chloride indirectly, together with a number of other substances, some containing phosphorus.

This study of the characteristics of glycine is being continued.

ORONO, MAINE

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[CONTRIBUTION FROM THE PHARMACOGNOSY LABORATORY, BUREAU OF CHEMISTRY, UNITED STATES DEPARTMENT OF AGRICULTURE]

## NEW SOURCES OF SANTONIN[1]

BY ARNO VIEHOEVER AND RUTH G. CAPEN

Received April 9, 1923

The discovery of a new source of santonin should attract attention, especially because it is now almost impossible to obtain the plant material, wormseed, as well as santonin itself, owing to the unsettled conditions in Russia. Both are now marketed at prices unusually high. Levant wormseed is quoted at $3.25 to $3.50 per pound, and santonin at $172 to $175 per pound.[2]

Supplies other than the normal source of santonin, *Artemisia cina* Bg. (*Artemisia maritima* var. *stechmanniana* Bees.), which grows exclusively in the region of Turkestan and Siberia, have been utilized by manufacturers of santonin. It is reported that the plant species *Artemisia gallica* Willdenow, which is indigenous to France, and *Artemisia brevifolia* Wallich contain santonin. No definite quantities of santonin are reported in the investigations of Heckel and Schlagdenhauffen[3] and, as far as is known, this plant (*Artemisia gallica*) was never utilized in the manufacture of santonin. *Artemisia brevifolia*, a form very closely related to *Artemisia maritima* Linné, growing abundantly in Thibet, has more recently been mentioned as a possible commercial source. In 1921 Greenish and Pearson[4] called attention to this source in which they found 0.85% of santonin. Another sample of the same plant, collected at Gurez, yielded 1.09% in the leaves dried at 100°, or 0.76%, calculated upon the air-dry leaves and stems as received.[5] Whether this material can be utilized as a commercial source is still undecided.

In 1920[6] a German firm patented a process to isolate santonin from the

[1] A preliminary note was presented at the meeting ot the American Chemical Society, Birmingham, Ala., April 3–7, 1922. An abstract was published in *Am. J. Pharm.*, **94**, 446 (1922).

[2] Oil, Paint and Drug Reporter, Jan. 10, 1923.

[3] Heckel, Ed., and Schlagdenhauffen, Fr., "De l'Artemisia gallica Willd., comme plante à santonin, et de sa composition chimique." *Compt. rend.*, **100**, 804 (1885).

[4] Greenish, H. C., and Pearson, C. E., "A new source of santonin." *Pharm. J.*, **52**, (4th ser.), 243 (1921).

[5] Greenish and Pearson, "Note on the Occurrence of Santonin," *Pharm. J.*, **109**, 85 (1922).

[6] Patentschrift Nr. 346,947, Klasse $12_0$, Gruppe 25, Jan. 11, 1922.

whole herb of *Artemisia maritima* L., growing in Germany on the North Sea and the Baltic Sea.

## Survey of Domestic Species of Santonin

Because of the scarcity of a needed drug, a survey of the domestic forms of Artemisia, as a possible source of santonin, was undertaken by the Bureau of Chemistry. This investigation, not fully completed, has yielded very interesting and promising results.

## Procedure

A few of the flower heads of the Artemisia species to be examined were placed in a sublimation apparatus. The apparatus, consisting of a small beaker-like container with a cup extending from the bottom, was immersed in an oil-bath kept at a temperature ranging from 150° to 170°. A cover slip (upon which the sublimate was received) was placed over the opening of the cup. A cooling device and vacuum were also used.[7]

The sublimed santonin was deposited on the cover slip in oily drops, which, upon standing, crystallized in large prismatic plates. By treating the sublimate with ether the formation of santonin crystals was appreciably hastened. Santonin was identified by four tests as follows.

**Crystalline Structure.**—Santonin forms very characteristic rhombic plates. On account of the solubility of santonin in most solvents having a high index of refraction, only an approximate value for its refractive index, namely, about 1.6, was established.[8]

**Melting Point.**—Purified santonin melts at 170°. The melting is preceded by a loss of the polarizing power, at 1° or 2° below 170°. The melting point can be readily observed under the microscope when the material is heated in a special heating chamber (micro-melting-point apparatus).[9]

**Furfural Reaction.**—The sublimate is dissolved in a small quantity of alcohol to which 1 to 2 drops of 2% furfural solution and 1 to 2 cc. of sulfuric acid are added. Upon evaporation of the alcohol the liquid is purplish-red, carmine-red, changing to bluish-violet, and finally shows a black precipitate. Furfural alone with sulfuric acid gives a red.

**Formation of Santonin Per-iodide.**—This has already been described.[10]

The species examined, the locality from which they were obtained, and the results of the examination are given in Table I.

[7] This apparatus, as well as a new sublimation flask suitable for this work, is fully described in a paper entitled "Sublimation of Plant and Animal Products, Third Report," by Arno Viehoever, *J. Assoc. Official Agr. Chem.*, **6**, 473 (1923).

[8] Determined by J. F. Clevenger of the Bureau of Chemistry.

[9] Ref. 7, p. 477.

[10] *J. Assoc. Official Agr. Chem.*, **5**, 557–8 (1922).

