A PHYTOCHEMICAL STUDY OF HYDRASTIS CANADENSIS (GOLDENSEAL).*

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INTRODUCTION.

The experimental work presented here is a continuation of the investigation begun in 1927, a report of which was presented before the Scientific Section of the AMERICAN PHARMACEUTICAL ASSOCIATION at Portland, Maine, August, 1928, under the title "A Pharmaceutical Study of *Hydrastis Canadensis*,"[1] by Ruby H. Hirose and H. A. Langenhan.

The experimental work included in the above study covered a period of one year. It presented information of value, yet not sufficiently conclusive. It was therefore deemed desirable to continue the investigation of Hydrastis.

Since 1927, seventy-seven samples were obtained from the Skagit Valley Goldenseal Farm and more than 500 assays were made.

For a more accurate assay the plant was divided into the conventional botanical classification of rhizome, root, leaf and stem, and each analyzed separately.

This study attempted to include:

1. A tentative standard of the age and weight relations of the different parts of the plant.

2. Relations of alkaloidal variability among the same parts with respect to age, monthly and seasonal changes.

3. Data on the approximate assays of non-alkaloidal constituents, such as moisture, acid-insoluble ash, acid-soluble ash and total ash, and the relation between the percentage of ether-soluble alkaloid and acid-soluble ash. An additional phase of the study will be the berberine content and its relation to the ether-soluble alkaloids and acid-soluble ash, as these three represent plant constituents.

PREPARATION OF THE SAMPLES.

The underground portion of Hydrastis consists of a root stock or rhizome and roots. The rhizome is the underground stem, but it is often conveniently thought of as a part of the root system because it creeps along the earth and resembles a root in appearance.

The half tone (Plate I) is from a photograph of an underground root system. The rhizome sends out tendrils which produce buds as observed by the white markings. These buds form a rhizome which in turn sends out tendrils which eventually thicken to form a matted mass.

The plants were harvested so as to remove not only the roots, but the rootlets. The weight percentage ratio of rhizome to root will often depend upon the care exerted in removing all the root fibres. Much of the adhering soil was shaken out

and the remainder washed out with a hose or just under the water tap.   It was then dried at approximately 95° Fahrenheit for several days, or until the rhizome was quite crisp and broke readily, after which it was weighed, separated into rhizome and root and these portions weighed.   These portions were ground separately in a laboratory mill and stored in well-closed containers.

VARIABILITY OF CONVENTIONAL DIVISIONS OF PLANT—THE RELATION BETWEEN THE PERCENTAGE WEIGHT OF ROOT AND RHIZOME IN PLANTS OF DIFFERENT AGE.

For this particular phase of the study, forty-seven representative samples of Hydrastis were harvested.   They included plants from 2 to 14 years of age. The weight of the samples varied; from that grown on four square feet of ground, approximating 150 to 500 Gm., depending on the age, to 25 pounds of drug.

Table I is explanatory without discussion.   However, to fully appreciate the significance of this and all other tables, accompanying graphs were made, the original size having been 10 x 20 inches.   These were photographically reduced to 5 x 7 inches. Otherwise, quite distinctive variations would be overlooked for want of magnification.

The alkaloidal content of the rhizome is greater than that of the root, hence a greater percentage weight of rhizome is desirable; although this is not always applicable.   There is approximately a difference of 1 per cent ether-soluble extract between rhizome and root.

With a few exceptions, the percentage weights of rhizome and root are fairly constant.   The general average was 28.1 per cent rhizome and 71.9 per cent root.   Several groups may be set forth for consideration.

Plate I.—Root system of Hydrastic (Goldenseal). 12-inch ruler for comparison. The dried rhizome and root of Hydrastis Canadensis, *Ranunculaceae*.

PERCENTAGE WEIGHT OF RHIZOME FROM PLANTS OF DIFFERENT AGE.

Age.	Weight per cent, rhizome.
2	20.60
3	24.75
4	20.30
5	25.90
6	29.80

The results represent the average for plants of the same age in years, irrespective of the date (year) collected.

PERCENTAGE WEIGHT OF RHIZOME COLLECTED FROM THE SAME PLOT TWO CONSECUTIVE YEARS.

Stock no.	Age.	Year.	Per cent weight, rhizome.
6	4	1927	16.7
30	5	1928	26.4

PERCENTAGE WEIGHT OF RHIZOME OF PLANTS REPRESENTING MAXIMUM PERCENTAGE.

