra* inner bark

5a. Schematic transverse section: *f* = fibers; *par* = parenchyma; *muc* = mucilage-containing idioblasts; *mr* = medullary rays.

5b. Transverse section: *mr* = medullary rays; *muc* = mucilage-containing idioblasts; *par* = parenchyma; *f* = fibers, tangentially arranged, with calcium oxalate prisms (*cox*).

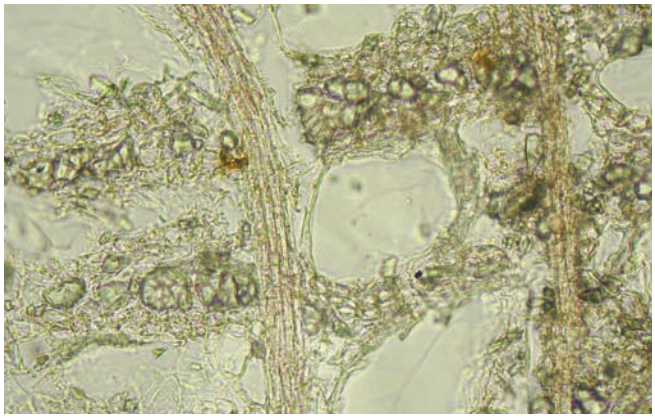
5c. Medullary ray and parenchyma with beaded cell walls (*ts*).

5d. Calcium oxalate prisms (*tls*).

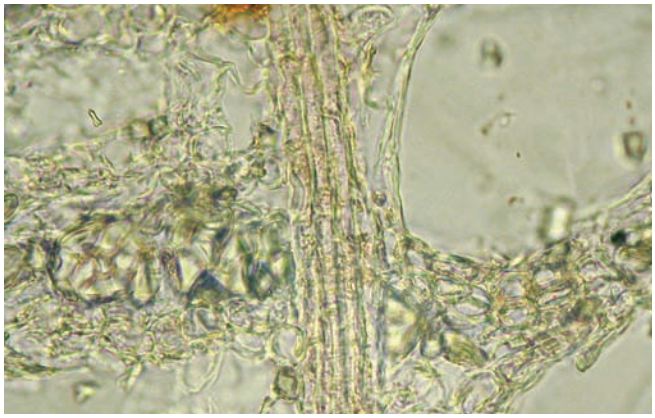
5e. Fibers, crystals, and a large mucilage-containing cell (*tls*).

tls = tangential longitudinal section; *ts* = transverse section.

Microscopic drawings courtesy of Reinhard Länger, AGES PharmMed, Vienna, Austria.



6a.



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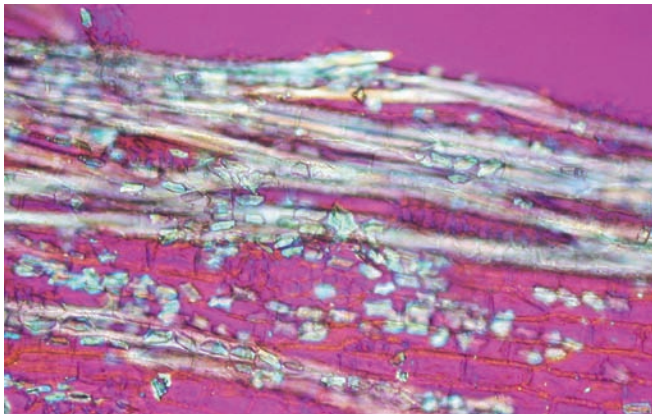

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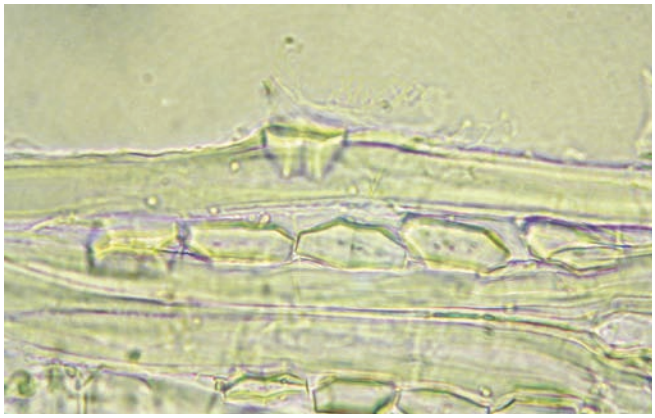

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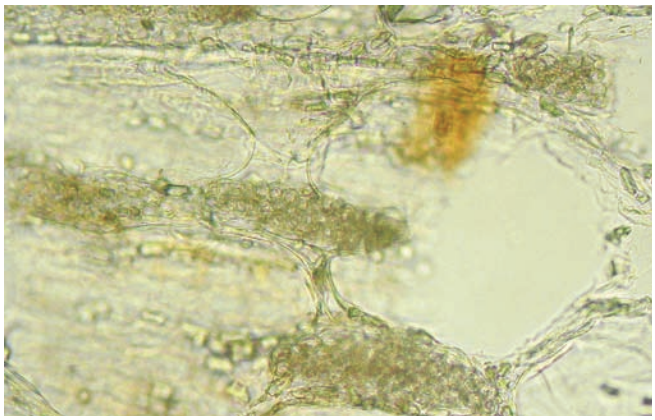

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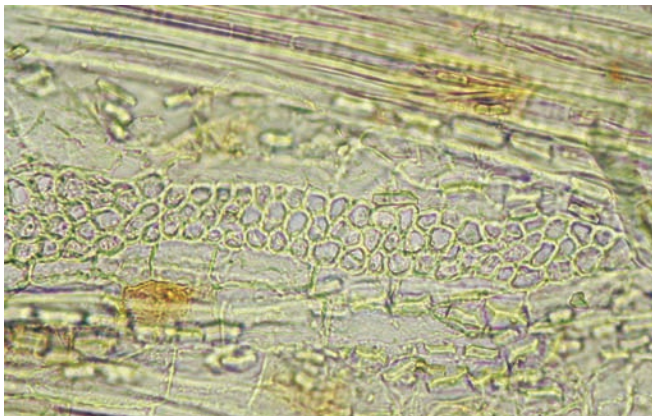


6f.

Figures 6a-f Microscopic characteristics of *U. rubra* inner bark

6a. Transverse section: narrow medullary rays, large mucilage-containing idioblasts, parenchyma, and tangential groups of fibers.

6b. Transverse section: medullary ray, mucilage-containing idioblasts, groups of fibers, and crystals.

6c. Fibers and crystals overlaying medullary rays and parenchyma (*tls*) (polarized light, compensator first order).

6d. Fibers with calcium oxalate prisms (*tls*).

6e. Mucilage-containing idioblasts and medullary rays (*tls*).

6f. Medullary rays, fibers, and crystals (*tls*).

tls = tangential longitudinal section; *ts* = transverse section.

Microscopic images courtesy of Reinhard Länger, AGES PharmMed, Vienna, Austria.

Commercial Sources And Handling

Slippery elm inner bark is the 4th largest harvested commodity in the herbal market, according to the American Herbal Products Association (AHPA) (Dentali 2009). The annual production from both wild-harvested and cultivated sources ranged from approximately 36 metric tons (dry weight) in 2004 to 154 metric tons in 2007. An average tree yields approximately 35-45 kg of fresh bark (Lockard 2006, personal communication to AHP, unreferenced) and the weight is reduced by 75% during drying (Strauss 2006, personal communication to AHP, unreferenced). Thus, it can be estimated that 4,000-19,000 trees were harvested annually to meet the demand for 2004-2007.

In recent years, the ongoing spread of elm diseases, poaching, and unsustainable harvest practices have continued to undermine native slippery elm populations throughout North America. Awareness of the issue is becoming increasingly important to ensure sustainable use of this resource. Collectors are encouraged to follow good harvesting and disease-managing practices and to apply the necessary measures for ensuring sustainable populations and preventing the spread of Dutch elm disease (DED) and other elm diseases.

Collection

Slippery elm bark is gathered from wild populations in eastern Canada and the United States, from southern Quebec west to North Dakota, south to south-central Texas, and Florida (Lockard and Swanson 2004). It is common throughout eastern-, southern-, and Midwestern USA and grows in more than 25 states. It is estimated that in Missouri alone, there are approximately 190 million trees of slippery elm of all age groups, with more than 50% of the trees being 40-75 years old (FIA 2010). In the early 20th century, when large quantities of the bark were collected in southern Michigan, it was reported that because the wood had no commercial value, the tree was fully stripped and consequently died (Grieve 1931). Today, an increasing amount of the commercial supply is being collected according to sustainable wild resource management plans as a condition of organic certification for wild crops, though illegal poaching and use of unacceptable harvesting techniques also occur.

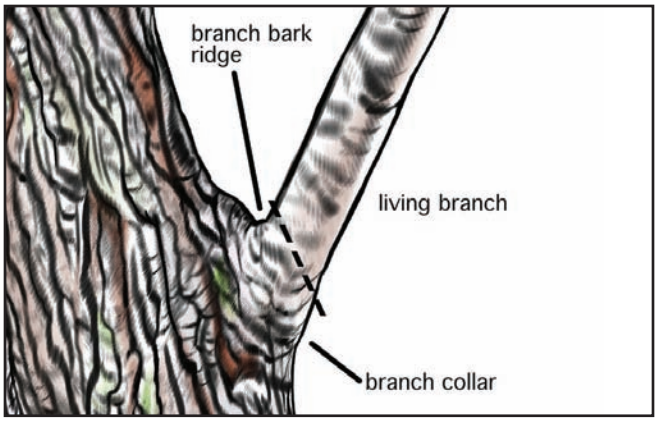
The bark from healthy tree branches should primarily be harvested in the early spring (March to mid-April) after the sap begins to rise. Late spring harvesting is discouraged as native elm bark beetles are known to begin their feeding season at this time and can be especially attracted to the fresh tree wounds resulting from bark harvesting (Ascerno and Wawrzynski 1994). However, collecting the bark from the trees already infected with DED can occur at any time in the season, preferably as soon after detection as possible (Haugen 2010). If harvested in the fall, the bark is more astringent but still mucilaginous (Strauss 2006, personal communication to AHP, unreferenced).

Harvesting should occur on dry, preferably warm days with no chance of precipitation and in late morning, after the dew and humidity disappear. If the mucilage in the harvested bark comes in contact with moisture, it begins to gel. Commercial bark collectors usually trim or prune the lowermost branches of trees that are at least 30-50 years old. The harvester stands atop a ladder leaned against the tree and prunes the lowest branch using either a hand or motorized saw on a long extended pole to reach the limb. To properly cut the branch with the least amount of damage to the tree, the cut is made just outside the "branch collar" and the "branch bark ridge" (Figure 7a). The cut should be made in such a manner that rainwater will not drop directly into the exposed cut area. This will allow the cut area to heal over. Wound dressings while not routinely used have been shown to significantly decrease the attraction of elm bark beetles to exposed wood, thus reducing the chances for DED infection, therefore, this practice is encouraged (Ascerno and Wawrzynski 1994).

While elm bark should not be gathered from already dead trees because of the deterioration of the mucilage, selective collection from dying trees, including those affected with DED, is feasible. DED affects only the sapwood and does not cause damage to the inner bark (Haugen 2010). The diseased tree can be dropped and the bark can be stripped from the entire tree. Harvesting such trees can also help prevent the spread of DED. Discolored (black-streaked) inner bark should be separated out and discarded (Strauss 2006, personal communication to AHP, unreferenced) because the mucilage yield and safety of such material are uncertain. Additionally, bark can be collected from those trees that are felled for timber.

Traditionally, for personal use, bark was harvested by stripping the tree branches or sides of the trunk. It is now known that such harvesting increases the risk of the DED infection. Volatile release from the exposed tissues attracts elm bark beetles that often carry spores of the DED-causing fungi. This can partially be mitigated by application of appropriate wound dressings, e.g., pruning paint (Ascerno and Wawrzynski 1994). However, an alternative method for low-scale harvesting proposed by plant pathologists of the United States Department of Agriculture (USDA) is to cut a young (10-20 year old) tree near the soil line and have all the bark from it removed. The beetles are less likely to attack a stump and use it as a breeding site (Haugen 2010, personal communication to AHP, unreferenced; Van Sambeek 2010, personal communication to AHP, unreferenced). Slippery elm is known to readily regenerate from stumps, and because of the already established root system the sprouts will initially grow faster than seed saplings and the cut tree will be rapidly replaced (Cooley and Van Sambeek 2010). Other factors to consider when choosing the tree for harvesting in this manner are lighting availability and competition from surrounding trees (Haugen 2010, personal communication to AHP, unreferenced).

It is also important to note that harvesting of the bark from the trees that are growing on public land is illegal without a permit, contract, or legal authorization and such violations can be penalized with up to $5,000 in fines and up to 6 months in prison (USDA Forest Service 2008).



7a.

7b.

7c.

Figure 7a-c Collection of *U. rubra* inner bark

7a. Illustration of the correct pruning technique used for collecting the bark from branches.

7b. Logs of *U. rubra* infected with Dutch elm disease ready for debarking.

7c. Using a drawknife to ross the bark.

Image and photographs courtesy of: (7a) Rebecca Cadman, Santa Cruz, CA; (7b) © 2011 7Song; (7c) © 2011 Simon Mills.

Certified Organic Bark Collection

Producers of certified organic wild crops (e.g., wild-harvested slippery elm bark) must comply with the same organic system plan requirements and conditions as their counterparts who produce cultivated crops (USDA 2010a). Wild collected tree barks that are to be certified organic must be harvested from a designated area that has had no prohibited substances applied to it for a period of 3 years immediately preceding the harvest and must be harvested in a manner that ensures that such harvesting or gathering will not be destructive to the environment and will sustain the growth and production of the wild crop. Wild-crop producers are required to promote ecological balance and conserve biodiversity. The producer of organic wild-harvested medicinal plants must initiate practices to support biodiversity and avoid, to the extent practicable, any activities that would diminish it. Production practices must maintain or improve the natural resources of the operation, including soil, water, wetlands, woodlands, and wildlife.

