

their arrangement and cell characteristics, must correspond somewhat to the imaginary piece of apparatus.

In other words, there are in the phloem two sets of alternating bands, one composed of larger and thinner walled cells, which will shrink more upon drying, than the second set, composed of narrow tangentially elongated and thicker walled cells which will resist shrinking and will, therefore, be subjected to the pull of the cells of the first set and as with the metal, a ridge will result.

The bands are more pronounced in some roots than in others, some showing practically no trace of them. Likewise, some roots form prominent keels, others do not.

In concluding, the author wishes to acknowledge the many valuable suggestions given by Professor E. H. Wirth, of the Department of Pharmacognosy, during the progress of this work.

---

### THE HISTOLOGY OF *CRACCA VIRGINIANA* LINNÉ ROOT.\*<sup>1</sup>

BY B. V. CHRISTENSEN<sup>2</sup> AND ELBERT VOSS.

*Cracca virginiana*, Linné, root (Leguminosæ—devil's shoestring, goat's rue, catgut, etc.) has recently come into special prominence following the discovery of its insecticidal properties by Little (1), and the isolation of rotenone and tephrosin from the root by Clark (2). The fact that commercial samples of rotenone are at present limited to foreign sources, being obtained only from derris and cube roots, makes it highly desirable to develop a native source yielding an abundance of this insecticidal material. The United States Department of Agriculture, Bureau of Plant Industry, is at present making an extended study of *Cracca virginiana* root, with the hope of finding varieties of it which may be of insecticidal value or of value as commercial sources of rotenone. Many samples have been collected by the author from the Southeastern United States, and others in other sections, and sent to the department for tests of their insecticidal value and rotenone-yielding qualities. Through these tests there is being accumulated a large amount of information as to localities, soil types and varieties of the root yielding the best quality of crude drug.

Should the findings of the Department of Agriculture confirm the hope that *Cracca virginiana* root offers an American source for the valuable chemical, rotenone, it will be desirable to know its essential histological characteristics and the histological characteristics of related species in order that they may be differentiated. The object of the present work is to present the histological and morphological characteristics of *Cracca virginiana* root, along with the histological and morphological characteristics of closely related species of *Cracca* available in this locality.

In addition to the histological and morphological characteristics there are

---

\* Scientific Section, A. P. H. A., Portland meeting, 1935.

<sup>1</sup> From an abstract of a dissertation presented in partial fulfilment of the requirements for the degree of doctor of philosophy at the University of Florida, School of Pharmacy, Gainesville, Florida, June 1935.

<sup>2</sup> Director of the School of Pharmacy, Head of Department of Pharmacognosy and Pharmacology, University of Florida.

also chemical tests for rotenone (3), and a chemical assay for rotenone (4) which may be used in evaluating samples of any of these materials.

In this paper the histological and morphological characteristics of *Cracca virginiana* root are discussed rather thoroughly; in discussing other species only the points of difference between these species and *Cracca virginiana* root are pointed out.

#### CRACTA VIRGINIANA ROOT.

The roots are long, often attaining a length of three or four feet and averaging about  $\frac{3}{4}$  cm. in diameter. They are hard, fibrous, and break with a short fracture.

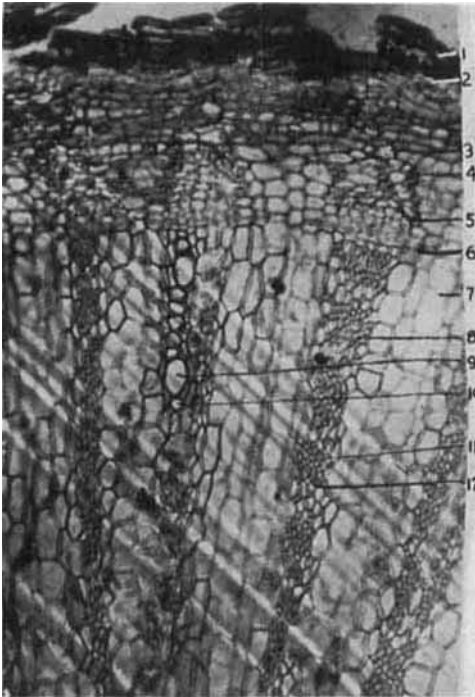


Fig. 1.--Transverse section of *Cracca virginiana* root through the outer stellar region and bark. 1, Cork; 2, phellogen; 3, cortical parenchyma; 4, bast fibres; 5, phloem; 6, cambium; 7, medullary ray; 8, xylem, including: 9, vessel; 10, tracheid; 11, wood fibres; 12, parenchyma cells.  $\times 100$ .

height; the individual cells are slightly lignified and most of them are irregularly pitted. They are generally quadrangular in outline in transverse and radial-longitudinal sections, and polygonal in tangential-longitudinal sections.

