

# Vaccine against Poison Ivy Induced Contact Dermatitis, A Lingering Scientific Challenge

## Abstract

The most common North American plant to cause contact dermatitis is poison ivy (*Toxicodendron radicans*). Urushiol is the oil of the plant to which the majority of people throughout the world are allergic. All parts of the plant contain urushiol which can remain active as allergen for many years.

According to the American Academy of Dermatology an estimated of up to 50 million people in USA annually have an allergic reaction to poison ivy. Canada experiences similar situation. Current scientific research and medical statistics indicate that the risks from high-allergenic plants are getting worse every year. In addition to the contact dermatitis urushiol may, in extreme cases, generate anaphylaxis and even death if contaminated smoke is inhaled after burning of the plant.

Biology and ecology of poison ivy have been abundantly described. Contrarily, medical impact of the plant remains not adequately studied.

In spite of the scope of health and its socio-economical problems, poison ivy dermatitis has not attracted an adequate interest from the scientific communities. Although, preventive measures are elaborate, some protective creams are commercialized, but scientific research on specific immune response and the development of vaccine against urushiol remains a lingering challenge.

## Introduction

Poison ivy urushiol-induced contact dermatitis is an allergic reaction characterized by rashes which usually itch, redden, burn swell and form blisters. Poisoning with urushiol can progress, in extreme cases, to fever, anaphylaxis and even death if contaminated smoke is inhaled after burning dead plants [1,2].

According to the American Academy of Dermatology about 85-90 % of people are sensitive to urushiol and will develop contact dermatitis. The other 10-15 % will never develop a rash [3].

The contact dermatitis may not occur after a person's first exposure to poison ivy. But after the second exposure, people who are sensitive will develop it. While the experts are researching whether the plant itself is stronger, a sensitive person's reactions can become worse every time after subsequent exposure.

In spite of the fact that measures to prevent contact with poison ivy are well known, numerous outdoor enthusiasts and gardeners alike know all too well the itchy or red skin rash caused by poison ivy. Treatment of the urushiol-induced contact dermatitis is rather symptomatic and based on use of over-the-counter (OTC) pharmaceutical products.

Highly allergenic, for thousands of years, poison ivy is ubiquitous plant, causing major health and socio-economic problems through the world. However, scientific and medical communities have not expressed an adequate interest in searching for immunological solution against so common allergy of mankind.

## Review Article

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## Description of Plant

Poison ivy (*Toxicodendron radicans*) is a woody vine with compound leaves comprised of three leaflets. The margins of the leaflets may either be smooth, toothed or lobed. Several subspecies morphologically similar with the plant exist through the world. The plant produces clusters of small, green flowers in June or July. The fruits are small, white berries. Many bird species use the fruit as food source and this spreads seeds to new areas [4].

Poison ivy is considered ubiquitous weed throughout much of its distribution and easily invades areas such as Dulgas-Fir and Ponderosa pine forest, frequently in moist quilles, on sandy, stony, or rocky shores, along the borders of wood, roadsides, fence lines on at the base of talus slopes, as well as many other locations.



**Figure 1:** Poison ivy climbing tree



**Figure 2:** Poison ivy shrub.

Plants may occur as effect shrubs or as vines climbing trees, fences or buildings. The spreading roots can extend for several yards from the plant.

Poison ivy plant has been abundantly illustrate and its taxonomy (biology) and ecologically adequately described is scientific and public literature [5,6] (Figure 1 & 2).

### Urushiol

Urushiol is an odorless, colorless toxic resin found in the sap of the leaves, stems, fruits, flowers and roots of the poison ivy which can cause redness, swelling and blistering of human skin within a few hours of contact. According to the American Academy of Dermatology, only a tiny amount of this chemical - one billionth of a gram- is enough to cause contact dermatitis in many people [7].

The word "urushiol" dates back to the early 1900s, it comes from Japanese "urushi" meaning lacquer. When the Japanese restore the gold leaf on the Golden temple in Kyoto, they painted

the urushiol lacquer on it in order to preserve and maintain the gold. Guess you could say you would be caught red handed if you stole it [1].