The above requirements are fulfilled, in part, by developing and executing a resource management plan that requires wild-harvesting to be done only from stable populations and/or to be accompanied by disease management practices (see Box on page 14), minimizing disruption of priority species/sensitive habitats, avoiding erosion, allowing re-establishment, and monitoring wild crop sustainability (NOSB 2005). An exception to the rules would be made if the habitat area is to be altered by other industries outside of the harvesters' control (e.g., commercial development). The field managers and collectors of certified organic wild-harvested slippery elm inner bark must be trained in conservation techniques and the collection site is subject to annual inspections by the organic certification agency (USDA 2010b).

To further ensure sustainable harvesting, the following practices are encouraged:

(1) The source of the elm is property that is managed under a Forest Service or Department of Natural Resources approved Forest Stewardship Plan;

(2) The material was removed in the application of an approved "timber stand improvement" practice, such as thinning or crop tree release;

or

(3) The timber was harvested under a 3rd party-issued forest sustainability certification.

Rossing

To obtain the medicinal material of commerce (rossed bark), the outer corky layer of the bark is removed and discarded, exposing the desired inner bark. A drawknife is considered the best tool for cork removal (Figure 7c), but a knife, hatchet, machete, or any other appropriate tool can also be used. After removal of the outer bark, the inner bark can be detached in strips, squares, or chips. All cut material must be debarked to prevent the elm bark beetles from using it for breeding.

Species Conservation

Slippery elm is not classified as an endangered or threatened plant in North America by either the Canadian Wildlife Service (CWS) or the United States Fish & Wildlife Service (USFWS), nor is it listed in the Convention on International Trade in Endangered Species (CITES). Since both slippery and American elms are prolific seeders at a fairly young age and the seedlings grow quickly, there continues to be a high occurrence of elms in native habitats (Cooley and Van Sambeek 2010; Haugen 2010, personal communication to AHP, unreferenced). However, slippery elm does have protected status in the state of Maine (Maine Department of Conservation 2004).

Diseases of Elms

Dutch elm disease (DED) has had a significant negative impact on the US elm populations beginning from the 1930s when it was found to affect over 50% of elm trees in the northern States (Stack et al. 1996). Slippery elm is generally less susceptible to DED than American elm (*U. americana*), but it is still frequently killed by it. DED has greatly impacted the number of large elms, altering the ecological role of elm trees (Haugen 2010, personal communication with AHP, unreferenced).

DED is caused by 2 species of fungi, *Ophiostoma ulmi* and *O. novo-ulmi*. The fungi are carried from tree to tree by the European elm bark beetle (*Scolytus multistriatus*), which, presumably, arrived in North America from Europe around 1930 on a boat of logs, and, to a lesser extent, by the native American elm bark beetles (*Hylurgopinus rufipes*, *Scolytus mali*, and *Xylosandrus germanus*).

The beetles seek out dead, dying, and/or diseased elms, broken limbs, or recently cut logs, in which they build egg-laying galleries. The insects are attracted to the volatile compounds released by trees that are weakened or damaged (e.g., by pruning or by storm). This is the point when DED infection typically occurs. New generation of adult insects, many of which carry DED spores, emerge in July-August and start feeding on healthy elms until fall. Beetles overwinter at the tree base and emerge in late April-May for a new life cycle (Ascerno and Wawrzynski 1994).

Elms appear to succumb to DED starting at about 10 years of age and then die off in a 2-year period (Rowe and Conner 1979; Strauss 2000). The disease usually begins only in a few branches before it spreads to the rest of the crown. When elms grow in close proximity to each other, they can form grafting (joining) roots. DED has been known to spread via grafting roots, quickly affecting many trees in pure stands of elms. In such cases the symptoms appear in the lower branches first (Haugen 2010).

Approved methods for managing Dutch elm disease include treatments with fungicides, herbicides, and insecticides. Application of chemicals to control DED is usually limited to urban areas or high-value landscape trees, and does not typically occur in the wild (Haugen 2010). Bark collectors are advised to be aware of the history of such applications in the collection area, and should avoid those trees that have been treated with chemical agents to avoid contamination of the raw material.

Harvest practices for preventing the spread of Dutch elm disease

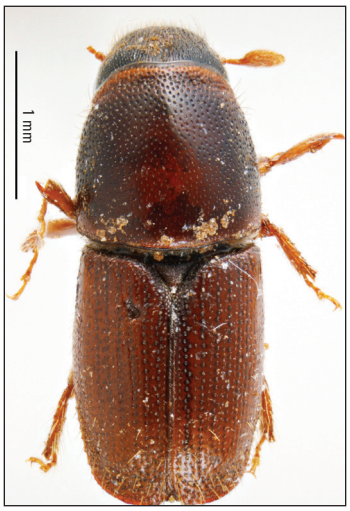
Trees that are already infected should be the first choice for bark harvesting. Removal of infected wood is the primary method for managing DED. Bark from infected trees can still be used medicinally. However, watch out for diseases that affect the inner bark, such as elm yellows, which makes the bark unsuitable for use. Elm yellows-infected bark has a wintergreen odor.
Remove and debark the whole diseased tree as soon as possible after DED is detected. This will prevent the infected tree from spreading more disease, and the harvested bark will be of better quality.
Harvesting by pruning should be limited to early spring (March to mid-April). Do not collect the bark by pruning during the growing season. Elm bark beetles are most active during late spring-summer months.
When pruning, apply a wound dressing to the cut area. This will reduce the attraction of bark beetles to the volatiles being released.
Best way to harvest the bark when small quantity is needed is to cut down a relatively young (up to 20-year-old) tree near the soil line and debark it completely. Sprouts will grow quickly from the stump due to the established root system.
Ensure complete debarking of cut trees and branches. This is necessary to prevent the residual attached bark from serving as breeding material for bark beetles.

Adapted from Haugen (2010).

Another disease that frequently affects elms is elm phloem necrosis, also called elm yellows (Figure 8f). This disease causes tan discoloration of inner bark, affects the whole crown simultaneously, and leads to tree death. The leaves of the trees affected with elm yellows turn yellow and drop prematurely, while those affected with DED turn brown and wilted (Figure 8d, e). Elm yellows can also be distinguished by a wintergreen odor of the inner bark, absent in other diseases (Haugen 2010). As a precautionary measure, because elm phloem necrosis affects specifically the inner bark, bark should not be collected from trees infested with this disease, although no information is available on mucilage yield or safety of such material.

Cultivation

Slippery elm trees can be propagated by cuttings or by seed. For propagation by seed, the ripe seeds are collected from April to June from healthy and successful (dominant) trees from an area similar to the proposed planting site. A ripeness indicator is the change of the samaras (fruit) color to green or light brown. A strong wind can blow much of the ripe seeds off in as little as 1 day. It is best to collect seed from trees within 160 km north or south of the planting site, as potential for success is optimal within this range from the parents. Seeds should be scattered at 25 seeds per square ft



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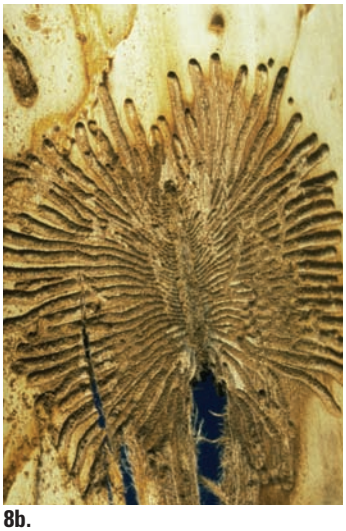

8b.

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Figure 8a-f Examples of Dutch elm disease and elm phloem necrosis

8a. Smaller European elm bark beetle (*Scolytus multistriatus*), the species primarily responsible for spreading Dutch elm disease.

8b. Egg-laying galleries of smaller European elm bark beetle seen underneath the bark.

8c. Elm branch showing discolored leaves, an early sign of Dutch elm disease.

8d. A close-up of an elm branch showing brown wilted leaves indicative of Dutch elm disease.

8e. A young elm-tree infected with Dutch elm disease.

8f. Elm tree infected with elm yellows (elm phloem necrosis).

Photographs courtesy of: (8a) Pests and Diseases Image Library; (8b) James Solomon, USDA Forest Service; (8c,d) Joseph O'Brien, USDA Forest Service; (8e) Petr Kapitola, State Phytosanitary Administration, Czechia; (8f) Pennsylvania Department of Conservation and Natural Resources – Forestry Archive; Bugwood.org.

and buried 0.6 cm deep (Meyer 1993). Slippery elm may be sown as in its normal cycle in the spring in a raised peat moss, soil, and sand bed. The seedbeds may need a wire top to protect young seedlings from grazing animals. The germination rate is 10-25% with light germination in summer and increased germination the following spring. The young trees can be transplanted into tree tubes within the 1st month of germination and field planted after 1 or 2 years depending on the size of the tree tube. The tree saplings must be watered during times of drought as well as routinely checked for insect predation and indications of fertilization needs (Strauss 2000).

Drying

Strips of the bark are cut into pieces of relatively equal length and bound into bundles. Fresh elm inner bark can be sun-cured at a temperature of 32-60 °C (90-140 °F) (Miller 1998, cited in Das et al. 2001). For ease of storage and transportation, the bark should be dried under pressure so that it remains flat. Drying can be carried out in a warm room with airflow, but also in a small greenhouse. Drying indoors can take 5-7 days depending on the heat source. Greenhouse drying takes about 3-4 days. Drying at commercial scale, however, is done typically in enclosed drying chambers. The strips of elm bark are placed onto a screen floor and dried over a 2-day period time at approximately 50 °C (122 °F) with fan-forced heat through the floor. The bark should be dried until attaining a loss-on-drying level of not more than 12.0% (USP 34-NF 29 2011). Approximately 75% of the fresh weight (moisture content) is lost during drying.

Processing

The dried flat strips are processed using a grinder or hammer mill to produce a coarse powder, best for use in poultices, or a finer powder, best for making mucilaginous liquids or for filling capsules. When milling slippery elm bark to a fine powder, there can be a high loss in dust. To minimize losses in processing, special ventilation and capture systems for airborne particles are recommended.

A dense granulate can also be produced, which is best for use in tea bags and also as an extraction cut. Slippery elm bark granules are extracted with water or with a water/ethanol solvent mixture to produce a soft viscous extract, which is then used as a component of various medicinal herbal products like pastilles (lozenges) (gum arabic and honey-based) or syrups (vegetable glycerin and honey-based).

If powder is used in extraction, the fine powder particles begin to block the sieve of the percolator, increasing pressure, reducing circulation, and reducing yield of extractive. Filtration can also be difficult and time consuming. For use in a complex mixture, it may also be advantageous to extract the elm bark separately from the other herbs, possibly using different apparatus, time and temperature controls, and larger mesh size for filtration, followed by admixing the separate extractives for the finished product.

Storage

Dried strips of the bark can be packed in burlap sacks and stored in unheated warehouses (Miller 1998, cited in Das et al. 2001). Cut or powdered bark should be preserved in well-closed containers and stored in a cool, dry place (USP 34-NF 29 2010). If packed in paper bags, tightly sealed inside of glass or plastic, and stored in a cool and dry building, the shelf life is expected to be several years, although stability must be determined on a case-by-case basis depending on the specific packaging, storage conditions, and testing parameters used for expiry dating purposes. Products containing slippery elm inner bark, such as lozenges, should be stored according to the manufacturer's instructions.

Adulterants

Powdered slippery elm inner bark has historically been adulterated with wheat, oat, rice, and corn starches or flours and with other, less mucilaginous, barks (Culbreth 1917). Adulteration with starches does not appear to be a prevalent practice today. If starch adulteration is suspected, it can be confirmed microscopically by the presence of a large quantity of starch cells. Starch is absent or only rarely occurs naturally in slippery elm inner bark. The most common adulterant of the pharmacopoeial quality elm inner bark today is the presence of more than 2% adhering outer bark, due to insufficient shaving and rossing.

The presence of adulterants results in a lower yield of mucilage, which is best determined by a swelling volume assay, and, consequently, a less pronounced demulcent action. An additional effect of excess outer bark is that the total ash content may exceed the 10% maximum allowable limit established by pharmacopoeial monographs (e.g., USP 34-NF 29 2010). The thick dark reddish-brown outer bark is readily discernible on the stripped/cut forms of slippery elm, due to its sharp contrast with the pale and thin inner bark. In the case of powdered material, a dark or reddish overall appearance may be indicative of the presence of excessive amounts of outer bark (Figure 10).

Some commercial material has been found to be completely lacking in mucilage cells suggesting extraction of mucilage and re-selling of the fiber (Sudberg 2011, personal communication with AHP, unreferenced).

Qualitative Differentiation

The primary quality indicator of the inner bark is its mucilage content, which is best assessed by the swelling volume assay, described in the Analytical section. The swelling volume of different inner bark samples may vary, however, it should not be below 24 mL. Unrossed bark, which includes both outer and inner bark, and "cotton cut," a by-product of the bark-milling process, typically show very low swelling volume values (< 10 mL) indicative of low mucilage content.