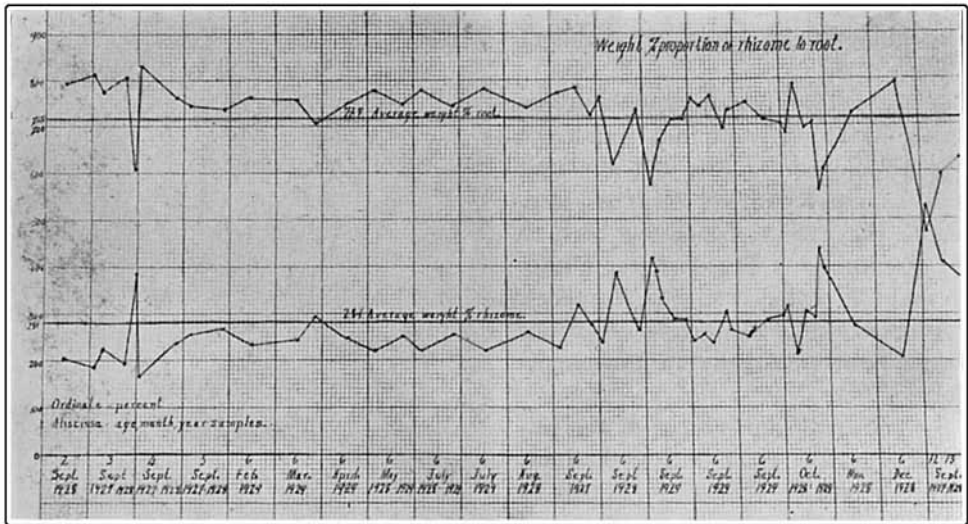| Stock no.	Age.	Month.	Year.	Per cent weight, rhizome.
32	3	Sept.	1928	38.8
66	6	Sept.	1929	42.5
73	6	Oct.	1929	43.7
77	6	Nov.	1929	39.3

Chart 1.—Weight percentage proportion of rhizome to root for plants varying in age from 2-14 years, harvested 1927, 1928, 1929.

	Rhizome.	Root.
Maximum	52.8	83.3
Average	28.1	71.9
Minimum	16.7	47.2

PERCENTAGE WEIGHT OF RHIZOME FROM PLANTS COLLECTED FROM THE SAME PLOT FOR THREE CONSECUTIVE YEARS.

Stock no.	Age.	Month.	Year.	Per cent weight, rhizome.
7	12	Sept.	1927	52.8
27	13	Sept.	1928	40.8
(b, d.) 68	14	Sept.	1929	37.2

No definite conclusion may be reached from the data compiled so far. The high percentage weight of the last group may be accounted for by the fact that it was impossible to dig up all the roots and rootlets belonging to the plant. The mass of rhizome and roots was about six inches deep, and was cut out of the solid bed.

Neither age nor seasonal effects manifest themselves consistently. Undoubtedly soil and climate conditions, from the time the seed is planted up to the time of harvest, as well as hereditary properties, influence the percentage weight.
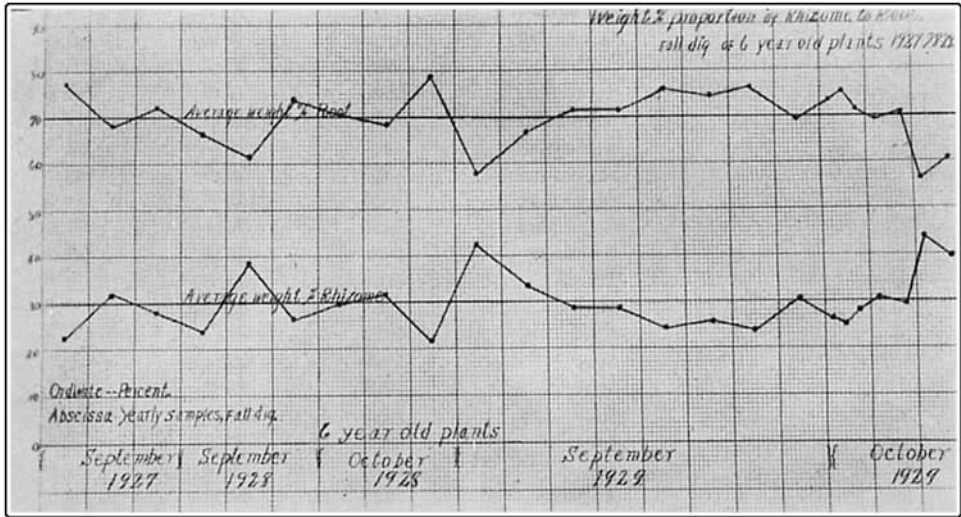
Chart 2.—Weight percentage proportion of rhizome to root of six-year-old plants for the years 1927, 1928, 1929.

	Rhizome.	Root.
Maximum	43.7	56.3
Average	29.8	70.2
Minimum	21.2	56.3

Chart 3.—The percentage of ether-soluble alkaloids of the rhizome and root from plants varying in age from 2–14 years.

	Rhizome.	Root.
Maximum	3.38	4.29
Average	2.50	3.50
Minimum	1.86	2.50

TABLE I.—WEIGHT PERCENTAGE PROPORTION OF RHIZOME TO ROOT FOR PLANTS VARYING IN AGE FROM 2–14 YEARS, HARVESTED 1927, 1928, 1929.