The phloem patches average three or four cells in width; the individual cells are thin-walled and polygonal in outline. The tissues composing the xylem areas are vessels, tracheids, wood fibres and parenchyma cells. The vessels vary greatly up to 100 microns in diameter and all are highly lignified. They occur most numerous in the central region; in the outer regions they occur singly, in pairs, or in groups of several, the latter often having a radial arrangement. In

The color externally is a light grayish brown, internally a pale whitish yellow. They have a spicy odor and faintly spicy taste that is followed by a moderate degree of pungency. The powder is of a light grayish yellow color.

#### HISTOLOGY.

Transverse, tangential-longitudinal and radial-longitudinal sections were examined. A study was also made of the isolated tissues and the powder.

The cork consists of up to 15 layers of radially arranged, tangentially elongated and slightly lignified cells; the cortical parenchyma region consists of about 15 layers of tangentially elongated, thin-walled cells. (See Fig. 1.) Bast fibres occur singly or in groups of up to ten, being most numerous in regions radial to the fibro-vascular bundles. The individual fibres are polygonal or oval in transverse outline, and generally contain a faint, dotlike lumen. Many are bordered by serially arranged parenchyma cells, each of the latter containing a solitary crystal of calcium oxalate.

The fibrovascular bundles are radially elongated, narrowly wedge-shaped and alternate with medullary rays of a width about equal to that of their own. The medullary rays are up to eight cells in width, the patches averaging from three to four millimeters in

longitudinal sections they are characterized by numerous transverse, slit-like or oval markings which often have a scalariform arrangement (see Fig. 2).

The tracheids occur in close proximity to the vessels. They are polygonal in transverse outline, average about 20 microns in width and 120 microns in length. Their side walls contain varying numbers of transverse, oval or longitudinal markings.

Parenchyma cells occur adjacent to the vessels, bordering the medullary rays, or serially arranged and superimposed upon the wood fibres and containing solitary crystals of calcium oxalate. They are polygonal in surface outline and have heavy, slightly pitted walls.

Wood fibres are numerous in rather compact groups between the vascular areas, and occasional ones occur in proximity to the vessels. Wood and bast fibres are not differentiable in the powder (see Fig. 3). Both are highly lignified, very long, the side walls parallel along the point. They generally contain a distinct, narrow lumen, which extends the greater length of the

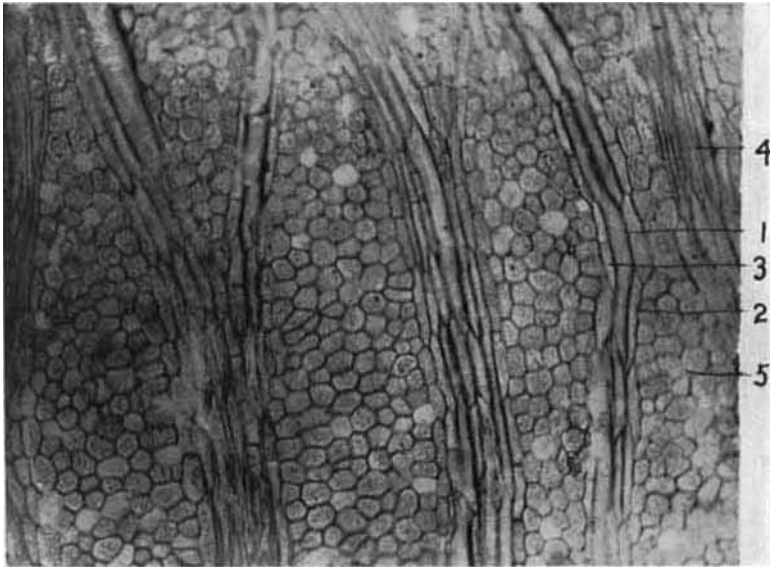


Fig. 2.—Tangential-longitudinal section of *Cracca virginiana* root. 1, Vessel; 2, tracheid; 3, parenchyma; 4, wood fibres; 5, medullary rays.  $\times 100$ .

fibre. Crystal fibres are rather numerous in the powder; the crystals are mostly of the rhombic type, occasional ones being of hexagonal or monoclinic types.

