# Why Certain Plants Are Acrid

Professor William B. Lazenby

# Table of Contents

# Why Certain Plants Are Acrid

## Professor William B. Lazenby



EVER since my first lessons in botany, the characteristic qualities and properties of plants have given me much thought. Why certain plants produced aromatic oils and ethers, while others growing under the same conditions produced special acids or alkaloids, was a subject of endless speculation.

The pleasing aroma of the bark of various trees and shrubs, the spicy qualities of the foliage and seeds of other plants; the intense acridity; the bitterness; the narcotic, the poisonous principle in woody and herbaceous species; all were intensely interesting.

This interest was biological rather than chemical. I cared less for the ultimate composition of the oils, acids, alkalis, etc., than I did for their use or office in the plant economy, and their effect upon those who might use them.

Perhaps no one plant interested me more from this point of view, than the well−known Indian turnip (Arisoema triphyllum). As a boy I was well acquainted with the signally acrid quality of this plant; I was well aware of its effect when chewed, yet I was irresistibly drawn to taste it again and again. It was ever a painful experience, and I suffered the full penalty of my rashness. As an awn from a bearded head of barley will win its disputed way up one's sleeve, and gain a point in advance despite all effort to stop or expel it, so did every resolution, every reflection, counteract the very purpose it was summoned to oppose, and to my sorrow I would taste the drastic, turnip−shaped corm wherever opportunity occurred.

It is a well−known fact that the liquid content of the cells of plants contain numerous inorganic substances in solution. Among these, not considering oxygen, hydrogen, nitrogen and carbon dioxide, there are the salts of calcium, magnesium, potassium, iron, sulphur and phosphorus. The above substances are found in the cells of every living plant. Other substances like salts of sodium and silica are also found, but these are not regarded as essential to the life and growth of plants. They appear to be present because the plant has not the power to reject them. Many of the substances named above, are found deposited either in an amorphous or crystalline form in the substance of the cell wall. In addition to this, crystals of mineral matter, having various shapes and sizes, are often found in the interior of cells. The most common of these interior cell crystals are those composed of calcium oxalate and calcium carbonate. Others composed of calcium phosphate, calcium sulphate and silica are sometimes found. These crystals may occur singly or in clusters of greater or less size. In shape they are prismatic or needle−like.

It is not the object of this paper to treat of plant crystals in general, but to consider the peculiar effect produced by certain forms when found in some well−known plants.

The extreme acridity or intense pungency of the bulbs, stems, leaves and fruit of various species of the Araceae or Arum family, was recognized centuries ago. The cause of this characteristic property or quality was, until a comparatively recent date, not definitely determined.

As far as I am aware the first scientific investigation of this subject was made by the writer. At a meeting of the American Association for the Advancement of Science held at Indianapolis in 1890, some studies and experiments were reported in a short paper entitled "Notes upon the Crystals in certain species of the Arum Family."

This paper expressed the belief that the acridity of the Indian turnip and other plants belonging to the same family, was due to the presence of needle−shaped crystals or raphides found in the cells of these plants. This conclusion was not accepted by Professor T. J. Burrill, of the University of Illinois, nor by other eminent botanists who were present and took part in the discussion that followed the reading of the paper.

The opposition was based mainly on the well−known fact that many other plants like the grape, rhubarb, fuchsia, spiderwort, etc., are not at all, or but slightly acrid, although the raphides are as abundant in them as in the Indian turnip and its allies.

Up to this time the United States Dispensatory and other works on pharmacy, ascribed the following rather indefinite cause for the acridity of the Indian turnip. It was said to be due to an acrid, extremely volatile principle. This principle was insoluble in water and alcohol, but soluble in ether. It was dissipated both by heating and drying, and by this means the acridity is destroyed. There was no opinion given as to the real nature of this so−called principle.

More recently it has been intimated that the acridity may be due to some ferment or enzyme, which has been derived in part from the self−decomposition of protoplasm and in part by the process of oxidation and reduction.