Urushiol is s mixture of catechols derivates which have long hydrophobic organic side chains on the carbon 3 position (catechols consist of a 1, 2 di-hydroxy benzene ring and are also known as a diphenols).

Urushiol is a transparent, non volatile olioresin which turns into a brownish lacquer when oxidized. The non-volatile nature of urushiol allows it to adhere to objects such as skin, clothes, tools, gloves and animal fur. It can be absorbed by the skin, inhaled or ingested. Allergic responses may vary depending on the type of exposure.

The allergic reaction displayed in people is a cell-mediated immune response, meaning there is a delay between exposure and visible irritation [8]. Up to 90% of North Americans are allergic to urushiol in poison ivy, small children are the most sensitive to the toxin [5].

Though the chemical is found in and not on the plants, the stems and leaves are easily broken by passing animals, chewing insects or blowing wind. This released the urushiol. Unfortunately, urushiol is sticky, very stable and can remain potent allergen for years even after the plant has died, especially if kept dry [4].

It is strictly recommended not to burn poison ivy. This may release the poison into the air, in the form of smoke. A severe reaction may happen if a sensitive person inhales this smoke, or even death [1].

### Mechanisms of action

After the contact, the urushiol is absorbed by the skin at different rates in different parts of the body, and does not penetrate to the blood and spread. The different exposed skin area though may not react in unison. One area will break out before another area. This gives the impression that the skin reaction is spreading from one place to another [7,9].



**Figure 3 & 4:** Clinical aspect of poison ivy urushiol - induced skin reaction.

Following penetration of the skin, urushiol is metabolized generating a covalent protein/urushiol complex, as a result of electrophilic attack on the amino acids of the protein (the nucleophile). The urushiol is then converted into a reactive quinone (oxidized form of a catechol). This reactive quinone binds to the Langerhan's cells in the epidermis which interact with T lymphocytes (CD8), an immune cell which then sets off immune cascade - resulting in the allergic contact dermatitis immunopathologic hypersensitivity reaction.

Immuno competent cells T lymphocytes (T-cells), which recognize the urushiol as antigen, send out inflammatory signals called cytokines which bring in white blood cells. The macrophages eat foreign substance, but in doing so they also damage normal tissue, resulting in skin inflammation, called delayed hypersensitivity [7]. Poison ivy dermatitis is delayed hypersensitivity immunopathologic reaction. This means that the body reacts to urushiol in a slow rather than fast way.

Within one to two days following contact with urushiol, skin develops rashes, which usually itch, redden, burn, swell and form blisters. The severity of the reaction often depends upon the quantity of urushiol that has penetrated the skin and the degree of sensitivity of exposed person. The rash may appear sooner in some parts of the body than in others, but it doesn't spread. It usually takes about 2 - 3 weeks to disappear [4] (Figure 3 & 4).

### Prevention and treatment

It is folklorically considered that the best treatment of poison ivy dermatitis is prevention. As young children, we learn "leaves of tree, let it be", to remind us to avoid the shiny green leaves of poison ivy. However, avoidance of contact with poison ivy plant and its urushiol is often not possible for the people spending time in nature.

To prevent urushiol penetration into the skin within ten minutes of exposure the following measures should be taken into consideration:

- I. Cleaning of exposed skin with rubbing alcohol. Commercial products like Zanfel Ivy Cleans Toilets and Tecnu Extreme Poison Ivy Scrub are also available over-the-counter, as alternative for alcohol.
- II. Washing of exposed skin with lots of cold water to remove urushiol completely. Hot water is not recommended since it will open up pores and allow more urushiol to penetrate.
- III. Taking a shower with soap and warm water.
- IV. Wearing disposable gloves and wiping of clothes, shoes, tools and anything else that may have been in contact with the urushiol with alcohol and water [4].

In 1996 the FDA approved IvyBlok by EnviroDerm Pharmaceuticals Inc. as a barrier cream. Other barrier creams include, Hollister Moisture Barrier, or Hydropel Moisture Barrier. Cortisone can stop the reaction, but only if it is taken soon after exposure. Other topical products that can soothe itching are Calamine lotion, Zinc oxide ointment, Baking soda paste, or Oatmeal lotions (Aveeno) [7].