Preparations

Historically, a variety of medicinal slippery elm preparations have been used, such as cold or hot infusions, poultices,

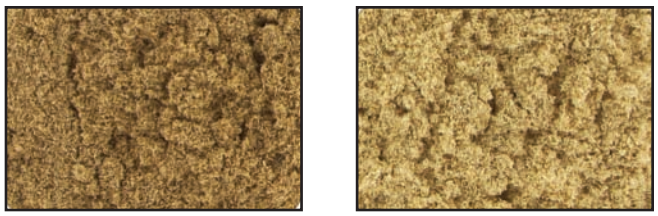

Figure 9 Comparison of powdered samples of unrossed (both inner and outer; left) and inner (right) bark of *U. rubra*

fomentations, lozenges, and nourishing gruels. Some sources report that mucilage is destroyed by prolonged exposure to hot water. However, a simple hot water infusion does not appear to reduce the quantity of extracted mucilage and, in fact, appears to accelerate the extraction. Mucilage can be extracted from either powder, chopped bark, or granules. Use of powder requires less of material by weight and yields a greater amount of mucilage than when using coarsely chopped inner bark. This is likely due to both increased surface area of the powder and its reduced content of bast fiber cells, which do not have mucilage, compared with pieces of coarsely chopped inner bark. Because of the fineness of the powder, the mucilage obtained from it cannot and need not be strained, and can be directly consumed or used externally. However, using whole pieces of inner bark for extraction results in a more clear and uniform mucilage, though a greater amount of the material is needed to yield an equivalent amount of mucilage, as noted below. Ethanolic extracts have not been used historically and do not yield sufficient quantities of mucilage to be medicinally relevant.

Cold infusion

Place 30 g of coarsely chopped inner bark in 500 mL or 4 g (approximately 1 tablespoon) of powder in 250 mL of cold water, cover, steep (at room temperature) for 1 hour or overnight, or until mucilage is extracted. When using coarsely chopped material, strain and press mucilage from the bark using cheese cloth or a strainer (make sure to wash hands well before this step or use sterile gloves). Cold infusions should be prepared fresh, stored in the refrigerator, and used within 1 day. To reduce the chance for microbial proliferation, heat the mucilage to just below boiling temperature while stirring to prevent burning. If using other forms of the inner bark material (e.g., shredded bark), adjust the bark/water ratio to get the desired consistency. The mucilage can also be used topically as an emollient.

Hot infusion

Prepare like cold infusion but with freshly boiled water. Steep for 10-20 minutes. Drink in sips.

Nutritive gruel

Mix the desired amount of slippery elm powder (1-4 g) in approximately 0.5-1 pint of cold water or milk; bring to just below boiling over low-medium heat until desired consistency. Add a sweetener and spices (e.g., cinnamon or nutmeg) if desired.

Elm lozenge

Lozenges made according to OTC requirements must contain 15.0% of slippery elm inner bark incorporated in an agar or other water-soluble gum base (FDA 1991).

Poultice

Spread clean cotton muslin or gauze, about twice the size needed for the finished plaster, on a tray. Put 120 mL (1/2 cup) of water in a saucepan and bring to boil. Pour in 4 grams (approximately 1 tbsp), or more, of finely powdered elm inner bark, stirring constantly, until a mucilaginous consistency forms. This takes about 10 minutes. Spread the paste onto one-half of a sterile gauze or cloth, leaving a margin around the plaster. Turn edges of the cloth up and fold the other half over. Apply to the affected area and cover with another oiled muslin cloth and/or towel. Secure with bandages if necessary. When applying to open or abraded skin, prepare with boiled water to reduce chances of bacterial infection.

Constituents

Mucilage

The primary constituent of interest in slippery elm is mucilage. Mucilages are complex carbohydrates (polysaccharides) of high molecular weight that somewhat resemble pectic compounds (Pallardy 2007). Mucilages are made up of pentose and hexose sugar residues and their oxidation products, uronic acid units (Samuelsson 1992). These compounds are highly hydrophilic and are capable of trapping water and other molecules in their cage-like structures. When mixed with water, mucilages swell to many times their original volume creating a viscous gel.

In slippery elm, mucilage is present in some of the cells of the phloem parenchyma. Early work showed that mucilage from slippery elm consists of L-rhamnose, D-galactose, and D-galacturonic acid. Hough et al. (1950) reported the ratio of sugars in slippery elm mucilage to be 21% D-galactose, 8% L-rhamnose, and 19% 3-*O*-methyl-D-galactose. The report of 3-O-methyl-D-galactose in slippery elm was the first time this compound was found in a natural source (Hough et al. 1950).

The most recent characterization of mucilaginous carbohydrates from slippery elm inner bark was performed by Beveridge et al. (1969, 1971a, b). They utilized several methods, including methylation analysis and nuclear magnetic resonance spectroscopy (NMR) to describe slippery elm polysaccharides. According to Beveridge et al. (1969, 1971a), the mucilage isolated from slippery elm inner bark contained 36% D-galacturonic acid and L-rhamnose, D-galactose, and 3-O-methyl-D-galactose in the ratios of 1.00: 2.70: 2.08. The precise ratio is prone to variation in different samples (cf. Hough et al. 1950). The main chain consists of alternating L-rhamnopyranose and D-galacturonic acid residues joined by α-linkages through the 4th position of the galacturonic acid and the 2nd position of L-rhamnopyranose. Side chains contain D-galactose and

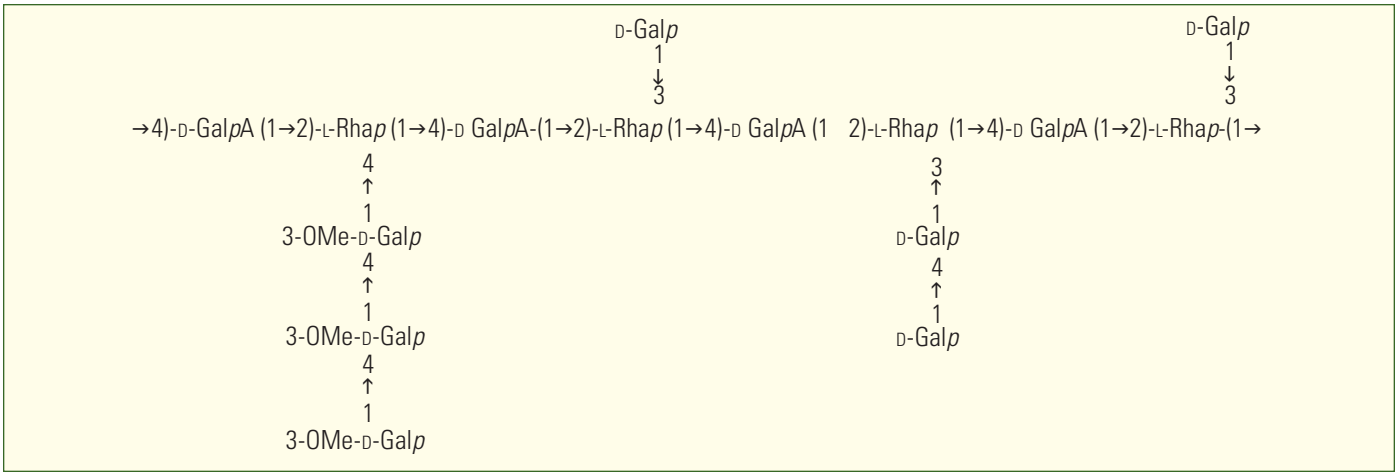

Figure 10 Polysaccharide of *U. rubra* inner bark mucilage

Source: Beveridge et al. (1969).

D-Gal*p*A – D-galactopyranosyluronic acid; L-Rha*p* – L-rhamnopyranosyl; D-Gal*p* – D-galactopyranosyl; 3-*O*-Me-D-Gal*p* – 3-*O*-methyl-D-galactopyranosyl.

3-O-methyl-D-galactose (1 or 2 residues), attached to the C-3 and, occasionally, C-4 positions of L-rhamnopyranose residues. The structure proposed for the polysaccharide from slippery elm inner bark is shown in Figure 11. Subsequent work by Beveridge et al. (1971b) confirmed their earlier conclusion that disaccharides containing 3-O-methyl-D-galactosyl residues are attached to certain L-rhamnose residues in the polysaccharide's backbone chain.

Polysaccharides with rhamnogalacturonan backbone and olygosaccharidic side chains have been shown to possess immunomodulatory activity, including anticomplementary and mitogenic effects, and enhanced immune complex clearance (Yamada and Kiyohara 2007).

Other substances

Apart from the mucilage, the inner bark contains small amounts of flavonoids. The outer bark is normally much richer in these protective compounds, which makes it also more astringent. The flavonoids present in the inner bark include procyanidins B1 and B2, catechin, epicatechin, and catechin-rhamnoside (Saleem et al. 2009). Additionally, an in vitro study (Choi et al. 2002) demonstrated a strong scavenging activity of slippery elm inner bark against peroxynitrite ($ONOO^-$). Peroxynitrite is associated with chronic inflammation of gastrointestinal mucosa (Potoka et al. 2003; Yue et al. 2001). The presence of flavonoids and the ensuing antioxidant activity of slippery elm inner bark may partially explain its historical use as an anti-inflammatory and for protection of fats from rancidity (Wright 1852).

Analytical

There are two primary analytical objectives for assessing the quality of slippery elm: identification and a quantitative evaluation of mucilage yield. The latter is correlated with its action as a demulcent. In addition to the botanical, macroscopic, and microscopic characteristics provided (see Identification), a standard HPTLC analysis for flavonoids as commonly used in the *European Pharmacopoeia* can be used to obtain a characteristic fingerprint. The current method was optimized for use on HPTLC plates.

For the quantitative assessment of slippery elm mucilage, a swelling volume assay is most appropriate. The current assay was developed after reviewing the swelling volume test of the USP monograph for Elm (USP 34-NF 29 2010) and the *European Pharmacopoeia* method for swelling index (EP 2010). The USP method is a non-quantitative subjective assay of swelling, whereas the EP method provides a quantitative value of mucilage yield. While the USP method is required for testing elm raw material that is to be used in drug products (lozenges), the method is not optimal for basic quality assessment of slippery elm raw materials for use in dietary supplements. However, the EP swelling index test, which is more objective than the USP method, takes a considerable amount of time that appears unnecessary for determining mucilage yield in slippery elm. Thus, after a three-lab investigation, the testing parameters presented in the EP method were optimized to obtain the results in a greatly reduced amount of time.

High Performance Thin Layer Chromatography (HPTLC) for the Identification of Flavonoids in Slippery Elm Inner Bark

Sample preparation

Place 0.5 g of milled raw material in a flask and add 5 mL of 60% methanol. Sonicate for 10 min. Centrifuge for 5 min at 5000 rpm. The supernatant is used as test solution.

Standard preparation (optional)

Individually dissolve 3.0 mg of rutin, 3.0 mg of hyperoside, and 1.0 mg of chlorogenic acid in 10 mL of methanol each.

Reagent preparation

Natural Products reagent (NP reagent): 1 g of diphenylborinic acid aminoethylester is dissolved in 200 mL of ethyl acetate.

Polyethylene glycol reagent (PEG reagent): 10 g of PEG 400 (Macrogol) are dissolved in 200 mL of dichloromethane.

Chromatographic conditions

Stationary phase:

HPTLC plates 10 x 10 cm or 20 x 10 cm silica gel 60 F 254.

Mobile phase:

Ethyl acetate, ethyl methyl ketone, water, formic acid (50:30:10:10)

Sample application:

5 µL of the test solution and of the standards are applied each as a 8 mm band with a minimum of 2 mm distance between bands. Application position should be 8 mm from lower edge of plate.

Development:

10 x 10 cm or 20 x 10 cm Twin Trough Chamber, saturated for 20 min with filter paper and 5-10 mL of developing solvent in each trough. Developing distance is 70 mm from lower edge of plate. Dry plate in a stream of cold air for 5 min.

Detection:

a) UV 254 nm

b) The plate is heated at 100 °C for 3 min, dipped while still hot in NP reagent, and dried in a stream of cold air. The plate is then dipped in PEG reagent and dried in a stream of cold air. Examination is performed under UV 366 nm.

Results:

Compare to the chromatograms provided.

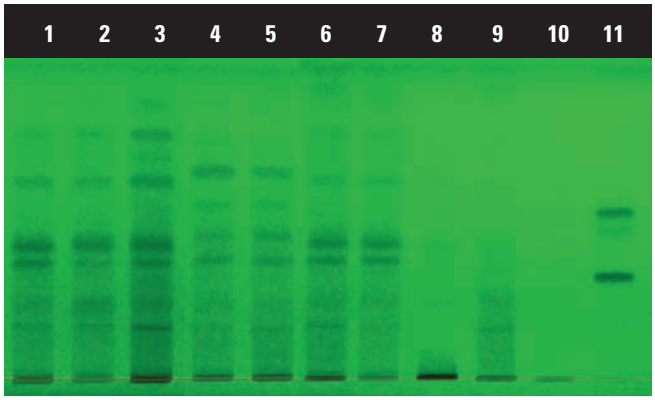

Figure 11a HPTLC chromatogram of *U. rubra* inner bark prior to derivatization (UV 254 nm)

Discussion of Chromatogram

The standards rutin (Lane 11, R_f = 0.30), and hyperoside (Lane 11, R_f = 0.49) show quenching zones. Chlorogenic acid (Lane 11, R_f = 0.42) shows a weak quenching zone. There is one principal band at R_f = 0.34 in all samples. A second prominent band at R_f = 0.39, below the position of chlorogenic acid is present in all samples, except cotton bark raw material (Lanes 4 and 5) where the zone is at the position of chlorogenic acid. Rutin and hyperoside are not detected in the samples. Most samples show several weak zones above the position of hyperoside.