Irregular, structureless, grayish white masses of inulin are occasionally seen in the powder.

Starch is abundant in the parenchyma, medullary rays and tracheids of the stellar region. It is abundant in the powder. Most of the grains are simple, with a fairly high percentage of di-compound grains and a few tri-compound grains. The simple grains are spherical, ovoid or polygonal in outline, vary up to 30 microns in diameter with the average about 20 microns. Some of the simple grains with straight sides appear to have been derived from compound grains. Simple grains and component elements of compound grains generally contain a distinct hilum, which is central or excentral, dotlike or cleft, the cleft sometimes branched; under polarized light each shows two dark bands crossing at slightly acute angles at or near the center.

#### CRACCA LATIDENS.

1. Roots of *Cracca latidens* are distinctly more grayish in outward appearance and of a whitish gray color internally; the powder is of a whitish gray color and not pungent when tasted.

2. Fewer vessels and associated tracheids in *Cracca latidens* root; the central region is distinctly less vascular, while in the intermediate areas of the xylem no groups of vessels were found to number more than four.

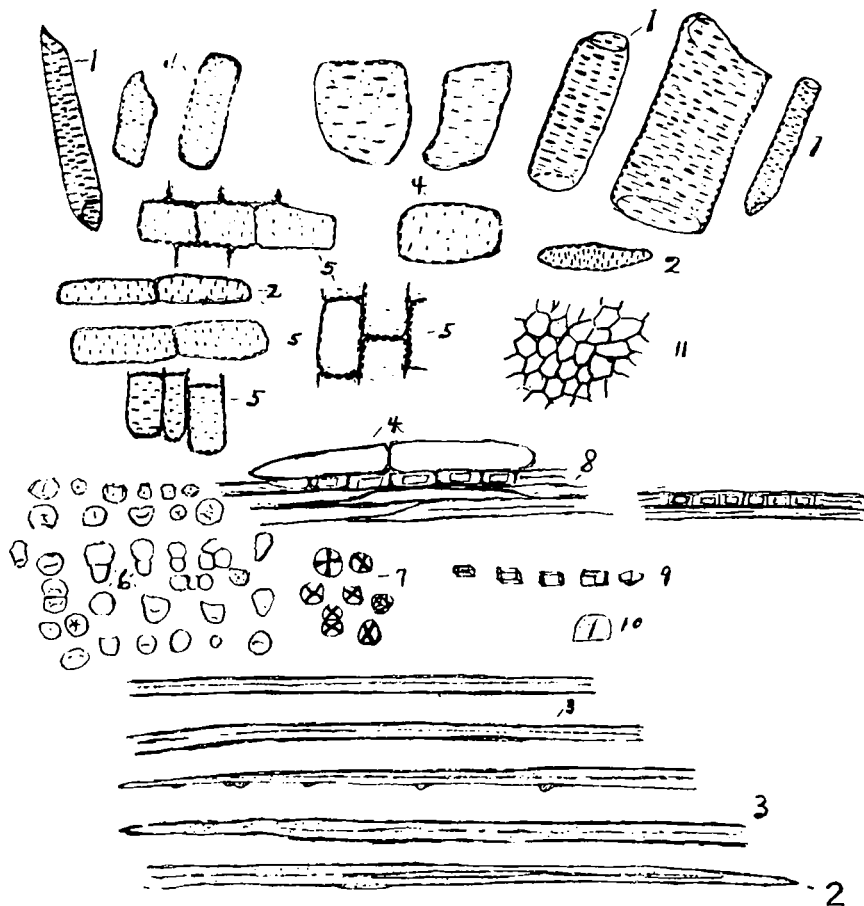


Fig. 3.—Powder and isolated tissues of *Cracca virginiana* root. 1, Vessels; 2, tracheids; 3, sclerenchyma fibres; 4, parenchyma cells; 5, medullary rays; 6, starch grains; 7, starch under polarizer; 8, crystal fibres; 9, crystals; 10, inulin; 11, cork.