Here the question appeared to rest. At all events I was unable to glean any further knowledge from the sources at my command.

Some time later the subject was taken up in a more comprehensive manner and the following report is the first detailed description of an investigation that has occupied more or less of my leisure for some years.

A dozen or more species of plants have been used for examination and study. Among these were:

Indian turnip (Arisoema triphyllum).
Green dragon (Arisoema dracontium).
Sweet−flag (Acorus).
Skunk cabbage (Spathyema).
Calla (Richardia).
Caladium (Caladium).
Calocasia (Calocasia).
Phyllodendron (Phyllodendron).
Fuchsia (Fuchsia).
Wandering Jew (Tradescantia).
Rhubarb (Rheum).
Grape (Vitis).
Onion (Allium).
Horse−radish (Armoracia).

Most of the plants selected were known to have crystals in certain parts. Some of them were known to be intensely acrid. In these the acridity was in every instance proportional to the number of crystals.

The following order of study was pursued and the results of each step noted. Only the more salient points of the methods employed and the conclusions reached are presented.

1. The Character of the Taste Itself. It was readily noted that the sensation produced by chewing the various acrid plants was quite different. For example, the Indian turnip and its close allies do not give the immediate taste or effect that follows a similar testing of the onion or horse−radish. When the acridity of the former is perceived the sensation is more prickling than acrid.

The effect produced is more like the pricking of numerous needles. It is felt not only upon the tongue and palate, but wherever the part tasted comes into contact with the lips, roof of mouth or any delicate membrane. It is not perceived where this contact does not occur.

The acridity of the onion and horse−radish is perceived at once and often affects other parts than those with which it comes into direct contact.

2. The Acrid Principle Is Not Always Volatile. This is shown by the fact that large quantities of the mashed or finely grated corms of the Indian turnip and allied species, produced no irritation of the eyes or nose even when these organs were brought into close contact with the freshly pulverized material. This certainly is in marked contrast with the effect produced by freshly grated horse−radish, peeled onions, crushed mustard seed when the same test is applied.

It seems fair to assume that in the latter case some principle that is volatile at ordinary air temperatures is present. The assumption that such principle is present in the former has no room.

In order to test this matter further a considerable quantity of the juice of the Indian turnip was subjected to careful distillation, with the result that no volatile principle or substance of any kind was found.

Various extractive processes were tried by using hot and cold water; alcohol, chloroform, benzene, etc. These failed in every instance to remove any substance that had a taste or effect anything like that found in the fresh Indian turnip.

3. The Acrid Principle Is Not Soluble in Ether. Inasmuch as various works on pharmacy made the claim that the active or acrid principle of the plants in question was soluble in ether, this was the next subject for investigation. The juice was expressed from a considerable quantity of the mashed Indian turnip. This juice was clear and by test was found to possess the same acrid property as the unmashed corms.

Some of the juice and an equal quantity of ether were placed into a cylinder and well shaken. After waiting until the ether had separated a few drops of the liquid were put into the mouth. For a little time no result was perceived, but as soon as the effect of the ether had passed away the same painful acridity was manifest as was experienced before the treatment with the ether. A natural conclusion from this test was that the acridity might come from some principle soluble in ether.

Observing that the ether was quite turbid and wishing to learn the cause, a drop or two was allowed to evaporate on a glass slide. Examining the residue with a microscope it was found to consist of innumerable raphides or needle−like crystals. Some of the ether was then run through a filter. The filtrate was clear. An examination showed it to be entirely free from raphides, and it had lost every trace of its acridity. The untreated acrid juice of the Indian turnip, calla, and other plants of the same family was then filtered and in every instance the filtered juice was bland and had lost every trace of its acridity. These tests and others that need not be mentioned, proved conclusively that the acridity of various species of the Arum family was not due to a volatile principle, but was due to the needle−shaped crystals found so abundantly in these plants.