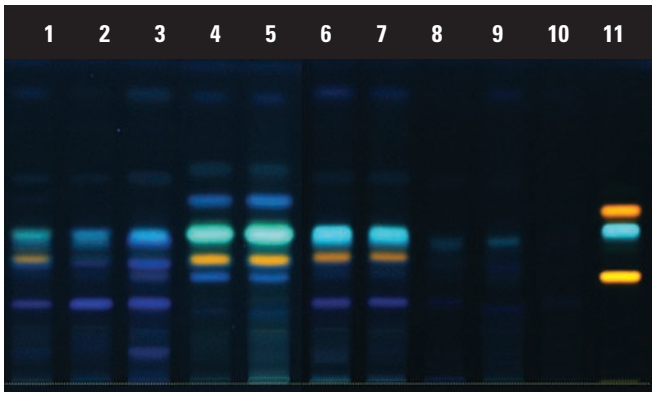

Figure 11b HPTLC chromatograms of *U. rubra* inner bark (NP reagent + PEG, UV 366 nm)

Discussion of Chromatogram

The standards rutin (Lane 11, R_f = 0.30), and hyperoside (Lane 11, R_f = 0.49) show orange fluorescent zones. Chlorogenic acid (Lane 11, R_f = 0.42) shows a light blue fluorescent zone. In the samples no orange zones are detected at the position of rutin or hyperoside. All samples show a blue or green fluorescent zone at the position of chlorogenic acid. Below this zone but above the position of rutin an orange zone is seen in all raw material samples except the ones in Lanes 2 and 3. There is a blue zone below the position of rutin in all samples except the "cotton cut" samples in Lanes 4 and 5*. The "cotton cut" samples show specific blue zones at R_f = 0.30 and R_f = 0.55. Additional weak zones are seen above the position of hyperoside. The slippery elm lozenge (Lane 8) and the fluidextract (1:1) (Lane 9), in comparison with raw material samples, show very faint zones or some of the bands are entirely lacking. No fluorescent zones can be observed in the liquid extract (1:3) (Lane 10).

*Note: The "cotton cut" samples (Lanes 4 and 5) have the brightest fingerprint. This may be due to the relative lack of mucilage, whose presence would otherwise decrease the concentration of flavonoids responsible for the fluorescence.

Lane 1: *U. rubra* whole bark
Lane 2: *U. rubra* inner bark (freshly powdered from whole material)
Lane 3: *U. rubra* inner bark (freshly powdered from whole material)
Lane 4: *U. rubra* cotton bark
Lane 5: *U. rubra* cotton bark
Lane 6: *U. rubra* pre-powdered bark (commercial sample)
Lane 7: *U. rubra* granules
Lane 8: *U. rubra* tablets
Lane 9: *U. rubra* fluid extract (1:1, 12-15% ethanol)
Lane 10: *U. rubra* liquid extract (1:3, 25-35% ethanol)
Lane 11: Rutin, chlorogenic acid, hyperoside

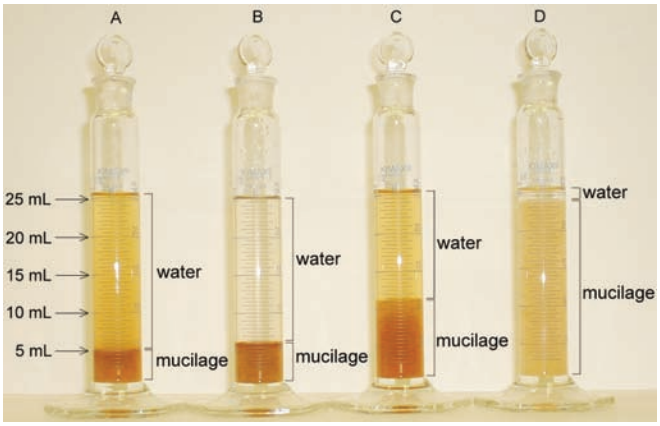

Figure 12 Swelling volume assay

A. Commercial bark powder. B. Unrossed ("natural", both inner and outer) bark. C. "Cotton cut." D. Inner bark of *U. rubra*.

Swelling Volume Assay

Sample preparation

Place 0.1 g of moderately fine powder (passed through #45 sieve; particle size ≤ 355 µm) into a 25 mL graduated cylinder sealed with a ground-glass stopper. Moisten the sample with 1.0 mL of ethanol.

Procedure

Add 25 mL deionized water (20 °C) to the sample. Immediately stopper the cylinder, shake vigorously, and start a timer for 90 minutes. Repeat vigorous shaking at 10 and 20 minutes. At 30 minutes rotate the cylinder about the vertical axis to release any large volumes of liquid retained in the mucilage. At 90 minutes measure the volume occupied by the mucilage.

Note: Prolonged maceration (> 2 hours) can result in a reduction of size of the mucilage layer.

Results

The mucilaginous layer should be not less than 24 mL. High quality material can swell to above 40 mL if given sufficient medium. Poor quality material, e.g., "cotton-cut" and whole (unrossed) powdered bark typically swells to 6-12 mL. Some shredded materials on the market are almost completely devoid of mucilage.

Limit Tests

Outer Bark:	Not to exceed 2% of adhering outer bark (USP 34-NF 29 2010).
Foreign Organic Matter:	Not to exceed 2% (USP 34-NF 29 2010).
Loss on Drying:	Not to exceed 12.0% determined on about 2 g of powdered elm, accurately weighed, in an oven at 105 °C to constant weight (USP 34-NF 29 2010).
Total Ash:	Not to exceed 10% (USP 34-NF 29 2010).
Acid-insoluble Ash:	Not to exceed 0.65% (USP 34-NF 29 2010).

Therapeutics

Slippery elm bark and its preparations are predominantly used for their demulcent properties, which are due to the rich content of mucilage in the inner bark. Numerous mucilaginous botanicals have been used historically both for their own medicinal action and for modulating the effects of other preparations. Slippery elm has been used topically and internally for soothing dry, irritated, and inflamed tissues and systemically as a nourishing tonic.

Slippery elm is one of the few botanicals approved in the US for medicinal use, as an oral demulcent ingredient in over-the-counter (OTC) products, such as lozenges. Such indication is congruent with the historical use of slippery elm, while at the same time being very limiting when compared with the broad spectrum of therapeutic uses for which this plant had been successfully utilized in the past. Nevertheless, little formal investigation of slippery elm's medicinal properties has been conducted. There is, however, a plethora of detailed historical medical literature supporting its use, with many sources describing it as among the best and most versatile of mucilaginous agents.

The mechanical effect of locally coating irritated mucosa with the viscous hydrocolloidal fiber from slippery elm has traditionally been viewed as the primary means by which slippery elm, or its aqueous extracts, exert their therapeutic activity. However, there is also indirect evidence to suggest that the putative effects of slippery elm may involve mediation by gut-associated lymphoid tissue (e.g., Peyer's patches). Additionally, there has been some investigation of the antioxidant constituents of slippery elm that may contribute to its widely reported anti-inflammatory and vulnerary effects on the bowel mucosa.

Pharmacokinetics

No published studies on the pharmacokinetics of slippery elm preparations were identified.

Mucilages are generally considered to be pectin-like carbohydrates due to similarities in the chemical composition between the two. Pectins are known to contain rhamnogalacturonan regions with alternating (1→4)-α-D-galacturonic acid and (1→2)-α-L-rhamnose residues substituted with side chains rich in neutral sugars (Knaup et al. 2008; Yamada and Kiyohara 2007). The mucilage from slippery elm inner bark contains a rhamnogalacturonan backbone with side chains composed of D-galactose and 3-O-Me-D-galactose (Figure 11). Considering this very close structural resemblance, it might be assumed that digestion of slippery elm inner bark mucilage occurs similarly to that of pectin. In healthy subjects, up to 90% of ingested pectin is recovered undigested at the end of the small intestine (Saito et al. 2005). Less than 5% of ingested pectin was found in the fecal contents of human volunteers (Holloway et al. 1983). Thus, pectin and, presumably, pectin-like slippery elm mucilage are mostly degraded by bacteria in the large intestine. The end products of bacterial fermentation of carbohydrates are short-chain fatty acids (SCFAs), which are known to be absorbed in the colon and used for energy production by the colonic epithelial cells or taken up via the

portal vein and used by the liver and other tissues (Gropper et al. 2009). This may account for the traditional use of slippery elm inner bark as a nourishing gruel.

Pectin has been shown to delay gastric emptying of foods and beverages. When pectin (10 g) and guar gum (16 g) were added to orange juice and drunk by healthy human subjects, gastric emptying at 30 min was 31.9%, compared to 53.9% ($P < 0.005$) for orange juice alone. The fibers caused an increase in gastric emptying half-time of orange juice from 23.1 ± 5.5 min to 49.9 ± 15.2 min ($P < 0.0025$) (Holt et al. 1979).

There is a significant amount of data on the pharmacokinetics of the phenolic compounds that are present in slippery elm. Generally, their bioavailability appears to be low, although it has been shown to improve when the compounds are administered in a whole plant (Bode and Dong 2009). Plasma concentration time curves of green tea catechins administered as green tea solids, obtained by freeze-drying the water extracts of green tea leaves, were analyzed using a one-compartment model by Lee et al. 2002. Epicatechin was detected in plasma mainly in a conjugated form (as glucuronide or sulfate conjugates). There was considerable inter-individual variation in pharmacokinetic parameters, as well as differences between different days in the same subjects, although the variation was smaller for epicatechin than for epigallocatechin-3-gallate (EGCG).

Several catabolites of procyanidin B_2 were identified in an in vitro study with human fecal microflora (Stoupi et al. 2010). When catechin, the procyanidin dimer B_3, and a grape seed extract containing catechin, epicatechin, and a mixture of procyanidins were fed to rats in a single meal, catechin and epicatechin were present in conjugated forms in both plasma and urine (Donovan et al. 2002). In contrast, no procyanidins or conjugates were detected in the plasma or urine of any rats. Procyanidins were not cleaved into bioavailable monomers and had no significant effects on the plasma levels or urinary excretion of the monomers when supplied together in the grape seed extract. The researchers concluded that the nutritional effects of dietary procyanidins are unlikely to be due to procyanidins themselves or monomeric metabolites with the intact flavonoid-ring structure, as they do not exist at detectable concentrations in vivo.

Clinical Efficacy and Pharmacodynamics

Effects on the Gastrointestinal Tract

Human Clinical and Case Studies

Two slippery elm-containing formulas were tested on subjects with irritable bowel syndrome (IBS) in an open-label uncontrolled pilot clinical trial performed in Australia (Hawrelak and Myers 2010). The formulas were designed with the primary goal to improve and "normalize" bowel habits of the individuals and secondarily to reduce abdominal symptoms. One formula designated as DA-IBS was administered to subjects with diarrhea-predominant IBS or alternate bowel habit IBS and contained 10.0 g of dried billberry (*Vaccinium myrtillus*) fruit, 4.5 g of slippery elm inner bark, 3.0 g of agrimony (*Agrimonia eupatoria*) dried aerial parts, and 1.5 g of cinnamon (*Cinnamomum zeylanicum*) bark per dose. Second formula designated as C-IBS was given to subjects with constipation-predominant IBS and contained 7.0 g of slippery elm inner bark, 3.0 g of lactulose, 2.0 g of oat (*Avena sativa*) bran, and 1.5 g of licorice (*Glycyrrhiza glabra*) roots per dose. Both formulas were powdered and the subjects were instructed to take their specific formula mixed in 250 mL of apple juice once every morning and evening for 3 weeks, after a 2-week wash-out period and 2-week run-in period. A total of 31 subjects were recruited, with 21 (76% female) assigned to the DA-IBS group and 10 (100% female) to the C-IBS group. Two of the subjects in the C-IBS group were excluded from the trial due to lack of compliance with the treatment protocols.

By the end of the treatment period, the DA-IBS group experienced a 9% increase in bowel movements ($P = 0.027$) and 22% decrease in straining scores ($P = 0.004$) with no change in stool consistency or sense of urgency scores (primary outcome variables), as well as a 19% decrease in abdominal pain scores ($P = 0.006$), 28% decrease in bloating scores ($P < 0.0001$), 18% reduction in flatulence scores ($P = 0.0001$) and 21% decrease in global IBS symptoms ($P = 0.002$) (secondary outcome variables). Additionally, at the end of week 4 (including the 2-week run-in period), 15 of 21 subjects (71.4%) stated they experienced adequate relief from the diarrhea over the previous 7 days; this number decreased to 14/21 (66.7%) at the end of week 5. Seventeen of 21 subjects (81.0%) believed that the study preparation improved their overall bowel habit. The authors concluded that this formula was ineffective for the purpose for which it was designed ("normalization" of the bowel habits), since it actually increased bowel frequency. However, the rest of the evaluated IBS symptoms improved.

In the C-IBS group, the treatment resulted in a 20% increase in bowel movements ($P = 0.016$), 65% decrease in straining scores ($P < 0.0001$), and 29% improvement in stool consistency ($P < 0.0001$) (primary outcome variables), as well as a 14% decrease in abdominal pain scores ($P = 0.032$), 13% decrease in bloating severity ($P = 0.034$), and 34% reduction in global IBS symptom severity ($P = 0.0005$). At the end of week 4, 7 of 8 subjects (87.5%) stated they had adequate relief from the constipation in the preceding 7 days, with the number increasing to 8 out of 8 (100%) by the end of week 5. All subjects believed their bowel habit was improved by the formula. Overall, the formula was determined as effective for the primary bowel habit outcome measures, as well as improving secondary symptomatic parameters.

No serious adverse events were reported during the study. Two mild adverse events were reported in the DA-IBS group, namely an occasional nausea immediately after taking the preparation (1 subject) and a complaint that the formula was making the stool too hard (1 subject), but therapy was continued in both cases. There were no changes in vital signs and no clinically relevant changes in laboratory tests (full blood count, liver function test, urea, electrolytes, and creatinine) were observed in either group.

The limitations of the trial acknowledged by the authors include no placebo control (as patients with IBS are known to produce good response to placebo treatments), small number of enrolled participants, only females in the C-IBS group, and use of apple juice as a carrier (since fructose malabsorption is considered a possible cause of IBS-like symptoms in some subjects).