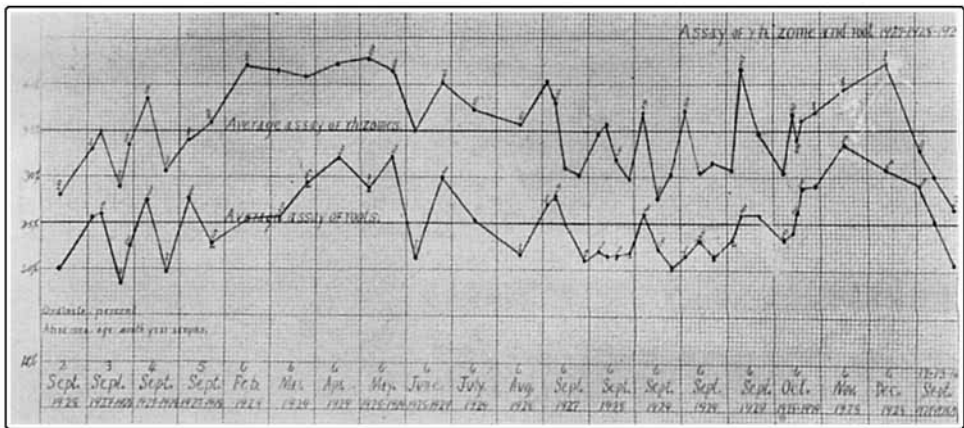| Stock no.	Age.	Month.	Year.	Weight per cent, rhizome.	Weight per cent. root.
33	2	September	1928	20.6	79.4
1	3	September	1927	18.6	81.4
5	3	September	1927	22.3	77.7
35	3	September	1928	19.4	80.6
32	3	September	1928	38.8	61.2
6	4	September	1927	16.7	83.3
31	4	September	1928	23.9	76.1
2	5	September	1927	25.5	74.5
30	5	September	1928	26.4	73.6
53	6	February	1929	23.8	76.2
52	6	March	1929	24.3	75.7
54	6	March	1929	29.2	70.8
55	6	April	1929	24.7	75.3
56	6	May	1929	22.1	77.9
36	6	May	1928	25.3	74.7
37	6	June	1928	22.1	77.9
58	6	June	1929	25.5	74.5
60	6	July	1929	22.0	78.0
39	6	August	1928	26.0	74.0
4	6	September	1927	22.7	77.3
3	6	September	1927	31.9	68.1
22	6	September	1927	27.8	72.2
28	6	September	1928	23.8	76.2
38	6	September	1928	26.4	73.6
66	6	September	1929	42.5	57.5
67	6	September	1929	33.2	66.8
70	6	September	1929	28.7	71.3
65N	6	September	1929	28.6	71.4
65J	6	September	1929	24.1	75.9
65I	6	September	1929	25.8	74.2
65A	6	September	1929	23.9	76.1
65C	6	September	1929	30.5	69.5
65G	6	September	1929	26.6	73.4
65D	6	September	1929	25.0	75.0
65L	6	September	1929	28.8	71.2
40	6	October	1928	29.6	70.4
41	6	October	1928	31.6	68.4
42	6	October	1928	21.2	78.8
72A	6	October	1929	30.6	69.4
72C	6	October	1929	29.1	70.9
73	6	October	1929	43.7	56.3
77	6	October	1929	39.5	60.5
46	6	November	1928	27.2	72.8
48	6	December	1928	20.7	79.3
7	12	September	1927	52.8	47.2
27	13	September	1928	40.8	59.2
68DB	14	September	1929	37.2	62.8
		Minimum		16.7	47.2
		Average		28.1	71.9
		Maximum		52.8	83.3

WEIGHT PERCENTAGE PROPORTION OF RHIZOME TO ROOT OF SIX-YEAR-OLD PLANTS
FOR THE YEARS 1927, 1928, 1929.

It is of interest to the grower to know approximately the proportion of rhizome to root; likewise, the average yield per given area for 3-, 4-, 5-year-old plants. However, the producer is immediately interested to know whether his harvested crop is average or above average, in accordance with certain standards.

Table II is the weight percentage proportion of rhizome to root of six-year-old plants harvested during the years 1927, 1928 and 1929.

The average weight percentage of rhizome for 1927 samples is 27.5.
The average weight percentage of rhizome for 1928 samples is 28.6.
The average weight percentage of rhizome for 1929 samples is 30.7.

The composite average for all samples for the three successive years is 29.8. Thus, from a study of the 24 samples it may be assumed that approximately 30 per cent is an average yield for the percentage of rhizome.

With the exception of the several samplings which approached a 40 per cent yield of rhizome, the variation for the percentage of rhizome from the line of averages is slight.

TABLE II.—WEIGHT PERCENTAGE PROPORTION OF RHIZOME TO ROOT OF SIX-YEAR-OLD PLANTS
FOR THE YEARS 1927, 1928, 1929.