TABLE I

EXAMINATION OF DOMESTIC ARTEMISIA SPECIES

| *Artemisia species* | Source | Sublimate | Furfural test for santonin |
|---|---|---|---|
| Atomifera Piper | Washington | —— | — |
| Absinthium L. | North Dakota | Fine crystals[a] | — |
| Albula Wooton | New Mexico | —— | — |
| Annua L. | Arlington Farm, Va. | —— | — |
| Arborescens Linn. | ..... | Fine crystals | — |
| Aromatica A. Nels. | Idaho | Long needles[b] | — |
| Biennis Willd. | Oregon | —— | — |
| Bigelovii A. Gray | New Mexico | Small needles | — |
| Californica Less. | California | —— | — |
| Cana Pursh. | New Mexico | —— | — |
| ..... | ..... | —— | — |
| Canadensis Michx. | Wisconsin | —— | — |
| ..... | Nebraska | —— | — |
| Caudata Michx. | Wisconsin | —— | — |
| ..... | Michigan | —— | — |
| Carruthii A. Wood | New Mexico | Fine crystals | — |
| Dracunculina S. Wats | Arizona | —— | — |
| Dracunculoides Pursh. | Utah | Fine crystals | — |
| ..... | Arizona | Many needles[c] | — |
| Filifolia Torr. | New Mexico | Fine crystals | — |
| ..... | ..... | Small needles | ? |
| Forwoodii Watson | South Dakota | —— | — |
| Forwoodii Watson | North Dakota | —— | ? |
| Frauserioides Greene | Colorado | Small needles | — |
| Frigida Willd. | Arlington Farm, Va. | Fine crystals[a] | — |
| ..... | New Mexico | Fine crystals | — |
| Gallica Willd. | ..... | Fine crystals | — |
| Gnaphalodes Nutt. | Arlington Farm, Va. | —— | — |
| ..... | North Dakota | —— | — |
| Heterophyllea Nutt. | California | Small plates | — |
| Kansana Britton | New Mexico | Fine crystals | — |
| Ludoviciana Nutt. | Arizona | —— | — |
| Mexicana Bakeri | Utah | —— | — |
| Mexicana Willd. | New Mexico | —— | — |
| ..... | ..... | Prisms[d] | + |
| ..... | ..... | Oily mass | ? |
| ..... | Arizona | —— | — |
| ..... | ..... | Oily mass | Green to dark blue |
| ..... | ..... | —— | — |
| Redolens Gray | New Mexico | Fine crystals | — |
| ..... | Mexico | —— | — |
| Vulgaris L. | Wisconsin | —— | — |
| ..... | Yosemite Valley | —— | — |
| Microcephale Wooton | New Mexico | Fine crystals | — |
| Neo-mexicana Wooton | ..... | Prisms[d] | + |
| Pontica L. | ..... | Fine crystals | — |
| Rhizomatus pubularis | Wyoming | —— | — |
| Tridentata Nutt. | California | Fine crystals | — |
| Wrightii Rausch. | New Mexico | —— | — |
| Wrightii Gray | ..... | Small needles | + |
| ..... | ..... | —— | — |
| ..... | ..... | Small crystals | — |
| ..... | ..... | —— | — |
| ..... | ..... | Small crystals | ? |
| ..... | ..... | Oily mass | — |
| ..... | ..... | Oily mass | ? |

Melting points: [a] 65° [b] 135° [c] 90–115° [d] 165°.

The survey of 56 species of Artemisia showed that santonin can be obtained from *Artemisia mexicana* Willd., from *Artemisia neo-mexicana*

Wooton, and probably from *Artemisia Wrightii*, all of which grow in the region of New Mexico and Mexico.[11]

Only very small quantities of material were available for experimental work. Attempts to obtain fresh and larger supplies of *Artemisia mexicana* and *Artemisia neo-mexicana* have thus far been unsuccessful. Sufficient plants could not be collected in time, and the seeds obtained failed to grow.

The closed flower heads, which in the case of *Artemisia cina*, contain the largest quantities of santonin, were used in the survey whenever possible. In many cases the open flower heads of old plants of various species had to be examined. The negative results, therefore, are not absolute proof of the absence of santonin in the species mentioned.

The results indicate a distinct possibility of utilizing domestic plants, growing as weeds in barren fields, for the manufacture of santonin.

## Summary

Of 56 species of domestic *Artemisia* pronounced tests for santonin were obtained from *A. mexicana* Willd., from *A. neo-mexicana* Wooton and probably from *A. Wrightii*, all of which grew in the region of New Mexico and Mexico.

The results indicate a distinct possibility of utilizing domestic plants, growing as weeds in barren fields, for the manufacture of santonin.

WASHINGTON, D. C.

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[CONTRIBUTION FROM THE BIOCHEMICAL LABORATORY, NEW YORK AGRICULTURAL EXPERIMENT STATION]

# A STUDY OF THE PHYTOSTEROLS OF CORN OIL, COTTONSEED OIL AND LINSEED OIL[1]

BY R. J. ANDERSON WITH M. G. MOORE

Received May 7, 1923

## Introduction

The present investigation was undertaken in connection with the work on the phytosterols in the fat from corn pollen.[2] The properties of the phytosterols from corn pollen differed so markedly from other plant phytosterols that we desired to extend the investigation in the hope of finding similar substances in other plant products. But the materials which we examined, corn oil, cotton seed oil and linseed oil, did not yield any phytosterols similar to those found in corn pollen.

The first substance to be investigated was corn oil. The unsaponifiable matter in corn oil was called cholesterol by Hoppe-Seyler,[3] but no data were

[11] Copies of the illustrations of the plants may be obtained from the author.

[1] Read at the meeting of the American Chemical Society, New Haven, Conn., April, 1923.

[2] Anderson, *J. Biol. Chem.*, **55**, 611 (1923).

[3] Hoppe-Seyler, "Med. Chem. Unters.," **1866**, p. 162.