POKEWEED

(Phytolacca americana): Possible Source of a Molluscicide

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COVER PHOTO—Birds like the attractive purple fruits of pokeweed, which have been used in Appalachia for a wide variety of home remedies.

MOLLUSCICIDAL PROPERTIES

POKEWEED, A PLANT ABUNDANT in Appalachia, exhibits some chemical similarities to a related species that has shown molluscicidal properties. Because this suggests that pokeweed, *Phytolacca americana* L. (*P. decandra* L.), has potential for controlling fresh-water snails, we have compiled this report of its chemical composition, uses, propagation methods, and other potentially useful species of the genus *Phytolacca.*

The related species, *Phytolacca dodencandra* L'Her, was found to be the source of a molluscicide, which could play an important role in control of bilharziasis, a parasitic disease of humans widespread in Puerto Rico, Africa, and other tropical areas *(22).*

Dead snails and small fish were observed in waterways in areas of Ethiopia where people washed their clothes with this *Phytolacca's* fruit, which is rich in saponins. Some distance downstream and immediately upstream from the washing places, abundant live snails were present, suggesting that the fruit contained a toxin acting as a molluscicide. This was subsequently confirmed by laboratory tests; tap-water extracts of the dried and powdered fruit had an LC_{100} (lethal concentration) of 10 parts per million against snails (*Biomphalaria, Bulinus,* and *Lymnea* spp.) after 24-hour exposure at 23°C. Furthermore, it was shown that molluscicidal potency was not affected by the presence of soil or vegetable matter, an important factor when the molluscicide is used under natural conditions.

BOTANY

The family *Phytolaccaceae* consists of about 17 genera and 125 species of herbs, shrubs, vines, and trees, occurring in the tropics, subtropics, and temperate zones.

Pokeweed is the most widely distributed member of the family native to this country. It is a strong-smelling branching plant that may reach a height of 9 feet, with leaves 4 to 12 inches long. Pokeweed is also known as pokeberry, American nightshade, cancer jalap, cancerroot, chongras, coakum, cocum, cokan, common pokeberry, crowberry, garget, inkberry, jalap, pigeonberry, pocan, pocan bush, poke, pokeroot, red-ink plant, redwood, scoke, skoke, and Virginia poke *(11)*.

The flowers are greenish white to purplish, about 1/4 inch wide, and appear on the vertical stalk in terminal racemes. The dark purplish berries (cover) are attached to the stalk by a short stem. The plant is found in fields, damp woods, roadsides, and strip-mined areas from Maine to Minnesota; south to the Gulf of Mexico and Texas; in Hawaii; and in parts of Europe.

Krochmal *(12)* has demonstrated that pokeweed seed coats are impermeable. Fresh or stored unscarified seeds failed to germinate: scarified seeds, fresh or stored 1 year, germinated.

CHEMISTRY

The roots of pokeweed (fig. 1) were mentioned in early American medicine as the source of a powerful drug, which in small doses was thought useful for the treatment of ulcers and skin disorders *(5)*. Toxic effects were noted with large doses. Much of the early literature has been summarized by Jenkins *(9)*, who also performed the first systematic chemical study of the plant. A pungent-smelling essential oil and an uncharacterized fraction giving positive alkaloid tests were the main organic extractives of interest.

In 1936, Goldstein and Jenkins *(6)* isolated and identified an unsaturated sterol, $C_{23}H_{40}O$, and a triterpenol, $C_{30}H_{50}O$, from the chloroform-extracted non-volatile oil of the roots. Several fatty acids were present as esters.

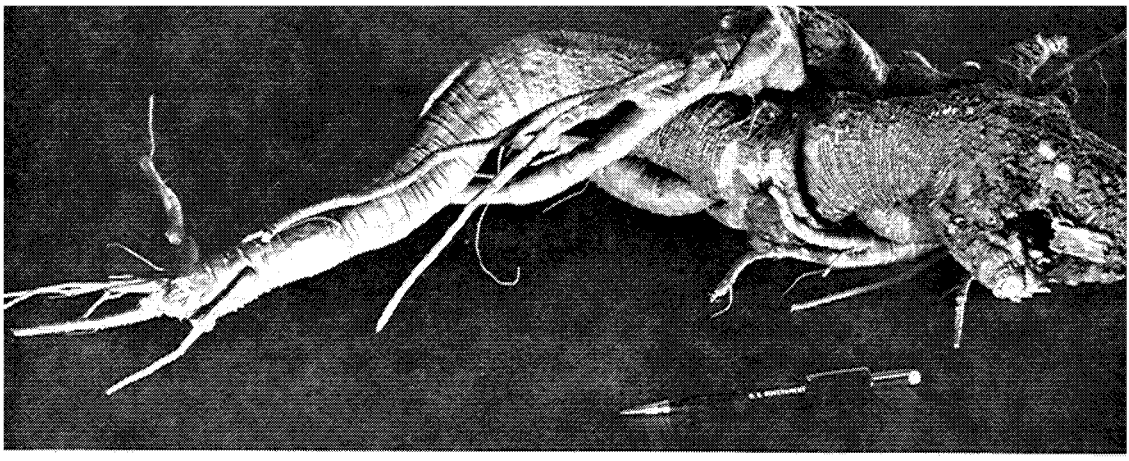
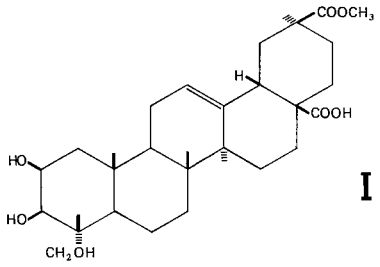


Figure 1.—Roots of Pokeweed.