3. More bast fibres in the cortical parenchyma region; groups containing as many as 20 fibres are frequently observed.

4. No calcium oxalate in *Cracca latidens* root.

#### CRACCA AMBIGIRA.

1. The roots are fleshy, 10 to 12 inches in length, and about  $\frac{1}{2}$  cm. in thickness and contain few secondary roots. They are grayish white externally and whitish internally; the powder is of a grayish white color.

2. The xylem areas are less vascular in the central and intermediate regions, but distinctly more vascular in the outer regions. The side walls of the vessels contain more numerous transverse markings.

3. The arrangement of tissues in the xylem areas differs further in that groups of parenchyma cells occur between compact groups of wood fibres and between the wood fibres and vascular tissues.

4. Numerous cells in the cortical parenchyma region and occasional ones in the xylem areas have a resinous content; solitary crystals of calcium oxalate are also more frequent.

5. Sclerenchyma fibres are less numerous in the powder, with a correspondingly greater amount of parenchyma and starch. The side walls of the parenchyma and medullary ray cells are more distinctly pitted.

6. Compound starch grains are more frequent and large aggregates of starch are also numerous; the simple grains are smaller, averaging from 6 to 10 microns in diameter.

#### CRACCA HISPIDULA.

1. The root is slightly fleshy, from 6 to 10 inches in length and about  $\frac{1}{2}$  cm. in thickness, and bears few secondary roots. Externally it is a grayish brown color and internally a faint grayish yellow color.

2. Central regions of this root vary considerable in structure. Some sections present large thin-walled parenchyma cells and a few vessels surrounded by tracheids, others contain a larger number of vessels in association with many tracheids and a few wood fibres and contain very few parenchyma cells. There are various gradations of structure between these two extremes. Vessels are fewer in the intermediate areas, but more numerous in the outer xylem areas.

3. Groups of parenchyma cells occur between compact groups of wood fibres and between the wood fibres and vascular areas.

4. Sclerenchyma fibres are less numerous in the powder with a correspondingly greater amount of parenchyma and starch.

5. In addition to di- and tri-compound starch grains, small aggregates of starch are rather frequent. The simple grains average about 10 microns in diameter, with occasional ones up to 15 or 20 microns.

6. The medullary rays are up to six cells in width, and average from 1.5 to 2 millimeters in height.

#### CRACCA SPICATA.

1. The root is slightly fleshy, from 6 to 10 inches in length and contains few secondary roots. The color externally is grayish, internally whitish gray; the powder is of a grayish brown color.

2. Large groups of bast fibres in the cortex; these number up to 35 or 40 fibres, the average number being about 15 or 20. The lumen of the bast fibres is relatively large, elliptic, ovoid or elongated in outline; individual fibres are only slightly lignified.

3. Vascular elements are relatively much less numerous. From 6 to 12 large vessels and associated tracheids are found in the central region and the vessels are also much less frequent in the intermediate and outer regions.

4. The arrangement of tissues in the xylem areas differs further in that groups of parenchyma cells occur between compact groups of wood fibres and between the wood fibres and vascular areas.

5. The medullary rays are up to five cells in width. The individual cells are not lignified and have smooth walls.

6. The powder contains a greater amount of parenchyma and starch. The walls of the parenchyma cells are smooth.

7. Practically all starch grains are simple, a few are di-compound. The simple grains are up to 20 microns in diameter, the average being about 12 microns.

#### REFERENCES.

(1) Little, V. A., "A Preliminary Report of the Insecticidal Properties of Devil's Shoe-string, *Cracca virginiana* Linné," *J. Econ. Entomol.*, 24, 743-754 (1931).

(2) Clark, E. P., "The Occurrence of Rotenone and Related Compounds in the Roots of *Cracca virginiana*," *Science*, 77, 311-312 (1933).

(3) Jones, H. A., and Smith, C. M., "A Color Test for Rotenone," *J. Ind. Eng. Chem.*, 5, 75-76 (1933).

(4) Jones, H. A., "Assay of Plant Material for Its Rotenone Content," *J. Ind. Eng. Chem., Anal. Ed.*, 5, 23-26 (1934).