Respiratory Effects

Human Clinical and Case Studies

A proprietary blend of herbs containing slippery elm inner bark (Throat Coat®, manufactured by Traditional Medicinals®, Sebastopol, CA) was studied in a randomized, placebo-controlled, double-blind trial for the symptomatic treatment of acute pharyngitis (Brinckmann et al. 2003). Patients were recruited in two medical centers in Minnesota and Wisconsin from December 2000 to May 2001 for this prospective, two-armed, parallel group trial. The 60 participating patients were 18 years of age or older of both genders with a baseline pain-on-swallowing score of 5 or more on a 0-10 scale. The sore throat symptom was of 7 days or less duration, and no other sore throat medication, herbal remedy, or dietary supplements were used within 4 hours of beginning the herbal treatment. Patients using analgesics, anti-inflammatory drugs, or steroids were excluded, along with those whose sore throats were due to local irritation from gastroesophageal reflux or caustic substances. Patient groups, 30 each who received the treatment or placebo, were similar in age, gender, weight distribution, and severity of symptoms. Of 11 patients tested, 3 were positive for *Streptococcus* infection and were in the active treatment group. One patient in each group was excluded from the final results due to failure to show up for the second visit.

The preparation was provided in tea bag form. Each tea bag contained 960 mg of a demulcent mixture with 760 mg licorice (*Glycyrrhiza glabra*) root, 80 mg of slippery elm inner bark, 60 mg of marshmallow (*Althaea officinalis*) root, and 60 mg of aqueous dried extract (8:1 w/w) of Chinese licorice (*Glycyrrhiza uralensis*) root, all of which have demulcent properties. The demulcents were combined with 1040 mg of a proprietary blend (in order of predominance) of wild cherry (*Prunus serotina*) bark, fennel (*Foeniculum vulgare*) fruit, cassia cinnamon (*Cinnamomum aromaticum*) bark, and sweet orange (*Citrus sinensis*) peel. The placebo was a non-demulcent combination of food ingredients with 160 mg of natural licorice flavor.

Patients were instructed to consume a cup of tea, 4 to 6 times daily, prepared by pouring 150-240 mL (5-8 oz) of boiling water over a tea bag in a porcelain cup covered with a lid, both of which were provided, and allowing to steep for 15 minutes. The tea bag was then removed and gently squeezed over the cup with a spoon. Without adding any sweetener, the tea was to be used slowly, first as a gargle and then swallowed. This treatment was continued for 2-10 days, depending on the persistence of the symptoms. No other sore throat treatments, including lozenges, were allowed.

Patient assessments for pharyngitis symptoms, throat pain intensity, and adverse effects were obtained by questionnaire at baseline (during the first clinic visit) and after 7 days during the second visit. Pharyngitis questionnaires were also completed 24 and 48 hours after beginning of treatment. Pain relief compared to baseline and throat pain on swallowing were assessed by patients at 1, 5, 10, 15, 20, and 30 minutes, and 3 hours after the first cup during the first visit and daily at the same time of day between 5-15 minutes after the last sip, as long as the pain symptoms persisted or until the second visit.

In the changes from baseline after the first dose the intention-to-treat analysis showed the treatment group had significantly less pain on swallowing after 5 ($P = 0.02$) and 10 minutes ($P = 0.03$), and nearly so after 15 minutes ($P = 0.051$), when compared to placebo. The sum of pain intensity differences over the first 30 minutes was also significant ($P = 0.041$). Comparisons of treatment to placebo pain relief scores at the various time intervals were used as a secondary efficacy parameter. In the intention-to-treat analysis the treatment group showed statistically significant improvement over the placebo group at 10 minutes ($P = 0.02$) and nearly so at 30 minutes ($P = 0.052$). Total pain relief, as assessed by the questionnaire, over the 30 minutes was also greater with demulcent treatment than with placebo, though this was not statistically significant ($P = 0.064$).

Scores on the sore throat questionnaire were not significantly different from placebo after 1, 2, or 7 days in the intention-to-treat analysis. Compliance with treatment (4 to 6 tea bags daily) was 100%, and the treatment was well tolerated. Six mild or moderate adverse events occurred in the treatment group and 9 in the placebo group; the only one associated with treatment was 1 day of mild diarrhea. No serious adverse effects, nor significant changes in blood pressure, heart rate, or body weight, resulted from treatment. While this formula is more appropriately characterized as a licorice compound, this demulcent treatment was determined to be effective for the temporary relief of sore throat.

The local effect of slippery elm on the throat and/or gastro-esophageal mucosa has also been used as a means of subduing a reflexive cough. A case was reported concerning a 47-year-old nonsmoking woman with a persistent dry cough associated with lymphangitic adenocarcinoma of the lung (Gallagher 1997). Talking aggravated the cough and its severity led to headaches and rib pain. Coughing spasms caused gastric reflux and vomiting and their severity and persistence resulted in cracked tracheal rings. Though chemotherapy with vinorelbine and cisplatin reduced the lung disease, the coughing did not abate. After trying numerous prescriptions (e.g., normethadone) and over-the-counter antitussives, over a year after the coughing began the patient relied on 15 mg of morphine every 12 hours with little beneficial effect.

The patient then began a systematic trial of medications, beginning with lidocaine 5 mg every four hours by nebulizer. No significant effect was derived from this or from nebulized morphine at 5 mg every four hours. Chlorpromazine 10 mg three times daily and carbamazepine 100-200 mg twice daily were both excessively sedating but still provided no relief. The reflux and vomiting were

reduced by cisapride, but resulting diarrhea limited its use. Omeprazole reduced pyrosis from the reflux, but the coughing was unremitting and vomiting followed spasmodic coughing.

A combination of slippery elm bark and plantain leaves (*Plantago* spp.) was used as antitussives to coat the mucosa with mucilage. The authors suggest that the large amount of mucilage forms a viscous solution that coats the mucosal tissues of the pharynx, larynx, and trachea and that protection from mechanical irritation of cough receptors reduces cough. Slippery elm bark in doses of 1 or 2 teaspoonfuls on cereal or pudding in the morning caused a marked reduction in her cough. A tea of the plantain leaves, prepared by infusing 2-3 g in 150 mL boiling water, was also helpful when drunk in small amounts throughout the day. No major side effects were detected from using these preparations. However, chest discomfort from the disease progressed, and while long-acting hydromorphone further helped suppress the cough, the herbal preparations continued to be used until brain metastases led to eventual death.

Antioxidant, Anti-inflammatory, and Immunomodulatory Effects

In Vitro Activity

Since slippery elm inner bark is used by patients with inflammatory bowel disease, it was assessed for its antioxidant effects and compared with several other herbal medicines and 5-aminosalicylate (5-ASA) as the positive control (Langmead et al. 2002). Superoxide scavenging was detected in a xanthine/xanthine oxidase cell-free system in which chemiluminescence was enhanced by luminol. A filtered and centrifuged water extract of slippery elm dose-dependently produced antioxidant activity similar to 5-ASA. Slippery elm inhibited reactive oxygen metabolite (ROM) by 50% at a concentration (IC_{50}) of 3×10^{-4} parts per volume (ppv), while 5-ASA IC_{50} was 10^{-5} M. In the same study, using fluorimetry to assess peroxyl radical scavenging by a phycoerythrin degradation assay, slippery elm and 5-ASA each dose-dependently reduced peroxyl radicals with IC_{50} of 1×10^{-3} ppv and 1×10^{-5} M, respectively.

Using biopsied colorectal mucosal tissue from 23 patients with ulcerative colitis treated with 5-ASA (n = 16), prednisolone (n = 5), and/or azathioprine (n = 4), the chemiluminescence levels after incubation with slippery elm or 5-ASA for 40 minutes were compared with control biopsies incubated in an inert vehicle. The slippery elm infusion dilution of 1 in 100 ppv was chosen to approximate the amount likely present in the colon lumen, assuming minimal absorption or digestion in the small intestine. At this dilution the slippery elm infusion significantly reduced chemiluminescence ($P < 0.02$) compared to controls, as did 5-ASA at 20 mmol ($P < 0.05$), an amount also resembling its in vivo colon lumen concentration. The authors concluded that slippery elm merited formal evaluation for treating inflammatory bowel disease (Langmead et al. 2002). In a preliminary report by the same researchers slippery elm at a 1 in 100 dilution inhibited ROM production in inflamed colorectal biopsies by 71% compared to controls ($P = 0.02$) (Langmead et al. 2000).

Slippery elm methanolic extract was screened for its scavenging activity against peroxynitrite using a fluorometric method (Choi et al. 2002). Peroxynitrite is a cytotoxicant that can cause lipid peroxidation, carcinogenesis, aging, and cell death. It is a strong oxidizing agent toward sulphydryl, lipid, amid acid, and nucleoside constituents in cells and has been associated with chronic inflammation of gastrointestinal mucosa (Potoka et al. 2003; Yue et al. 2001). The production of peroxynitrite was monitored in this study by measuring the oxidation of dihydrorhodamine 123 to rhodamine 123. Slippery elm was extracted with methanol for 3 days, the solvent evaporated, and the residue concentrated and dried. This extract was then dissolved in water and 10% ethanol and diluted to different concentrations. The scavenging activity of peroxynitrite by slippery elm extract was 82.34% at 5 µg/mL, fifth among the 28 herbs tested.

Potential Effects on Immunity

Evidence exists that various types of complex polysaccharides of botanical origin, including polysaccharides similar to those found in slippery elm, are able to promote immunomodulatory effect via interaction with lymphocytes in gut-associated lymphoreticular tissue (GALT) (Yamada and Kiyohara 2007). IgA receptors were found that could contribute to the uptake of polysaccharide-IgA complexes into Peyer's patches (Mantis et al. 2002). Peyer's patches are an important part of GALT and are known to be inductive sites of IgA production. The epithelium overlaying the patch contains specialized cells, called M or microfold cells, which are able to engulf food macromolecules, particles, as well as bacteria and viruses, from the intestinal lumen and present them to the lymphoid cells in the Peyer's patches (Neutra et al. 1996). After interaction with antigens, lymphocytes differentiate, mature, and enter systemic circulation (Yamada and Kiyohara 2007).

Other pectin-type polysaccharides possessing a rhamnogalacturonan backbone regions were shown to activate the complement and anticomplement systems, enhance immune complex clearance activity, exert mitogenic effect on lymphocytes, and enhance IL-6 production (Kiyohara et al. 1988, 2006; Matsumoto et al. 1993; Yamada and Kiyohara 2007). Although these studies do not illustrate the mechanism of action of slippery elm inner bark, they may provide a possible explanation for its putative therapeutic actions, which traditionally have been described as "soothing," and its apparent usefulness in the treatment of a variety of inflammatory conditions. Further research is needed to determine exactly if slippery elm possesses any systemic immunomodulatory effects.

Inhibiting Aberrant Cell Proliferation

Human Case Studies

Slippery elm helped produce significant improvements in psoriasis patients as part of an integrative approach addressing bowel function, when used together with an infusion of safflower (*Carthamus tinctorius*) and a restrictive diet (McMillin et al. 1999). To evaluate this approach

5 patients diagnosed with chronic plaque psoriasis took part in a 10-day live-in program to assess and treat psoriasis and bowel permeability according to a protocol based on Edgar Cayce's readings (Brown et al. 2004). Medication use before the study was maintained throughout. The newly instituted therapies were then continued at home for 6 months with assessments before and after this intervention measured by the Psoriasis Area and Severity Index (PASI), the Psoriasis Severity Scale (PSS), and a lactulose/mannitol test for intestinal permeability. Photographs of the lesions were also compared to assess the cosmetic impact of the program on patient appearance. Two men and 3 women ages 40-68 years old returned for the 6-month assessment.

During the 10-day program the subjects were provided a diet rich in whole grains and alkaline-forming fresh fruits and vegetables (except plants of the *Solanaceae* family), with small amounts of protein from fish and fowl and avoidance of red meat, processed foods, and refined carbohydrates, along with daily use of slippery elm bark water and safflower tea. The slippery elm water was prepared by placing "a pinch" of raw bark in a glass of cool water, allowing it to infuse for 5 minutes, and then stirring and consuming the water without straining. No information was provided regarding the frequency of use of the slippery elm water, except that it was used daily. The safflower tea was made by pouring 4 oz of boiling water over a pinch of the herb and steeping for 15 minutes; it was consumed 1/2 hour before a meal. In addition, external castor oil packs were applied over the abdomen to enhance bowel elimination, colonic irrigations further assisted elimination, and appropriate spinal adjustments were included during the 10-day program. The patients were instructed to use the castor oil packs over the next 6 months and encouraged to find local clinicians to administer further spinal adjustments and colon hydrotherapy. Maintaining the fruit and vegetable diet at home was emphasized, supplemented by slippery elm and safflower tea, together with regular elimination and a positive attitude toward healing.

In assessing the outcomes after 6 months, a reduction in the high PASI and PSS scores and lactose/mannitol ratios were primary goals that were each achieved by all 5 patients. The improvements of mean pre- to post-therapy scores for PASI were from 18.2 ± 15.0 to 8.7 ± 9.7 and for PSS were from 14.6 ± 7.8 to 5.4 ± 4.2. The change in mean pre- to post-treatment lactulose/mannitol ratios was from 0.066 ± 0.044 to 0.026 ± 0.007, with a ratio of 0.01-0.06 considered normal. The group size was considered too small for statistical analysis. The before and after photographs in the 3 more severe cases revealed changes described as "major improvement," "substantial healing," and "clearly visible improvement." In the 2 cases that were initially mild the photographic changes were assessed as "difficult to detect" and "difficult to perceive."

Since psoriasis is considered incurable and the pharmaceutical medications used in its oral or injectable treatment are potentially toxic (Tristani-Firouzi and Krueger 1998), there is a great need for a non-toxic alternative approach to help control symptoms. However, not withstanding the use of slippery elm in this study and its potential ability to soothe irritated intestinal mucosa, it is impossible to correlate the outcomes with any one of the therapies used. This highlights the inherent challenge in assessing efficacy of multidisciplinary protocols without adequate controls and also underscores the context in which many herbal medicines are utilized, as part of multi-faceted programs encompassing lifestyle, diet, stress reduction, and often a host of adjunctive therapies.