Stock no.	Age.	Month.	Year.	Weight per cent, rhizome.	Weight per cent, root.
4	6	September	1927	22.7	77.3
3	6	September	1927	31.9	68.1
22	6	September	1927	27.8	72.2
28	6	September	1928	23.8	66.2
32	6	September	1928	38.8	61.2
38	6	September	1928	26.4	73.6
40	6	October	1928	29.6	70.4
41	6	October	1928	31.6	68.4
42	6	October	1928	21.2	78.8
66	6	September	1929	42.5	57.5
67	6	September	1929	33.2	66.8
70	6	September	1929	28.7	71.3
65N	6	September	1929	28.6	71.4
65J	6	September	1929	24.1	75.9
65I	6	September	1929	25.8	74.2
65A	6	September	1929	23.9	76.1
65C	6	September	1929	30.5	69.5
65G	6	September	1929	26.6	73.4
65D	6	September	1929	25.0	75.0
65L	6	September	1929	28.8	71.2
72A	6	October	1929	30.6	69.4
72C	6	October	1929	29.1	70.9
73	6	October	1929	43.7	56.3
77	6	October	1929	39.5	60.5
		Maximum		43.7	56.3
		Average		29.8	70.2
		Minimum		21.2	56.3

SUMMARY.

The weight percentage distribution for rhizome for all three years is as follows:

Minimum weight percentage for rhizome is 21.2.
Average weight percentage for rhizome is 29.8.
Maximum weight percentage for rhizome is 43.7.

The distribution for root:

Minimum weight percentage for root is 57.5.
Average weight percentage for root is 70.2.
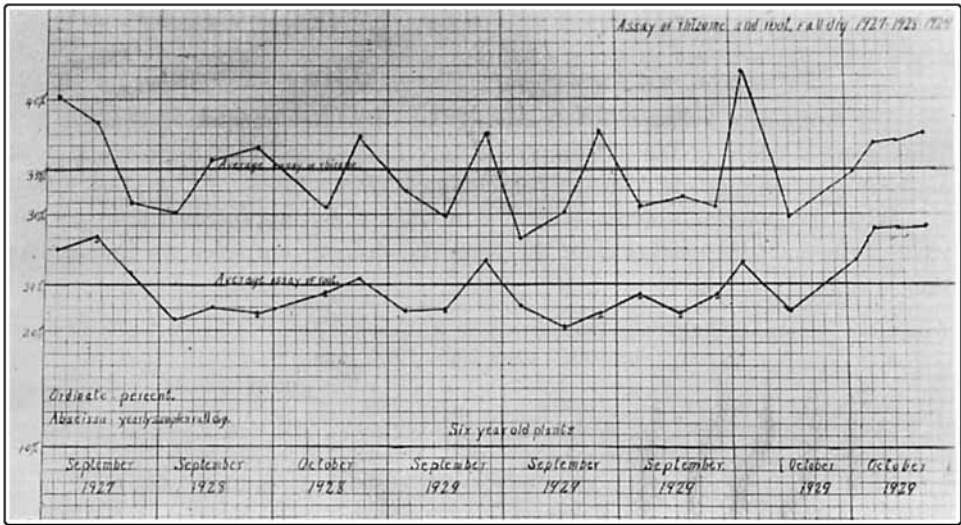Maximum weight percentage for root is 78.8.

Chart 4.—The percentage of ether-soluble alkaloids of rhizome and root of fall harvest plants for the years 1927, 1928, 1929.

	Rhizome.	Root.
Maximum	2.89	4.25
Average	2.40	3.39
Minimum	2.03	2.77

ALKALOIDAL VARIABILITY—ASSAY.

The United States Pharmacopœia method of assay was followed.

Ten grams of the powdered drug were transferred to an Erlenmeyer flask. To this were added 100 cc. of ether and the mixture allowed to stand five minutes, then adding 10 cc. of a 10 per cent solution of ammonia water. The containers were placed in a mechanical shaker, agitated for two hours and allowed to stand over night. After again agitating for half an hour, 50 cc. of the ether solution were measured into a separatory funnel. The ether solution was extracted with successive portions of

20 cc. of 5% sulphuric acid
15 cc. of 1.5% sulphuric acid
10 cc. of 1.0% sulphuric acid
10 cc. of 1.0% sulphuric acid

Lugol's solution was used to test for the complete removal of alkaloidal salts from the ether-soluble extract.

The acid solution was made faintly alkaline with stronger ammonia water and allowed to cool before shaking out with ether. The following proportions of ether were used successively:

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20 cc. ether
· 15 cc. ether
10 cc. ether
10 cc. ether

</div>

The acid solution was then tested with Lugol's solution for absence of alkaloid.

The ether was allowed to evaporate spontaneously and the residue then dried at 100° C.

THE PERCENTAGE OF ETHER-SOLUBLE ALKALOIDS OF THE RHIZOME AND ROOT FROM PLANTS VARYING IN AGE FROM 2–14 YEARS.