Several questions yet remained to be answered. (1) If these needle−like crystals or raphides are the cause of the acridity of the plants just mentioned, why do they not produce the same effect in the fuchsia, tradescantia and other plants where they are known to be just as abundant? (2) Why does the Indian turnip lose its acridity on being heated? (3) Why does the dried Indian turnip lose its acridity?

It was first thought that the raphides found in plants having no acridity, might be of different chemical composition than those which produce this effect.

A chemical examination proved beyond question that the raphides were of the same composition. The needle−shaped crystals in all the plants selected for study were composed of calcium oxalate. The crystals, found in grape, rhubarb, fuchsia and tradescantia were identical in form, fineness and chemical composition with those found in the plants of the Arum family. How then account for the painfully striking effect in one case and the non−effect in the other? This was the perplexing question.

In expressing some juice from the stems and leaves of the fuchsia and tradescantia it was found to be quite unlike that of the Indian turnip and calla. The juice of the latter was clear and limpid; that of the former quite thick and mucilaginous. There was no difference as to the abundance of crystals revealed by the microscope.

After diluting the ropy, mucilaginous juice with water, and shaking it thoroughly with an equal volume of ether, there was no turbidity seen in the supernatent ether. Allowing a few drops of the ether to evaporate scarcely any crystals could be found. Practically none of them had been removed from the insoluble mucilaginous covering. Here and there an isolated specimen was all that could be seen. So closely were these small crystals enveloped with the mucilaginous matter that it was almost impossible to separate or dissect them from it.

It was now easy to explain why certain plants whose cells were crowded with raphides were bland to the taste, while other plants with the same crystals were extremely acrid.

In one case the crystals were neither covered nor embedded in an insoluble mucilage, but were free to move. Thus when the plant was chewed or tasted the sharp points of these needle−like crystals came into contact with the tongue, lips and membranous surface of the mouth.

In the other case the insoluble mucilage which surrounded the crystals prevented all free movement and they produced no irritation.

Why do these intensely acrid, aroid plants lose their acridity on being heated? It is well known that the corms of the Indian turnip and its allies contain a large amount of starch. In subjecting this starch to heat it becomes paste−like in character. This starch paste acts in the same manner as the insoluble mucilage. It prevents the free movement of the crystals and in this way all irritant action is precluded. In heating the Indian turnip and other corms, it was found that the heat applied must be sufficient to change the character of the starch or the so−called acridity was not destroyed.

One other question remains to be answered. It has long been noted that the old or thoroughly dried corms of the Indian turnip are not acrid like those that are fresh. The explanation is simple. As the plant dries or loses its moisture, the walls of the cells collapse and the crystals are closely encased in the hard, rigid matter that surrounds them. This prevents free movement and the crystals can not exert any irritant action.

It is generally believed by biologists that the milky juice, aromatic compounds, alkaloids, etc., found in plants have no direct use in the economy of the plant. They are not connected with the nutritive processes. They are excretions or waste products that the plant has little or no power to throw off. There can be little doubt, however, that these excretory substances often serve as a means of protection. Entomologists have frequently stated that the milky juice and resins found in the stems of various plants act as a protection against stem boring insects. In like manner the bulbs, stems and leaves of plants that are crowded with crystals have a greater immunity from injurious biting insects than plants that are free from crystals. It is quite generally believed that the formation of crystals is a means of eliminating injurious substances from the living part of the plant. These substances may be regarded as remotely analogous to those organic products made by man in the chemical laboratory.

Some progress has been made in this direction, but so far the main results are certain degradation−products such as aniline dyes derived from coal tar; salicylic acid; essences of fruits; etc. Still these and many other discoveries of the same nature do not prove that the laboratory of man can compete with the laboratory of the living plant cell.

Man has the power to break down and simplify complex substances and by so doing produce useful products that will serve his purposes. We may combine and re−combine but so far we only replace more complex by simpler combinations.

The plant alone through its individual cells, and by its living protoplasm has fundamentally creative power. It can build up and restore better than it can eliminate waste products.