Effects on Malignant Cell Growth

Slippery elm inner bark is an important component of some commercial herbal combinations used for respiratory and alimentary conditions. Research on such formulas does not equate to its use as a stand-alone therapeutic agent, but these combinations do reflect common usage of slippery elm. Other combinations with slippery elm bark as a component include the herbal mixtures Essiac™ and Flor-Essence™ that are used in cancerous conditions. Based on the equivocal extant research on these formulas, it is not possible to determine whether slippery elm has an appreciable impact on the purported activity or the lack thereof (Tamayo et al. 2000).

In Vitro Studies

In a screening test to evaluate medicinal herbs for dose-dependent tumoricidal effects, extracts were assessed using Neuro-2α, a neuroblastoma cell line of spontaneous malignant origin (Mazzio and Soliman 2009). Extraction of the plant material was achieved using 250 mg of powder that was macerated, homogenized, and extracted for 7 days at 4 °C in 1000 µL of absolute ethanol. The extract was diluted to 10 mL with a stock solvent solution and adjusted for pH. Six serial dilutions were tested across a 1000-fold concentration gradient span with the highest set at 5 mg/mL. Slippery elm extract was found to be weak in this anticancer screen with an $LC_{50} > 5.0$ mg/mL.

Other *Ulmus* Species

Historical uses and phytochemical characteristics (containing mucilage, other polysaccharides, and flavonoids) of other species of *Ulmus* are similar to *U. rubra*. Studies with these species may provide additional insights into its use.

A study of the stem bark of *Ulmus davidiana* var. *japonica* containing the flavonoids catechin and catechin rhamnoside investigated its metal-chelating activity. Used as a tea and thickener in soup, the stem bark was used as a source of (–)-catechin (100-2000 mcg/mL) (Jung et al. 2010). At a concentration of 180 µg/mL in methanol, (–)-catechin showed moderate chelating activity of ferrous ions. It also exhibited moderate (35.8%) protective activity against DNA cleavage in Fenton's reagent at a concentration of 50 µg/mL, but was only a weak inhibitor of lipid peroxidation (12.9% inhibition at 250 µg/mL) induced by ferric chloride ($FeCl_3$).

Another group of researchers (Lee et al. 2010) investigated an ethanolic extract (70% ethanol) of *Ulmus davidiana* var. *japonica* in an ovalbumin (OVA) murine mouse model for asthma. The animals were orally administered 100 and 200 mg/kg of the extract daily 1 hour prior to OVA challenge. The extract showed a protectant effect on lung

tissue with significant reductions in allergic markers such as interleukins 4 and 5, IgE production, and reactive oxygen species. These were accompanied by marked reductions in inflammatory cell infiltration and mucus production. These researchers identified several catechins and procyanidins as constituents, while other researchers (Eom et al. 2006) reported on the presence of polysaccharide fractions made up of rhamnose, galactose, and glucose (20,000 kDa in extract). The latter group also reported the extract showed almost the same moisturizing effect as hyaluronic acid and similarly observed significant reductions in inflammation (Eom et al. 2006).

Another species of "slippery" elm (*Ulmus macrocarpa*) was used in animals by organic farmers prohibited from using conventional medications as part of organic certification programs. An unspecified elm preparation showed low to moderate anti-protozoal activity against *Toxiplasma gondii* and *Neospora caninum*. One-day-old chicks infected with *Emeria tenella* were given various herbal extracts. Survival rates, lesion scores, body weight gains, bloody diarrhea, and oocysts excretions were measured after the first and second week after infection. All birds treated with an unspecified elm preparation survived and lesion scores were lower than in untreated animals (Lans et al. 2007).

Medical Indications Supported by Traditional Use

There is an almost universal agreement in the historical American medical literature for the use of slippery elm as one of the most relied upon demulcents both for internal and external use. The preparations used internally varied between cold, warm, and hot infusions to nutritive gruels and lozenges. Externally, poultices, cataplasms, and fomentations were widely employed and continue to be used today. Demulcent properties can be greatly lessened with prolonged cooking. Thus, infusions (both cold- and hot water) provide the greatest amount of mucilage, while boiled preparations yield a greater concentration of tannins and thus may be more appropriate when the astringent tonic actions are desired.

Actions of Demulcents

Edwards and Vavasseur (1829) in their *Manual of Materia Medica and Pharmacy* provide a good synopsis of the traditional use of demulcents, the word demulcent being derived from the Latin *demulcere*, meaning *to soften*. According to this text, the actions of demulcents are to relax the tissues with which they come into contact, to lessen the tone of tissues, and "blunt their sensibilities." All demulcents are reported to possess both medicinal and nutritive properties and are generally inodorous with an insipid or sweet taste and viscous quality. The mode of action appears to be the same whether administered orally or applied externally. Demulcents soothe and relax inflamed cutaneous tissues resulting in alleviation and abate the heat, thirst, and cough that accompany mucosal inflammatory conditions. However, according to these authors, if taken for too long of a time, demulcents can result in a loss of vitality and diminished strength (Edwards and Vavasseur 1829). No modern literature reports such a precaution.

Cullen in his *Treatise of the Materia Medica* (1808) described the nature of demulcents as preventing "the actions of acrid or stimulant matters" and that, due to their viscous quality, demulcents act to prevent caustic or irritating substances from coming in contact with tissues. Noting that such viscous substances lose their effects when sufficiently diluted and that such a dilution occurs as demulcents move through the stomach and intestines, Cullen asserts that the demulcent effects are predominantly local and do not occur in the blood. However, modern studies demonstrate that plant polysaccharides may induce complex interactions with local and systemic immune tissues, rather than being purely physico-mechanical in action (e.g., see Yamada and Kiyohara 2007). This mechanism of action remains hypothetical for slippery elm mucilage until further studies are conducted.

In *Biddle's Materia Medica and Therapeutics* (Biddle 1886), demulcents are described as "medicines, which *soften* and relax the tissues, and, when applied to irritated or inflamed surfaces, diminish heat, tension, and pain." The "constitutional" effects of demulcents are described as principally nutritive, though the effects of mucilages may "to some extent relieve irritation in distant organs by modifying the acridity of the secretions." When taken internally, demulcents can be used as follows:

(1) To protect the gastrointestinal lining from the injurious effects of irritating substances, "particularly acrid poisons."
(2) To relieve irritation and inflammation of the alimentary canal as in gastritis, enteritis, diarrhea, and dysentery. For these latter purposes it can be administered orally and rectally.
(3) In catarrhal affections, likely due to the "transmission of their lubricating and soothing properties on the fauces and esophagus by reflex action to the laryngeal and bronchial membranes, and in part, by modifying the acridity of expectorated matters."
(4) In affections of the urinary passages as in "ardor urine" and cystitis.
(5) As a hydrating and nutritive tonic, chiefly due to the quantity of mucilage produced.
(6) As a light diet for the sick.
(7) For pharmaceutical purposes to suspend substances that are insoluble in water.

Externally, demulcents, prepared by mixing with water, were extensively employed for their emollient, i.e., softening, or soothing, effects as follows:

(1) To relieve the heat, swelling, and pain of inflammation.
(2) To soothe wounds and burns.
(3) To hasten suppurations where inflammation will not resolve.
(4) To cleanse foul and scabby ulcers.
(5) To promote suppuration of granulating surfaces.

When applied to healthy tissues, poultices and cataplasms promote relaxation of the tissues. When applied in the early stages of inflammation, demulcents visibly lessen

the amount of blood at the area of injured tissue and prevent stasis in the area. This is followed by improved healing that is likely due to the soothing and relaxing effects on the tissues. When used in excess, such applications can cause the tissues to become pale, too soft, lax, shriveled, and in extreme cases, devitalized (Biddle 1886).

Use of Slippery Elm by Thomsonian Practitioners, Physiomedicalists, and Domestic Physicians

According to the American ethnobotanical review of Sumner (2004), the use of slippery elm as a mucilaginous tea was common in the homes of early settlers. Internally, infusions and decoctions of slippery elm were and are primarily used in two ways: to soothe inflammation and as a nutritive tonic. For their soothing demulcent properties, slippery elm preparations are drunk for inflamed and irritated mucosae, especially of the alimentary tract, and, secondarily, for urinary passages. Most specifically, slippery elm was universally used for aphthous ulcers, gastritis, enteritis, diarrhea, and dysentery (Wood 1856).

Edwards and Vavasseur (1829) report that slippery elm was used in the Revolutionary War and specifically by the army of General Anthony Wayne (1745-1796). Poultices of the bark were applied to the wounds, "which were soon brought to suppuration and to a disposition to heal." Angier (1978), likely referring back to writings of Rafinesque, advises that Native American tribes also mashed the bark for gunshot wounds and to ease the removal of the lead. Edwards and Vavasseur (1829) go on to report on the almost daily use of slippery elm for the treatment of dysentery, diarrhea, and infantile cholera, as well as its efficacy in catarrhal affections, pneumonia, and consumption (often correlated with tuberculosis). The efficacy of slippery elm (as well as flax and other demulcents) for frostbite was also reported.

Samuel Thomson in his *System of Practice* (1833), described using 1 teaspoon of slippery elm powder with an equal part of sugar mixed well in a teacup. A little cold water was then added and stirred until "a jelly thick enough to be eaten with a spoon" was formed. This preparation was used for sore throat, stomach, and bowels caused by "canker." Additional hot water could be added and drunk freely. Thomson also reported on his use of slippery elm poultice, preparing it by mixing the powder of slippery elm bark with crackers and ginger. He described it as "the best poultice I have ever found; for burns, scalds, old sores," and "the best thing I have met with, to allay inflammation, ease the pain, and heal them in a short time."

Externally, fomentations and poultices were applied to a large variety of inflammatory conditions ranging from simple irritations to obstinate herpetic and syphilitic sores (Griffith 1847). The effects reported suggest more than a local symptomatic relief but rather local soothing with an ability to facilitate the healing process. Often, such consistency of uses is due to medical authorities repeating information uncritically. This does not appear to be the case with slippery elm as a large number of 19th century medical writers report on their own clinical experiences.

Gunn in his *Domestic Physician* (1863) described slippery elm as a nutritive, demulcent, emollient, expectorant, and diuretic, specifically recommending a cold or hot infusion for inflammations of the mucosal surfaces of the mouth, throat, lungs, stomach, bowels, and urinary organs. For these purposes, he recommended that the infusion be drunk cold. Gunn considered slippery elm to be especially good in diarrhea, dysentery, sore throat, and pleurisy, inflammation of the bladder, strangury (painful urinary obstruction), coughs, bronchitis, and other similar conditions. Gunn also preferred the fresh bark but also commented that the fine powder was very effective and could be bought in almost every drug store. To make his cold infusion, Gunn soaked a handful of bruised bark in half a gallon of water overnight to make enough for several days. As a poultice for all the previously ascribed conditions, Gunn considered slippery elm to be without equal "within the bounds of medical knowledge." For this purpose, an ounce of powder was stirred into a little hot water, or equal parts of water and milk. Alternatively, Gunn prepared a poultice by pounding the fresh bark until soft and then covering with hot water and allowing it to soak a few hours, and then thickened it with a little wheat bran; or he mixed the powder with enough water until somewhat thick and boiled it for a few minutes, recommending that the poultice be applied warm. Gunn also described his use of an "injection" (enema) of the infusion for "bloody flux" (dysentery), hemorrhoids, and other similar conditions.

According to *The Physiomedical Dispensatory* of William Cook (1869), slippery elm inner bark when chewed or chipped and macerated in cold water was used for mucosal irritations and inflammations of the bronchi, lungs, stomach, bowels, kidneys, bladder, and uterus, thus for treating pneumonia, bronchitis, gastritis, dysentery, and nephritis. Elm mucilage was used as a vehicle for any remedy administered by rectal injection, e.g., cayenne pepper (*Capsicum* spp.), ginger (*Zingiber officinale*), or lobelia (*Lobelia inflata*). Cook also described the elm as a demulcent and adhesive powder to use as a component of troches or suppositories, as well as for preparing emulsions and demulcent poultices.

Use of Slippery Elm by Eclectic Physicians

Slippery elm was featured in numerous Eclectic writings and other works of *materia medica*. Wooster Beach, the founder of the American Reformed (Eclectic) practice of medicine, classified slippery elm bark as a demulcent, diuretic, deobstruent (removes obstructions), emollient, and refrigerant (Beach 1859). Beach considered it useful in all urinary and bowel complaints, strangury, sore throats, catarrh, pneumonia, pleurisy, or inflammation of the lungs, stomach, and bowels, scurvy, scorbutic affections, herpes, and inveterate eruptions. For external use as a poultice, Beach considered slippery elm "far exceeding any other known production in the world for ulcers, tumors, swellings, chilblains, burns, cutaneous diseases, erysipelas, felons, old obstinate ulcers, and scabs." Beach used it orally as a wash for oral thrush and sore mouth and considered slippery elm to act "quickly and powerfully" as an anti-inflammatory, noting its ability to promote the resolution and suppuration of sores to facilitate a speedy healing. For these purposes, the bark was ground to a consistency of flour and applied directly to the wound, sore, or ulcer.