Table III summarizes the ether-soluble alkaloidal content of the root and rhizomes of plants varying in age from 2–14 years.

By a study of Chart 3 the tendency of an increase of alkaloidal content of rhizome followed by an increase of alkaloidal content of root becomes quite apparent. Of the forty-six samples studied in this group, thirty-two samples complied with this.

TABLE III.—THE PERCENTAGE OF ETHER-SOLUBLE ALKALOIDS OF THE RHIZOME AND ROOT FROM PLANTS VARYING IN AGE FROM 2–14 YEARS.

Stock no.	Age.	Month.	Year.	Root.	Rhizome.
33	2	September	1928	2.08	2.83
1	3	September	1927	2.56	3.30
5	3	September	1927	2.60	3.50
35	3	September	1928	1.86	2.93
32	3	September	1928	2.25	3.34
6	4	September	1927	2.75	3.86
31	4	September	1928	1.98	3.07
2	5	September	1927	2.77	3.40
30	5	September	1928	2.28	3.58
53	6	February	1929	2.54	4.21
52	6	March	1929	2.57	3.15
54	6	March	1929	2.94	4.18
55	6	April	1929	3.20	4.21
56	6	May	1929	2.88	4.29
36	6	May	1928	3.22	4.14
37	6	June	1928	2.13	2.50
58	6	June	1929	3.00	4.02
60	6	July	1929	2.53	3.73
39	6	August	1928	2.16	3.57
4	6	September	1927	2.70	4.03
3	6	September	1927	2.80	3.80
22	6	September	1927	2.50	3.10
28	6	September	1928	2.10	3.02
29	6	September	1928	2.20	3.48
38	6	September	1928	2.15	3.57
66	6	September	1929	2.16	3.20
67	6	September	1929	2.18	2.99
70	6	September	1929	2.60	3.70
65N	6	September	1929	2.21	2.77
65J	6	September	1929	2.034	3.02

Table III.—*Concluded.*

Stock no.	Age.	Month.	Year.	Root.	Rhizome.
65I	6	September	1929	2.15	3.72
65A	6	September	1929	2.31	3.06
65C	6	September	1929	2.15	3.15
65G	6	September	1929	2.32	3.06
65D	6	September	1929	2.59	4.25
65L	6	September	1929	2.19	2.97
41	6	September	1928	2.33	3.05
42	6	September	1928	2.44	3.67
72A	6	September	1929	2.61	3.38
72C	6	September	1929	2.89	3.61
73	6	September	1929	2.88	3.63
77	6	November	1929	2.90	3.90
46	6	November	1928	3.38	3.94
48	6	December	1928	3.08	4.20
7	12	September	1927	2.90	3.29
27	13	September	1928	2.50	3.00
68DB	14	September	1929	2.06	2.65
		Maximum		3.38	4.29
		Average		2.50	3.50
		Minimum		1.86	2.50

TABLE IV.—THE PERCENTAGE OF ETHER-SOLUBLE ALKALOIDS OF RHIZOME AND ROOT OF FALL HARVEST PLANTS FOR THE YEARS OF 1927, 1928, 1929.

Stock no.	Age.	Month.	Year.	Assay, root.	Assay, rhizome.
4	6	September	1927	2.70	4.03
6	6	September	1927	2.80	3.80
22	6	September	1927	2.50	3.10
28	6	September	1928	2.10	3.02
29	6	September	1928	2.20	3.48
38	6	September	1928	2.15	3.57
41	6	October	1928	2.33	3.05
42	6	September	1928	2.44	3.67
66	6	September	1929	2.16	3.20
67	6	September	1929	2.18	2.99
70	6	September	1929	2.60	3.70
65N	6	September	1929	2.21	2.77
65J	6	September	1929	2.03	3.02
65I	6	September	1929	2.15	3.72
65A	6	September	1929	2.31	3.06
65C	6	September	1929	2.15	3.15
65G	6	September	1929	2.32	3.06
65D	6	September	1929	2.39	4.25
65L	6	September	1929	2.19	2.97
72A	6	October	1929	2.61	3.38
72C	6	October	1929	2.89	3.61
73	6	October	1929	2.88	3.63
		Maximum		2.89	4.25
		Average		2.40	3.39
		Minimum		2.03	2.77