In 1949, Jenkins and his co-workers *(1)* reported a more thorough search for alkaloid constituents, with only negative results; but the presence of starch, gum, oxalates, potassium nitrate in considerable quantities, hemicelluloses, and the toxic saponin was established. The physiological properties of this compound, which is characterized by melting point (m.p.) 212°F. (decomposition) and empirical formula $C_{55}H_{90}O_{22} \cdot 2H_2O$ $[\alpha]_D^{25}$ + 46°F. ethyl alcohol, showed that it is responsible for the medicinal properties of the roots. It has a strong hemolytic action, is toxic to protozoa and fish, is strongly irritant to the gastrointestinal and respiratory tracts, and depresses circulation and respiration in rabbits. A second compound, melting point 159-162°F., $C_9H_{17}O_4$, was also obtained. It was physiologically inactive.

In 1964, Stout, Malofsky, and Stout *(19)* described a further extraction of the toxic compound from pokeweed roots, and named it phytolaccatoxin. Acid hydrolysis of this compound gave glucose and xylose. A sapogenin named phytolaccagenin, melting point 317-318°F. (decomposition), $C_{31}H_{48}O_7$, was identified by paper chromatography. This compound was investigated by X-ray chrystallography, which showed the structure to be that shown in fig. 2 (I). This highly oxygenated structure is characteristic of several physiologically active triterpenoids discovered in recent years. Also, it is closely related to the well known oleanic acid shown in fig. 2 (II). This compound has



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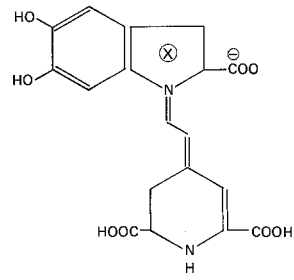

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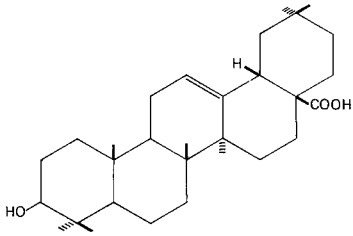


II

Figure 2.—Structures of (I) phytolaccagenin, (II) oleanic acid, and (III) betanin.

been identified as the aglycone of a powerful molluscicidal saponin isolated from *Phytolacca dodecandra.*

The purple color of the berries of pokeweed is due to the pigment betanin (fig. 2 (III)), which is commonly found in many plants of the family Centrospermae *(17).*

A mitogenic substance has been reported in pokeweed *(3,4)* and is being investigated at the National Institute of Health.

TOXIC PROPERTIES

The root is the most poisonous part of the plant, and most serious illnesses attributed to pokeweed result from the mistaking of roots for parsnips or horseradish *(13).*

An alcohol extract of the root yielded a resin-like material, which acted as a powerful depressant to the central nervous system and was fatal to cats in doses of 50 mg. per kilo body weight *(7).*

An aqueous extract containing a saponin was a topical irritant and emetic *(7).*

Cats vomited violently when 5 to 10 ml. of fluid-extract was administered; 4 ml. of fluid-extract, alcohol-free, stopped heart beat and respiration *(14)*.

Poisoning symptoms include vomiting 1 to 2 hours after ingestion, often without pain or spasm; drowsiness; dizziness; and poor vision *(13)*. In extreme cases, the toxin can cause convulsions and death due to paralysis of the respiratory organs *(15)*.

The berries are relatively nontoxic and have been used in pies without adverse reactions. Nevertheless, uncooked berries may possess sufficient toxin to affect children.

USES

In the 24th edition of the DISPENSATORY OF THE UNITED STATES OF AMERICA *(16)*, the definition of *Phytolacca* is the "dried root of *P. americana*", and for medicinal purposes that is the most commonly used part. It has been used in the treatment of parasitic skin diseases and chronic rheumatism. The fruit juice reportedly has been used to treat tremors, cancer, and hemorrhoids; and as a diuretic *(10)* alternative, emetic, and purgative *(20)*.

In certain sections of the southeastern United States, the sprouts and stems are boiled and eaten after discarding the water. These cooked greens are known colloquially as sallets (salads). Newcomers to Appalachia have sometimes prepared salads from overly mature pokeweed, precipitating cases of moderate to severe poisoning.

In Appalachia, a wine made of ripe fresh pokeweed berries has been used for the treatment of rheumatism.