Table 3 **Slippery elm preparations and indications used historically**

Preparation	Indication	Instructions	References
Cold infusion	Inflammation of the mucosa; diarrhea, dysentery, sore throat, pleurisy, inflammation of the bladder, strangury, coughs, bronchitis, etc.	1 handful of bruised bark in 0.5 gallon of water.	Gunn (1863)
Sugary paste or hot beverage	Sore throat, stomach, and bowels caused by "canker."	1 tsp of powdered bark with an equal part of sugar, mixed with a little water and eaten, or drunk with extra hot water added.	Thomson (1833)
Custard	Diarrhea, dysentery, convalescent patients with inflammation of the digestive tract; children with weak digestive organs.	1 tsp of slippery elm powder, 2 tsp sugar, a pinch of cinnamon, boil in 0.5 pint of water, stirring, until a thick jelly.	King (1864)
Nutritive gruel	As a food for convalescent and consumptive patients.	1 tsp of powder mixed with sugar, cold water, and then hot water to the desired consistency.	Beach (1859)
Hot milk decoction	Prevention of bowel complaints in children recently weaned from the breast.	1 tbsp of the bark cooked in a pint of milk.	Felter and Lloyd (1905)
Poultice	A variety of inflammatory conditions from simple irritations to herpetic and syphilitic sores; to allay inflammation, ease pain, and expedite healing of burns, chilblains, cutaneous diseases, erysipelas, felons, gunshot wounds, old sores, scabs, scalds, swellings (including swollen glands), tumors, ulcers (including old and obstinate ones).	Pound the fresh bark until soft and then cover with hot water and allow to soak for a few hours; thicken with a little wheat bran if needed. Alternatively, stir 1 oz of powder (sometimes mixed with crackers and ginger) into a little hot water or equal parts of water and milk, or mix the powder with enough water until thick and boil for a few minutes. Apply warm. The powder was also applied directly to the wound, sore, or ulcer.	Beach (1859); Good (1845); Griffith (1847); Gunn (1863); Herrick (1995); Thomson (1833)

Beach also gave an account of the use of slippery elm by Native Americans (specific tribes not reported) 2-3 months prior to labor to facilitate a smooth labor. This use was also described by Herrick (1995) and Angier (1978), who noted that the slipperiness of the bark facilitated a smooth birth and expulsion of any foreign matter from the body, such as phlegm.

The noted Cincinatti Eclectics Lorenzo Elbridge Jones and John Milton Scudder classified slippery elm as an emollient, demulcent, and nutritive, disregarding many of the uses ascribed to elm by Beach (Jones and Scudder 1858). However, like Beach, Jones and Scudder write: "Among the various agents employed as emollients none surpass this for all ordinary purposes. In burns, scalds, abraded surfaces, boils, irritable and painful ulcers, wounds, painful inflammatory tumors, and indeed all cases where a soothing, softening, and relaxing application is required, none will be found to answer a better purpose." As a soothing and drawing cataplasm, the fine powder was simmered in fresh milk and used to allay inflammation and promote suppuration. Also like Beach, these authors report on its use for inflamed mucous membranes and catarrh, as well as irritated oral mucosa and as a gargle for sore tonsils and throat. Adding to Beach's indications, Jones and Scudder report on its use as a rectal injection for fistulous hemorrhoids or lavement (enema) in dysentery. Amongst its other uses, Jones and Scudder write that slippery elm is one of the best substances for acute gastritis from various causes and recommend its use in urinary tract and respiratory irritations.

In a dramatic use of mucilages, the Eclectic physician Harvey Wickes Felter recommended the use of slippery elm and flax seed, in conjunction with the use of emetics, in cases of poisoning from overdose of the Specific Medicine Oenanthe, which was made from fresh roots of hemlock water-dropwort, *Oenanthe crocata* (Felter 1927). Felter had previously (1922) explained that elm mucilage was "one of the best agents to use after poisoning by irritants, to allay the distress and protect the inflamed tissues." Felter and Lloyd (1905), however, noted earlier that "Notwithstanding its general value as an application to ulcers, it will often be found injurious, especially when used as a cataplasm to ulcers of the limbs, rendering the ulcer more irritable and difficult to heal, and frequently converting a simple sore… into an almost intractable ulcer; much care is, therefore, required in the application of this bark externally."

In addition to its use as a topical anti-inflammatory, Lloyd (1921) reported that early settlers relied on a "cold decoction" of slippery elm as a soothing drink in fevers, noting that it had been learned from Native Americans. Earlier, Lloyd (1889) had specified that the bark "should be stripped fresh from the tree, torn into shreds and suspended in cold water in order to produce the soothing, cooling, mucilaginous drink that is so refreshing to feverish patients. Its richness depends on its freshness. Each day this infusion should be prepared anew, and the vessel containing it should be kept in a cold situation, and outside of the sick room to avoid absorption of foul exhalations." Slippery elm also became widely used by domestic practitioners for the treatment of

diarrhea associated with fever.

Use as a Nutritive Tonic

Various species of elm have been used historically in form of a tea, broth, or gruel as a nutritive tonic, especially for infants, invalids, and convalescent patients and when other foods could not be retained in the stomach. One of the earliest reports of this use is found in the French work of Edwards and Vavasseur (1829). These authors report on the common use of pulverized elm bark boiled with water or milk as a nutritive tonic for children with diarrhea and dysentery. According to this translation, a Dr. Joseph Strong of Philadelphia who served as a surgeon in the Western Army recounted a story of a lost soldier who survived in the woods on slippery elm bark and sassafras mucilage for 10 days.

The Eclectics routinely employed slippery elm as a nutriment. Beach (1859) considered slippery elm superior to arrowroot (*Maranta arundinacea*), stating that a teaspoon of the flour first mixed with a little sugar, cold water, and then hot water to the desired consistency, was very nutritious for convalescent and consumptive patients. Jones and Scudder (1858) reported: "Its nutritive qualities are so great, that it is capable of sustaining life in the absence of other means."

John King, in his *The American Family Physician* (1864), provided a recipe for "slippery elm custard" instructing that 2 teaspoons of sugar, 1 teaspoon of slippery elm, finely powdered, and a pinch of cinnamon were to be boiled in 1/2 pint of water, stirring for a few minutes until a thick jelly formed. The resulting jelly was used in those with diarrhea, dysentery, and in convalescents from inflammation of the stomach and bowels, as well as in consumptives and children with weak digestive organs. King further wrote of slippery elm: "It possesses nutritive, expectorant, diuretic, demulcent, and emollient properties. As a diuretic and demulcent it is valuable in all mucus inflammations of the lungs, stomach, bowels, bladder, or kidneys. It is used in the form of a mucilaginous drink, taken freely; coughs, strangury, etc. are benefited by its use and it is useful in preventing summer-complaint of infants. As an injection, the cold infusion is valuable in diarrhea, dysentery, tenesmus, piles, gonorrhea, and gleet. The powdered bark sprinkled on the surface of the body will prevent and heal excoriations and chafings and allay the heat of erysipelas."

Felter and Lloyd (1905), in *King's American Dispensatory* recommended a tablespoon of the powdered bark cooked in a pint of milk as a "nourishing diet for infants weaned from the breast, preventing the bowel complaints to which they are subject, and rendering them fat and healthy." In 1931, Grieve noted that the "gruel forms a wholesome and sustaining food for infants and invalids. It forms the basis of many patent foods." For these same purposes, the powdered bark was also mixed with honey or maple syrup and a little cinnamon or nutmeg (Angier 1978; Grieve 1931).

An English medical herbalist, John G. Hatfield, recommended taking slippery elm for catarrhal complaints as a food, prepared similarly to arrowroot. Additionally, Hatfield documented the use of aqueous decoctions of the sliced inner bark and/or aqueous or cow's milk infusions of the powdered inner bark of slippery elm for treatment of diarrhea, dysentery, debility of the uterine system, and uterine discharges. He classified this dietary form of slippery elm bark as tonic and expectorant, employed not only in consumption, but in inflammation of the lungs, pleuritis, bronchitis, and aphthous sore mouth, or thrush, of infants (Hatfield 1886).

Other Medical and Historical Uses

Other uses reported in the late 19th to early 20th centuries include preparations of the fresh bark whittled into the shape of tents for the dilation of fistulae, strictures, and the os uteri; and the powder for the preparation of vaginal and rectal suppositories (Culbreth 1917; Remington et al. 1918; Stillé et al. 1896).

Detailed descriptions regarding the use of the slippery elm for cervical, vaginal, and uterine dilation can be found, e.g., in the *Manual of Gynecology* by Byford (1902). In cases where the cervix was too small and a flexible "bougie" could not be passed without causing excessive pain, a small conical "tent" was whittled out of a thick piece of slippery elm bark. Prior to insertion, the "tent" was dipped for a few seconds in a 5% solution of carbolic acid both as an antiseptic and to soften so that it could be bent in the appropriate angle for insertion, and inserted for 2-3 minutes when lubrication of the bark was sufficient. If necessary, this was followed by progressively larger "tents" 2-3 times, or until different instrumentation could be used. It was noted that the strictest antiseptic precautions must be observed in probing the uterus. The patient was instructed to take a copious douche before treatment. The attending surgeon was instructed to thoroughly swab the vagina and cervix prior to dilatation and adhere to the strictest of antiseptic practices when preparing and handling the "tent" (Byford 1902). Slippery elm "tents" were used for the treatment of "puerile uterus", an abnormally small vagina, cervical canal, and uterus. The "tents" were to be used at home by the patient 2-3 times weekly with antiseptic precautions. Each "tent" was to be left in for 10-12 hours. This treatment was considered to be beneficial in cases of moderate deformity. The "tent" was withdrawn by the patient by means of an attached string and immediately followed by a sterile douche. Slippery elm bark dilators were also used as a way to apply other medications (e.g., iodized phenol) to the mucous membranes of the uterine and cervical walls (Tuckerman 1881).

In addition to the above medical uses, slippery elm has had utility as a preservative, stemming from the Omaha use of the bark to render buffalo fat tallow. This was described by a Dr. Charles Wright in the *American Journal of Pharmacy* (1852) as a preservative in ointments and salves (cerates). Dr. Wright states that heating fatty substances for several minutes with slippery elm bark in the proportion of 1 drachm to 1 pound of fat (ratio 1:125) reduces their potential for rancidity thus allowing for the prolonged storage. Wright experimented by doing this with several other oils, all with reported success, including a claim of preparing butter in this manner, which was then preserved for 1 year despite the butter's constant exposure to air, heat, and light.

Use of Slippery Elm by Modern Herbalists

Naturae Medicina and Naturopathic Dispensatory (Kuts-Cheraux 1953) recommends the infusion of slippery elm bark for all kinds of inflammations of the gastrointestinal tract (stomatitis, pharyngitis, esophagitis, gastritis, and enteritis), including those caused by corrosive substances, and as an irrigation for vaginitis and proctitis. Topically the mucilage is used for dermal and subdermal inflammations, such as eczema, poison ivy, hemorrhoids, and fissures. As a colonic irrigation in diarrhea, dysentery, and ulcerative colitis, it is mixed with barley (*Hordeum vulgare*) water and goldenseal (*Hydrastis canadensis*), barberry (*Berberis vulgaris*), or rhatany (*Krameria* spp.). In addition to these uses, the noted naturopathic physician John Bastyr also mixed slippery elm with lobelia (*Lobelia inflata*) and echinacea (*Echinacea* spp.) to use as a cataplasm for drawing out suppurations (Mitchell 2003).

In the current herbal literature (e.g., Hoffmann 2003; Mills and Bone 2000; Priest and Priest 1982; Weiss 1988), demulcents are reported to be employed clinically in a manner that is consistent with traditional uses. Internally, they are used for a number of mucosal conditions: respiratory diseases such as dry cough, acute or chronic bronchitis, whooping cough, emphysema, sore throat, and to ease coughing by soothing bronchial tension; irritation of the alimentary tract, protection of the intestinal mucosa from gastric acids, to help heal gastritis and gastric ulcers, and to prevent and treat diarrhea; and to relax painful spasms in the bladder and urinary systems. Topically, demulcents are used as emollients for dry skin conditions and burns and as cataplasms for drawing out suppurations.

Slippery elm lozenges are reported to be beneficial for oral mucositis (Snow 2011, personal communication to AHP, unreferenced) and are recommended for the treatment of reflux in pregnancy (Romm 1997). Additionally, slippery elm is the primary ingredient in a laxative protocol for infants and young children (Romm 2000). According to Angier (1978), people of Appalachia have used the powdered inner bark as the base for suppositories, vaginal douches, and enemas, a practice that remains today. As an enema, the decoction was combined with a "nutritive oil" and warm milk. Yance (1999) recommends slippery elm for the treatment of ulcers, diverticulitis, inflammation of any internal tissues, hemorrhoids, irritable bowel syndrome, constipation, diarrhea, and for various lung conditions, as well as to counter the effects of radiation treatment of cancers of the respiratory and digestive systems.

Conclusion

In summary, the formal clinical and preclinical data on slippery elm is sparse. What human data there is provides some support for the use of slippery elm in conjunction with other demulcents for sore throat and cough, as part of a natural medicine protocol in the treatment of psoriasis, and for irritable bowel syndrome.

The predominant utilization of slippery elm as a demulcent comes from extensive historical medical literature that supports its use for a wide range of internal applications where a soothing demulcent is indicated, in irritated and inflamed mucous membranes and tissues. Specifically, when used internally as a cold or hot infusion, slippery elm is considered as a primary therapy for inflammations of the alimentary, respiratory, and urinary systems. Based on historical and current use by medical herbalists, there is a belief that mucilage is beneficial in the treatment of diarrhea due to inflammation and irritation by soothing irritated tissues, absorbing irritating compounds, and likely providing nourishment for beneficial intestinal bacteria. However, a single study on diarrhea associated with irritable bowel syndrome found no change in stool consistency and an actual increase in the number of daily bowel movements after administration of slippery elm as part of an herbal preparation. At the same time, the majority of the patients reported that they experienced adequate relief from their diarrhea during the study. More studies are needed to precisely determine the level of benefit of slippery elm for diarrhea.

The traditional literature also provides strong support for the use of slippery elm as a nourishing tea, gruel, or food additive, especially useful in wasting syndromes, convalescing patients, and infants with digestive disturbances. Among modern herbalists, slippery elm continues to be used as a primary demulcent for many of the conditions for which it was historically used.

Externally, the poultice and fomentation were routinely considered among the best of demulcent applications for a wide variety of skin inflammations, burns, and even gouty arthritis and frostbite. Additionally, slippery elm was a featured ingredient in suppositories.

Actions

Anti-diarrheal, anti-inflammatory (locally, topically, and systemically), antioxidant, antitussive, demulcent, emollient, expectorant, laxative, nutritive, prebiotic.