NOTE: According to Table III (Chart 3) the average for the rhizome is 3.50% and for the root 2.50%. This might indicate that September is not a desirable month for harvesting in this region.
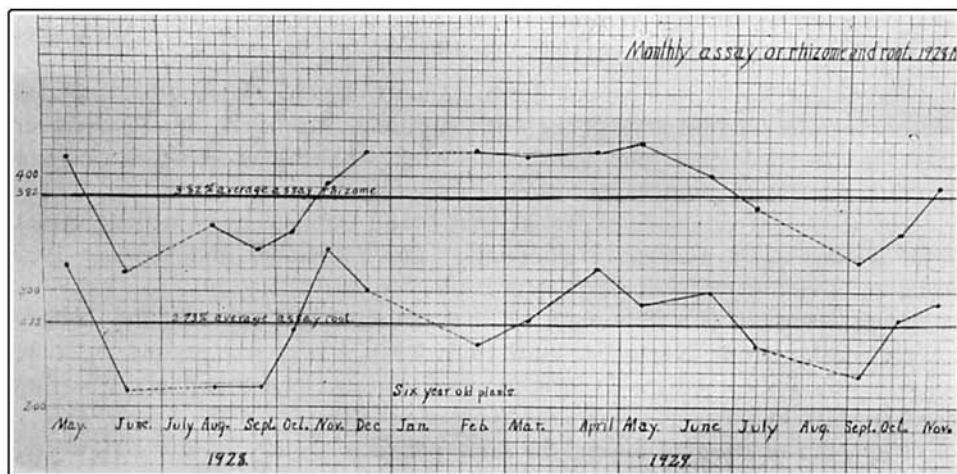
Chart 5.—Monthly assay of rhizome and root (1928 and 1929).

	Rhizome.	Root.
Maximum	4.29	3.38
Average	2.83	2.73
Minimum	3.15	2.13

These samples were obtained from the same plot.   July for 1928 and January and August for 1929 are missing.

Chart 6.—Alkaloidal content of plant (rhizome and root).

Maximum	3.45%
Average	2.82%
Minimum	2.22%

MONTHLY ASSAY OF RHIZOME AND ROOT

(1928 AND 1929).

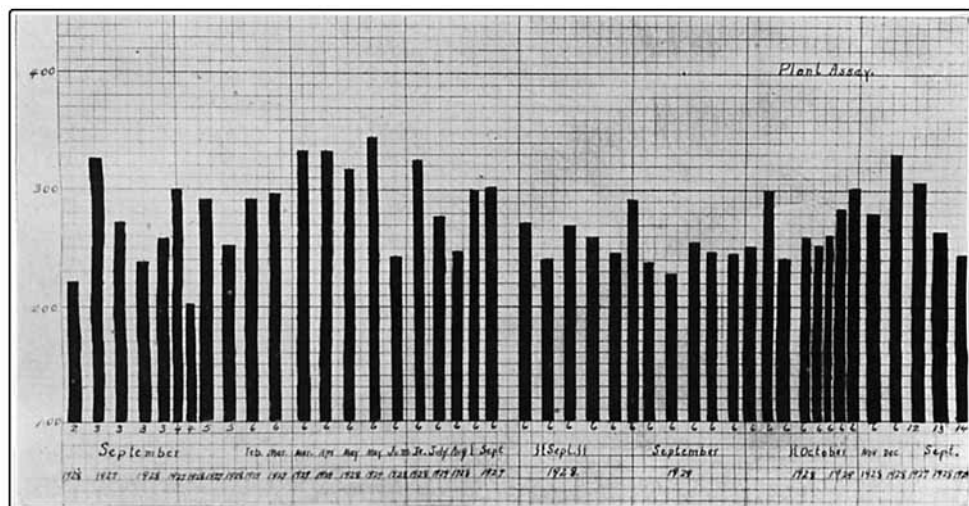The Skagit Valley Goldenseal Farm, Mount Vernon, Washington, supplied monthly samples for this phase of the work, beginning May 1928, until November 1929. It was hoped that some information could be obtained from this range of sampling, relative to monthly variations.

The alkaloidal values given for September and October are composite values or the averages of a number of samplings. For September and October 1929 eleven and five different samplings were made, respectively.

From Chart 5 it is readily observed that the alkaloidal value for the rhizome is fairly constant from November until June, when it is on the decline, reaching its lowest level in September. It increases again during October and finally reaches the same value in November 1929 as in November 1928.

The assay of the root during the same period is slightly erratic. However, the curve for the root follows the same general tendency of the rhizome from June when it is on the decline until it reaches its lowest level in September and then it is on the incline during the months of October and November.

Chart 5 includes additional sampling, covering the period from May until November 1928. The assay is high in May, declining until September when it is on the increase in October and November. The sampling for May in both years is high.

TABLE V.—MONTHLY ASSAY OF RHIZOME AND ROOT (1928 AND 1929).

Stock no.	Age.	Month.	Year.	Assay, root.	Assay, rhizome.
36	6	May	1928	3.22	4.14
37	6	June	1928	2.13	3.15
39	6	August	1928	2.16	3.57
38	6	September	1928	2.15	3.36
Comp.	6	October	1928	2.68	3.51
46	6	November	1928	3.38	3.94
48	6	December	1928	3.08	4.20
53	6	February	1929	2.54	4.21
52–54	6	March	1929	2.75	4.16
55	6	April	1929	3.20	4.21
56	6	May	1929	2.88	4.29
58	6	June	1929	3.00	4.02
60	6	July	1929	2.53	3.73
Comp.	6	September	1929	2.26	3.26
Comp.	6	October	1929	2.75	3.50
77	6	November	1929	2.90	3.90
		Maximum		3.38	4.29
		Average·		2.73	3.82
		Minimum		2.13	3.15

THE ALKALOIDAL (ETHER-SOLUBLE) CONTENT OF HYDRASTIS (RHIZOME AND ROOT), FROM PLANTS VARYING FROM 2–14 YEARS FOR 1927, 1928, 1929.