Topical application of cold water compresses, corticosteroids relative to itching are recommended. Anytime the skin has breaks in it, infection is a possibility. Therefore, it is to avoid scratching the blisters because they may become infected. Should the blisters start draining yellow pus or have honey colored crusts, then antibiotics should be used for healing [4].

### Vaccines

Allergic contact dermatitis to urushiol is a common problem for which avoidance is often not possible. Native Americans and early pioneers purposefully eating poison ivy to induce immunity through self hypersensitisation has recently been questioned. Despite anecdotal reports, there is little clinical evidence to prove a difference in susceptibility to poison ivy between human races, though rare individuals can show surprising immunity. However, the nature of their immunity has not been investigated.

The susceptibility of animals to poison ivy urushiol is fairly well documented. Only primates and hamsters are known to have an allergic reaction to urushiol, while other animals and birds appear to be immune to its allergic effect [1].

Rare scientific publications show successful immunotherapy in animals but not for humans. Andrews (1930) has stated the "Innumerable attempts have been made to immunize against dermatitis due to poison ivy by ingestion of the leaves, oral administration of the tincture and by hypodermic injection of the toxic extract. None of these measures has definite value either as preventive or as a cure, and sometimes they seem to have detrimental allergenic effect" [9].

Since then, several reports have opened on attempts to desensitization or immunization against urushiol but without convincing results [10,11]. The desensitization obtained appears to be of rather short duration, lasting in some individuals only a few months [12].

### Discussion

Poison ivy has been known by North American natives for its blistering effects for thousands of years, and similar plants were described in the 7<sup>th</sup> century in China, and 10<sup>th</sup> century in Japan [13].

The first European to describe poison ivy was Captain John Smith in 1609. It was him who gave the English name "poison ivy" [13,14].

Poison ivy is listed as noxious weed in the US state of Minnesota and Michigan and in Canada the province of Ontario.

Most people don't have a reaction the first time they touch poison ivy, but develop an allergic reaction after repeated exposure. Since the skin reaction is an allergic one people that show no immune response on the first contact, may develop progressively stronger reaction after repeated exposures.

Everyone has a different sensitivity, and therefore slightly different reaction to poison ivy. Sensitivity usually decreases with age and with repeated exposure to the plant [7].

Contact dermatitis to urushiol of poison ivy has an important impact on the quality of life of people living and involved in direct contact with the nature. The urushiol seems to be most common allergen causing skin rash of the global population.

It is important to point out the consideration that 10-15 % of population will never develop a rash to poison ivy urushiol which is not supported by any known scientific study [3].

In spite of the fact of high medical importance of the urushiol induced contact dermatitis, this condition simply has not yet triggered an adequate attention of the scientific and medical communities.

The majority of the scientific reports, regarding urushiol-induced contact dermatitis, date from the beginning of the last century. Since then most of the information about urushiol induced health problems are coming from the free media publications. Studies of specific immune response are almost nonexistent and studies on desensitization are rather anecdotal without due scientific rigor.

Poison ivy sufferers may be dismayed to learn of recent research of Dr. Jacqueline Mahan and colleagues from Duke University on the impacts of enhanced carbon dioxide levels in poison ivy. Plants grow under higher concentration of this green house gas were found to produce significantly more saturated urushiol (the form that is more allergenic to humans) and to grow faster. They conclude that poison ivy will become more widespread, more aggressive and more toxic in the projected warmer world of the future [6,15]. More evidence is needed to support it!

## Conclusion

Contact dermatitis due to poison ivy urushiol has not attracted an adequate scientific attention, in spite of its high incidence and medical importance through the world. Specific immune response to urushiol has not been studied yet, and the contact dermatitis to urushiol is simply classified as delayed hypersensitivity reaction. Some attempts of desensitization of animals are reported showing no convincing results. Studies of desensitization/immunization in humans carried out at the beginning of the last century

have provided partial and anecdotal results. Urushiol induced contact dermatitis remain an important challenge for scientific communities and vaccine producing industries.

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