Indications

Slippery elm inner bark or its aqueous preparations are used locally to soothe irritations and inflammations of the skin or mucous membranes of the upper respiratory and digestive tracts. Pharyngitis with associated soreness on swallowing can be temporarily relieved with use of infusions, and a dry, irritable cough can be diminished. As a nutritive tonic, slippery elm aqueous preparations and gruels are easy to digest and are considered specific for convalescing patients and infants with digestive disturbances.

Substantiated Structure and Function Statement

Slippery elm inner bark soothes and moistens tissues and mucous membranes by providing a viscous coating of mucilage when used locally and soothes and moistens tissues when consumed orally. Slippery elm has been shown to have antioxidant activity in vitro.

Dosages

Powder:

1-4 g (~ 1 tsp to 1 tbsp).

Cold or hot infusion:

Approximately 120 mL (~ ½ cup), 3 times daily drunk freely; taken by sips if for pharyngitis.

Lozenges:

200-300 mg of the bark powder per dose.

Safety Profile

There are no formal toxicological studies on slippery elm or its preparations. There is, however, a very long history of safe use of *U. rubra*, as well as other species of elm, worldwide. Traditionally, slippery elm inner bark has been used as a food-like herb and its constituent profile, consisting primarily of polysaccharidic mucilage and small amounts of flavonoids (catechins and procyanidins), supports such use. There are numerous botanicals containing the same constituents in higher amounts that are similarly regarded as food-safe botanicals (e.g., green tea and bilberry). Additionally, elm is presently a Generally Recognized As Safe and Effective (GRASE) active drug ingredient (demulcent) (FDA 1991).

Adverse Reactions

Reports of adverse events in the modern herbal or medical literature associated with slippery elm when taken internally or applied topically are rare. There are at least two case reports of attempted vaginal insertion of strips of slippery elm bark resulting in bladder calculus due to pieces of the bark entering the bladder (Williams 1954).

According to historical authors, taken for too long of a time, demulcents can result in a loss of vitality and diminished strength (Biddle 1886; Edwards and Vavasseur 1829), however, there is no modern evidence to support this assertion. The Eclectic physicians Felter and Lloyd (1905) reported that external application of slippery elm cataplasm can inhibit the healing of "ulcers of the limbs," possibly referring to ulcers for which astringent tonics would be indicated rather than emollients.

Two mild adverse events were observed in the study by Hawrelak and Myers (2010) on the use of slippery elm-containing preparations in subjects with irritable bowel syndrome (IBS) (see Therapeutics). Both events happened in participants with diarrhea-predominant or alternating bowel habit IBS (DA-IBS). One of the individuals experienced occasional nausea immediately following the intake of the preparation, while the other noted that the preparation was making her stool too hard. However, since this formula contained the astringents agrimony, cinnamon, and bilberries, the stool hardening and possibly the nausea are more likely due to these ingredients.

Interactions

There are no reports of slippery elm interacting with any medication. Due to its rich content of mucilage, concerns have been raised that slippery elm may interfere with drug absorption (e.g., Brinker 2010; MSKCC 2010; UMMC 2006). This is largely a theoretical rather than an actual concern (Gardner et al. 2011). However, since slippery elm mucilage shares structural similarities with pectin (see Constituents), known interactions between pectin and other substances may also be applicable to slippery elm preparations.

Pectin has been shown to delay gastric emptying and have varying effects on the rate of absorption of pharmaceutical drugs and certain nutrients when administered simultaneously. In one study (Holt et al. 1979), researchers administered orange juice with added paracetamol (acetaminophen), with and without pectin (10 g) and guar gum (16 g), to 14 healthy volunteers. The transition of food through the alimentary tract was tracked with the chelate of Indium-113m and diethylene triamine pentaacetic acid (^{113m}In-DTPA), a non-absorbable marker. Administration of the fibers reduced the relative amount emptied from the stomach 30 minutes after ingestion from 53.9% to 31.9% ($P < 0.005$) and increased gastric emptying half-time from 23.1 min ± 5.5 min to 49.9 min ± 15.2 min ($P < 0.0025$). The peak plasma concentrations of paracetamol were lowered by the ingestion of fibers from 19.7 μg/mL to 12.6 μg/mL ($P < 0.0025$), and there was a reduction in the urinary recovery of the drug 2 hours after the administration (8.8% vs. 13.4%, $P < 0.05$). However, no reduction in drug absorption that could not be explained by the diminished rate of gastric emptying was observed, and the 24-hour urinary recovery was not significantly different from the control.

According to a brief report by Richter et al. (1991), the experimental addition of pectin (15 g) to the daily diets of patients taking lovastatin significantly increased their levels of low density lipoprotein (LDL) cholesterol. After discontinuing the fiber regimen, the cholesterol returned to initial levels. It is not known if the effect was due to changes in absorption of the drug.

The effect of various types of dietary fiber, including pectin, on the absorption of β-carotene, lycopene, lutein, canthaxanthin, and α-tocopherol, administered with a meal, in women was studied by Riedl et al. (1999). Six young (26-29 years old), non-pregnant women were given a balanced standard meal with or without added fiber and a supplement. Blood samples were collected at multiple time-points for the next 24 h. Levels of the antioxidants in blood plasma were determined by HPLC. Pectin decreased plasma levels of β-carotene, lutein, and lycopene by 40-42% ($P < 0.05$) during 24 hours after the experimental meal. There were significant interindividual variations in the absorption levels, especially in the case of β-carotene. Canthaxanthin and α-tocopherol levels were not significantly affected.

Based on the review of the absorption studies, taking slippery elm 60-90 minutes before a medication or a meal should obviate most risks of affecting drug or nutrient absorption.

Reproductive and Developmental Effects

There are no formal reports on the safety of oral consumption of slippery elm in pregnancy. Slippery elm is used by some herbalists for reduction of heartburn in pregnant women (Romm 1997). Due to its widespread use as a food, its benign constituent profile, and long history of safe use, there is no rationale for avoiding ingestion of slippery elm and its preparations in pregnancy or while breastfeeding (Kemper et al. 2005).

Some popular sources (e.g., Drugs.com 2010; Wikipedia 2010) report that slippery elm is abortifacient. However, this warning is inappropriately applied to oral ingestion. This reputation of slippery elm was a result of the practice of vaginal insertion of slippery elm branches and sticks to mechanically induce abortion, which resulted in fatalities due to hemorrhage caused by perforated uterus (Hanson 2003) or bacterial infection (Romalis 2008). The exact number of deaths, however, is not known, as many doctors would list appendicitis or peritonitis, instead of abortion, as the cause of death (Hanson 2003). This use has led to the development of legal restrictions on the availability of slippery elm sticks and whole bark in retail commerce, e.g., in the United Kingdom (MHRA 2005). Additionally, some Native American nations (e.g., Cherokee), believed that the slippery quality of the mucilage helped facilitate the smooth delivery of a baby, which could lead some to mistakenly imply an abortifacient activity.

Carcinogenicity

There are no reports of carcinogenicity of slippery elm.

Toxicology

There are no toxicology reports on slippery elm. The ubiquitous nature of the primary constituents of slippery elm (polysaccharides, flavonoids) suggests that no toxicological concerns exist.

Contraindications

None reported.

Precautions

None noted.

Lactation

There is no indication that slippery elm needs to be avoided in lactation.

Influence on Driving

No negative effects of using slippery elm when driving are to be expected.

Overdose

There are no reports of overdose with slippery elm and it appears to be a very safe herb even when consumed as part of the diet (e.g., Felter and Lloyd 1905; Jones and Scudder 1858).

Treatment of Overdose

No information is available.

Classification of the American Herbal Products Association

The forthcoming revision of the *Botanical Safety Handbook* currently proposes a safety classification of 1 (Herbs that can be safely consumed when used appropriately) and an interaction classification of A (Herbs for which no clinically relevant interactions are expected) for slippery elm inner bark. The *Handbook* also provides a Notice for mucilage content and its accompanying cautions with mucilages in general, such as consuming with adequate amounts of water (8 ounces) (Gardner et al. 2011).

Conclusion

Slippery elm is considered to be a very safe herb by the overwhelming majority of past and modern herbal medicine practitioners, supported by the preponderance of data regarding its constituents. It is eaten as gruel and in this regard is considered to be food-safe. Due to its mucilaginous character the same precautions as is appropriate for all mucilages should be applied including the potential for mucilages to interfere with absorption and the need to consume adequate liquid when taking them. Fatalities have occurred in women attempting to self-abort through vaginal insertion of strips of the bark. This is not a recommended practice. There are no concerns regarding the internal ingestion of slippery elm or its topical application.

International Status

United States

Slippery elm bark is regulated as an active ingredient of oral demulcent over-the-counter (OTC) drug products for human use (FDA 1991, 2010). OTC drug products do not require pre-marketing authorization but the finished product must be registered annually with the Food and Drug Administration (FDA). **Quality:** Compliance with a *United States Pharmacopeia* (USP) monograph is mandatory for all FDA-approved drugs. The active ingredient should comply with the specifications outlined in the Elm USP monograph (USP 34-NF 29 2010). **Action:** Oral demulcent (FDA 1991). **Indications:** 10-15% elm bark in a solid dosage form (agar or water-soluble gum base lozenge): For temporary relief of minor discomfort and protection of irritated areas in sore mouth and sore throat (FDA 1991). Slippery elm preparations may also be labeled and marketed as dietary supplement products (USC 1994), requiring FDA notification and substantiation to support permissible structure/function claim statements. While slippery elm dietary supplement products may not be labeled for relief of sore throat, which is classified as a disease, the supplements may be labeled and marketed for relief of occasional mild heartburn or occasional indigestion because these are not classified as diseases.

Australia

Slippery elm is a substance that may be used as an active ingredient in 'Listed' medicines in the Australian Register of Therapeutic Goods (ARTG) for supply in Australia (TGA 2007). **Quality:** For active ingredients of listed medicines, the quality standards of the *British Pharmacopoeia* (BP) are the minimum standard that must be applied in its entirety (TGA 2006). The monographs of the *European Pharmacopoeia* (PhEur) and *United States Pharmacopeia* (USP), respectively, have also been adopted as additional default standards under the Therapeutic Goods Act (PCA 2009). **Standard indications:** Various slippery elm monopreparations have been granted marketing authorization with approved indications including, among others, slippery elm powder 400 mg in capsules or tablets for oral administration for: (1) the symptomatic relief of heartburn; (2) relief of the symptoms/pain/discomfort of gastritis (TGA 2004); and (3) to help maintain healthy digestive function (TGA 2010). Various poly-preparations, that contain slippery elm bark as one of the active ingredients, have also received marketing authorization. For example, a capsule product containing slippery elm stem bark powder in combination with marshmallow root powder, papaya fruit powder, and dry extract of gentian root, for relief or treatment of diarrhea (TGA 2008).

Canada

Slippery elm bark is regulated as an active ingredient of Natural Health Products (NHPs) requiring pre-marketing authorization and issuance of a product license for over-the-counter (OTC) human use. It is also a Category IV demulcent drug listed in the monograph for throat lozenges (HC 1995). **Quality:** The finished product must comply with the minimum specifications outlined in the current NHPD Compendium of Monographs (NHPD 2007a). For active ingredient specifications, pharmacopoeial standards currently accepted by the NHPD are the *British Pharmacopoeia* (BP), *European Pharmacopoeia* (PhEur), and *United States Pharmacopeia* (USP) (NHPD 2007b). The active ingredient should comply with the specifications outlined in the Elm monograph published in the *United States Pharmacopeia* (USP 34-NF29 2010). **Indications:** Throat lozenges (concentration: 10-15%; 200-300 mg powder per dose) are allowed to be used as a demulcent/emollient for the temporary relief of irritated or sore throat (HC 1995; NHPD 2010a). Capsules (400 mg powder per capsule) are allowed to be used as a demulcent for soothing the stomach (NHPD 2009). Various poly-preparations, that contain slippery elm bark as one of the active ingredients, have also received marketing authorization. For example: an herbal tea infusion product containing slippery elm bark in combination with licorice root, wild cherry bark, bitter fennel fruit, and marshmallow root for "temporary relief of minor throat irritations" (NHPD 2007c) and a tincture of slippery elm bark (1:1.6) with marshmallow root (1:0.8), "traditionally used in Herbal Medicine to relieve minor irritations of the digestive tract" (NHPD 2010b).

European Community

Regulated as an active ingredient of Traditional Herbal Medicinal Products (THMPs) requiring pre-marketing authorization and product registration (EPCEU 2004). **Quality:** Herbal medicinal products must be composed of pharmacopoeial quality active ingredients. Because there is no *European Pharmacopoeia* monograph for slippery elm, the monograph of the *United States Pharmacopeia* may be used for the active substance specification. **Indications:** Product-specific indications depending on the levels of evidence submitted by the applicant in its traditional herbal registration application.

United Kingdom

Slippery elm powdered bark is a General Sale List (GSL) medicine appearing on List B ("Substances, which are present in authorized medicines for general sale") (MHRA 2009). Traditional Herbal Medicinal Products (THMPs) containing slippery elm bark as an active ingredient require pre-marketing authorization and registration through the Medicines and Healthcare products Regulatory Agency (MHRA). **Indications:** Various slippery elm preparations have been granted marketing authorization with approved indications including, among others, slippery elm powder (400 mg in capsules or tablets) for oral administration as "A herbal remedy traditionally used for indigestion, dyspepsia, heartburn and flatulence" (PHM 2007).

Note: The whole bark, however, is subject to the controls of legal category SI 2130, Part I (The Medicines: Retail Sale or Supply of Herbal Remedies, Order 1977), meaning that it can only be sold in premises, which are registered pharmacies, and by or under the supervision of a pharmacist (MHRA 2005).

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Slippery elm (*Ulmus rubra*)
Source: Sargent, *The Silva of North America* (1891-1902).

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