It is difficult to obtain representative samples for an assay by grinding up the whole root system. The proportion of rhizome or root may vary, depending upon the method used in collecting the sample, as can be seen by referring to Tables II and III.

A more satisfactory method is to carefully divide the root system into root and rhizome. Weigh and assay these separately, and from the results obtained compute the alkaloidal content of the drug as marketed. The results recorded in Tables VI and VII were so obtained.

TABLE VI.—ALKALOIDAL CONTENT OF THE PLANT (RHIZOME AND ROOT).

Stock no.	Age.	Month.	Year.	U. S. P. method, % alkaloids.
33	2	September	1928	2.22
1	3	September	1927	3.27
5	3	September	1927	2.73
35	3	September	1928	2.38
32	3	September	1928	2.57
6	4	September	1927	3.00
31	4	September	1928	2.22
2	5	September	1927	2.91
30	5	September	1928	2.52
53	6	February	1929	2.94
52	6	March	1929	2.95
54	6	March	1929	3.30
55	6	April	1929	3.33
56	6	May	1929	3.19
36	6	May	1928	3.45
37	6	June	1928	2.43
58	6	June	1929	3.26
60	6	July	1929	2.79
39	6	August	1928	2.47
4	6	September	1927	3.00
3	6	September	1927	3.12
22	6	September	1927	2.71
28	6	September	1928	2.41
29	6	September	1928	2.69
66	6	September	1929	2.60
67	6	September	1929	2.45
70AB	6	September	1929	2.93
65N	6	September	1929	2.38
65J	6	September	1929	2.28
65IO	6	September	1929	2.56
65AB	6	September	1929	2.48
65CE	6	September	1929	2.46
65GH	6	September	1929	2.51
65DF	6	September	1929	3.00
65LM	6	September	1929	2.42
40	6	October	1928	2.60
41	6	October	1928	2.53
42	6	October	1928	2.63
72AD	6	October	1929	2.85
72GB	6	October	1929	3.11
46	6	November	1928	2.80
48	6	December	1928	3.31
7	12	September	1927	3.08
27	13	September	1928	2.65
68	14	September	1929	2.44

Maximum alkaloidal content of plant		3.45
Average alkaloidal content of plant		2.82
Minimum alkaloidal content of plant		2.22

As an experiment, the method of representing the quantities in the chart was changed from the conventional curve to a block system as illustrated by Charts 6 and 7.

THE ABSOLUTE ALKALOIDAL (ETHER-SOLUBLE) CONTENT OF HYDRASTIS (RHIZOME AND ROOT).

Two factors that influence the alkaloidal content of Hydrastis are the acid-insoluble ash (sand and the like) and the moisture content.   Both were determined and the "absolute" alkaloidal content of the samples in Table VIII was computed and recorded in Table VII (Chart 7).

TABLE VII.—THE ABSOLUTE ALKALOIDAL (ETHER-SOLUBLE) CONTENT OF HYDRASTIS (RHIZOME AND ROOT).

Stock no.	Age.	Month.	Year.	% alkaloids.
33	2	September	1928	2.37
1	3	September	1928	3.41
5	3	September	1927	2.89
35	3	September	1928	2.61
32	3	September	1928	2.85
6	4	September	1927	3.13
31	4	September	1928	2.34
2	5	September	1927	3.06
30	5	September	1928	2.77
53	6	February	1929	3.14
52	6	March	1929	3.19
54	6	March	1929	3.68
55	6	April	1929	3.73
56	6	May	1929	3.57
36	6	May	1929	3.65
37	6	June	1928	2.69
58	6	June	1929	3.59
60	6	July	1929	3.01
39	6	August	1928	2.79
4	6	September	1927	3.19
3	6	September	1927	3.32
22	6	September	1927	2.85
28	6	September	1928	2.71
29	6	September	1928	2.95
66	6	September	1929	3.13
67	6	September	1929	2.71
70AB	6	September	1929	3.29
65N	6	September	1929	2.69
65J	6	September	1929	2.51
65IO	6	September	1929	2.79
65AB	6	September	1929	2.73
65CE	6	September	1929	2.79
65GA	6	September	1929	2.73
65DE	6	September	1929	3.20
65LM	6	September	1929	2.65
40	6	October	1928	2.90
41	6	October	1928	2.81
42	6	October	1928	2.95
72AD	6	October	1929	3.21
72CB	6	October	1929	3.45