In the Pennsylvania Dutch regions, the berries were used to make ink and to color wines *(23)*. The plant is believed to have mild laxative qualities.

Although rarely prescribed in the United Kingdom, it is considered to be mildly narcotic, emetic, and purgative and has been prescribed to treat rheumatism *(21)*.

In Spain, a pomade made of the roots is used to treat skin eruptions, skin rash, and ringworm *(18)*. The fruit is used as a purgative and emetic.

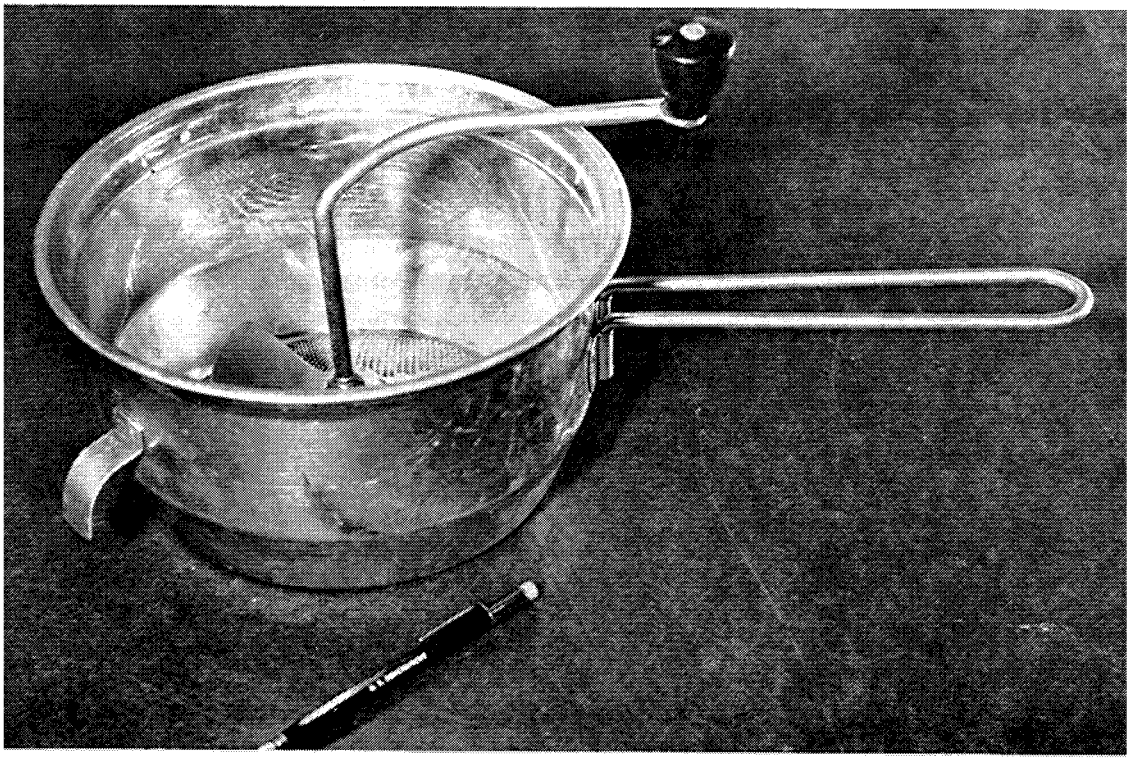
EXTRACTING JUICE FROM BERRIES

Saponin-containing plants and plant parts are not easy to work with, because separation methods are tedious and cumbersome because of the viscous nature of the saponins.

To obtain juice for analyses, we used a hand-operated mechanical colander (fig. 3). In the first pressings, the juice flowed freely; but towards the end, we found increasing quantities of saponins adhering to the seeds.

As this sticky material was pressed from the seeds, we removed it from the underside of the screen with a rubber spatula. The liquid was then put into triple plastic refrigerator bags and was frozen for subsequent analyses.

Figure 3.—Colander used in extracting juice from pokeweed berries.



OTHER POTENTIALLY USEFUL SPECIES

P. acinosa **Roxb.**—Tropical Asia, China, Japan, and Himalayas. Cultivated in some parts of India. The berries are used in Chinese medical practice, and the boiled leaves are eaten as a vegetable. During the middle 1800's, it was grown in Germany, and eaten as a vegetable *(8)*.

P. chilensis **Miers. Carmin.**—Chile. The berries are used as a dye *(22)*.

P. dodecandra **L. (*P. abyssinica* Hoffm.)**—Ethiopia, Guinea, and other areas of Africa. Believed to exhibit molluscicidal properties in Ethiopia. Young leaves are eaten *(2)*.

P. octandra **L.**—Mexico, Guinea, and Jamaica. Green fruits are used to make suds for washing clothes. Parts of the plant are used in Sonora and Baja California, Mexico, to treat rabies. It has been cultivated in home gardens in Jamaica. It is eaten in China *(8,15)*.

P. rivinoides **L. Kunt, and Bouche.**—South and Central America. Roots used as a soap substitute. The cooked leaves and shoots are eaten as a vegetable in some areas *(22)*.

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