Stock no.	Age.	Month.	Year.	% alkaloids.
73	6	October	1929	
77	6	November	1929	
46	6	November	1928	3.10
48	6	December	1928	3.52
7	6	September	1927	3.27
27	6	September	1928	2.92
68	6	September	1929	2.69
		Maximum		3.73
		Average		3.01
		Minimum		2.34
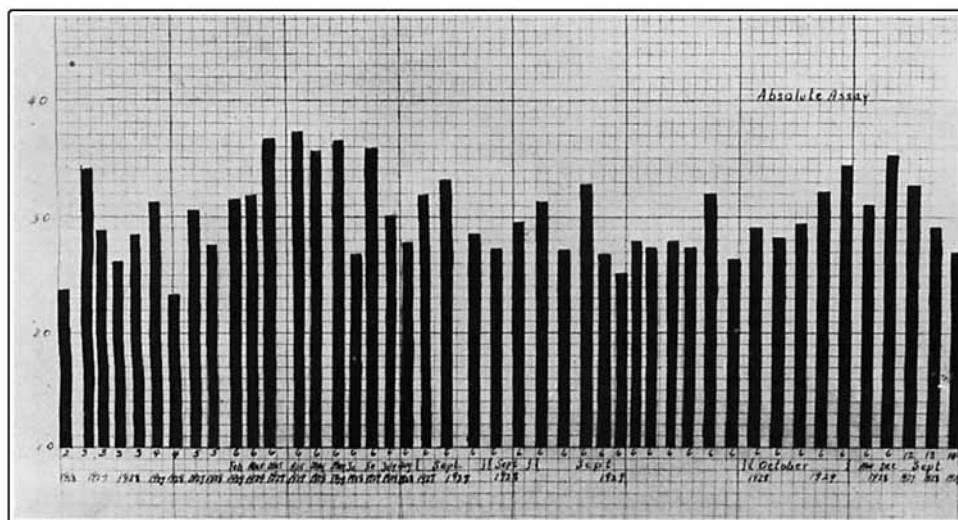
Chart 7.—The absolute alkaloidal (ether-soluble) content of hydrastis (rhizome and root).

	Rhizome.
Maximum	3.73%
Average	3.01%
Minimum	2.34%

TABLE VIII.—A COMPARISON OF UNITED STATES PHARMACOPŒIAL AND ABSOLUTE ASSAYS (TABLES VI AND VII COMBINED).

Stock no.	Age.	Month.	Year.	U. S. P. assay.	Absolute assay.
33	2	September	1928	2.22	2.37
1	3	September	1927	3.27	3.41
5	3	September	1927	2.73	2.89
35	3	September	1928	2.38	2.61
32	3	September	1928	2.57	2.85
6	4	September	1927	3.00	3.13
31	4	September	1928	2.22	2.34
2	5	September	1927	2.91	3.06
30	5	September	1928	2.52	2.77
53	6	February	1929	2.94	3.14
52	6	March	1929	2.95	3.19
54	6	March	1929	3.30	3.68
55	6	April	1929	3.33	3.73

Table VIII.—*Concluded.*

Stock no.	Age.	Month.	Year.	U. S. P. assay.	Absolute assay.
56	6	May	1929	3.19	3.57
36	6	May	1928	3.45	3.65
37	6	June	1928	2.43	2.69
58	6	June	1929	3.26	3.59
60	6	July	1929	2.79	3.01
39	6	August	1928	2.47	2.79
4	6	September	1927	3.00	3.19
3	6	September	1927	3.12	3.32
22	6	September	1927	2.71	2.85
28	6	September	1928	2.41	2.71
29	6	September	1928	2.69	2.95
66	6	September	1929	2.60	3.12
67	6	September	1929	2.45	2.71
70AB	6	September	1929	2.93	3.29
65N	6	September	1929	2.38	2.69
65JK	6	September	1929	2.28	2.51
65IO	6	September	1929	2.56	2.79
65AB	6	September	1929	2.48	2.73
65CE	6	September	1929	2.46	2.79
65GH	6	September	1929	2.51	2.73
65DF	6	September	1929	3.00	3.20
65LM	6	September	1929	2.42	2.65
40	6	October	1928	2.60	2.90
41	6	October	1928	2.53	2.81
42	6	October	1928	2.63	2.95
72AD	6	October	1929	2.85	3.21
72CB	6	October	1929	3.11	3.45
73	6	October	1929		
77	6	October	1929		
46	6	November	1928	2.80	3.10
48	6	December	1928	3.31	3.52
7	12	September	1927	3.08	3.27
27	13	September	1928	2.65	2.92
68	14	September	1929	2.44	2.69
		Maximum		3.45	3.73
		Average		2.82	3.01
		Minimum		2.22	2.34

(*To be continued*)

A PHYTOCHEMICAL AND PHARMACOLOGICAL STUDY OF MITCHELLA REPENS (LINNÉ), N. F. V.[*]

BY W. PAUL BRIGGS.[**]

The experimental research here reported was undertaken with the intention of determining the active constituents, if any, contained in the drug, *Mitchella repens*, Linné.

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