

AZTEC PHARMACOLOGY¹

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The great prestige of Aztec pharmacology is based mainly on indirect evidence such as the statements of the 16th century chroniclers and the medical reports from prescientific years. Modern, well-conducted experimental studies are scarce. However, the laboratory confirmation of the pharmacological properties of several plants used in precolumbian medicine lends modern support to the old reputation of Aztec materia medica.

The historical background is important both for explaining the interest in the subject and for judging the possible activity of a product. The Aztecs had developed an advanced culture based on keen observation and empirical knowledge. Their materia medica contained products of vegetable, animal, and mineral origin but plants were the main source for medicines. The plants were cultivated in well-kept botanical gardens located at places of different climates. The Spanish conquerors were bewildered by the beauty, grandeur, and distribution of the gardens in Tenochtitlan, Atzacapotzalco, Oaxtepec, Texcoco, and other towns (1). The description of Indian collecting expeditions and even wars to obtain new species occupied many pages of the historical chronicles. In 1570 Philip II, King of Spain, sent his own physician, Francisco Hernández, to study the medicinal flora of Mexico. It is interesting to read Hernández' *Natural History of New Spain* (2), written after seven years of traveling, collecting, and testing the medicinal properties of the plants he found. At times, he stated his surprise because the plants were prescribed without consideration to their intrinsic "cold or warm, dry or humid nature." In one case, referring to the root of *costicapotoncaxochitl* which he says is of "warm and dry nature in the second degree," he states: "The root is, they say, admirable against fevers, but I do not see how it could be, unless they refer to the chills (fríos) of fevers. . . ." Finally he suggests a conciliation between the facts and his doctrines by accepting a possible mechanism of action, "evacuation of the cause (of fever) in some other way" (3).

The clash of learned philosophical European medicine with the native, empirical knowledge of Aztec physicians was striking. The value of unbiased experience in precolumbian Mexico is worth considering. The weight of old evidence in the general use of a medicinal plant is a good lead for modern research.

Three books are the most reliable first hand 16th century reports on Aztec medicine. The first is Shagún's *Historia General de las Cosas de Nueva España* (4), written by a Franciscan priest after many years of well-conducted field research through informants, among them a group of old Aztec physicians. The statements of these informants were collected as

¹The survey of the literature pertaining to this review was concluded in July 1965.

protocols in Nahuatl, the *lingua franca* of the central Mexico at the time of the Spanish conquest. Sahagún's "History" has been the most valuable text for the study of Aztec culture, but now much attention is being paid to the protocols on which Sahagún's writings were based. These documents are kept at the Laurenzian Library in Florence and at the Royal Palace and Academy of History Libraries in Madrid. It is only four centuries later that these valuable Nahuatl manuscripts are being translated into Spanish by Garibay & León Portilla (5) and English by Anderson & Dibble (6). The second is de la Cruz' *Libellus de Medicinalibus Indorum Herbis*, a manuscript written in 1552 by an Aztec physician. This document has reached us through the Latin translation by another Indian, Juan Badiano. The manuscript kept in the Vatican Library was published in 1940 by the Johns Hopkins Press in a beautiful edition that included color facsimiles, English translation, and commentaries by Emmart (7). A new edition, also with facsimiles, transcription, Spanish translation, and botanical, historical, medical and other commentaries by different authors, was published recently by the Instituto Mexicano del Seguro Social and edited by us (8). This book is the only one we have on Aztec materia medica that was written by the Aztecs themselves. In addition, it has the great value of the color paintings of the plants with Aztec hieroglyphical indication of their ecology, their Nahuatl names, and their uses; 185 plants are illustrated and 251 mentioned. However, since the manuscript was written 31 years after the conquest of Mexico and by a physician working in a school founded 16 years previously and run by the Spaniards, we have found many signs of Western contamination (9). The third is Hernández' *Historia Natural de Nueva España*. Hernández prepared an extensive natural history of New Spain, which contains the description, medical and popular use of the plants. His books contain abundant information, but often the reader detects the unavoidable presence of his European dogmatic judgment. Hernández did not succeed in seeing his manuscripts published during his lifetime. The first publication based on his writings appeared by Ximenez in 1615 in Mexico (10). It was a brief abstract which included additional prescriptions. Ximenez was a priest who worked in a hospital in the village of Oaxtepec, where one of the botanical gardens of Moctezuma was located. His contact with popular and Indian medicine was undoubtedly extensive and his information is valuable. The second abstract of Hernández' writings prepared by Reccho, a Neapolitan physician, was published in Rome by the Accademia dei Lincei in 1651 (11). Then, the Hernández original manuscripts and drawings were lost in a fire. One century later a good edition was started in Madrid when a copy was discovered. Three volumes in Latin were published in 1790 and even a botanical expedition was sent to Mexico to obtain new drawings of the plants described by Hernández. The drawings were lost again, this time during the Napoleonic wars in Spain, and the publication was left unfinished [see Rickett (12)]. Finally, the *Historia Natural* of Hernández was published in Spanish in Mexico, and the great amount of information obtained on the spot in the 16th century has become available (13). Other books and short papers include reference to Aztec medicine

and *materia medica*. Among these are medical books written and published in Mexico during the 16th century by Spanish physicians who included some information on indigenous plants used by the natives: Bravo, 1570 (14); López, 1578 (15); Farfán, 1579 (16); Cárdenas, 1591 (17). The chronicles on life and customs of the Aztecs, written by the first evangelists, also contain valuable data [Motolinia, 1554 (18); Mendieta, 1596 (19); Torquemada, 1615 (20)]. Some priests and lay brothers wrote booklets on popular medicine and Indian herbs [López, 1672 (21)].

All these documents must be read with critical eyes because Western interpretations are mixed with the aboriginal data. Even the Cruz-Badiano manuscript written by an Aztec physician, as we have shown, contains European adulterations as is proven by a reference to Plinius in the original text (22).

However, these data should be studied in order to acquire information on Aztec pharmacology. The cultural values of precolonial Mexico were systematically destroyed after the Spanish conquest. The remaining Aztec population diminished and took refuge in faraway places. In 1577, Hernández asked the King of Spain to publish his writings soon in order to preserve the information as the Indian population was dying and disappearing. Thus, he said it would be impossible to obtain the valuable knowledge again. The color paintings drawn by the Indians (*tlacuilos*) for Hernández were lost in the Escorial fire and left us without the most valuable source for identification of the plants. The black and white cuts published in the Roman edition are undoubtedly European redrawings of the original paintings.

At the present time, the Aztec or Nahuatl names of the plants, as used in the 16th century, are the only clues to their identification. However, the names change from one place to another, and have varied during the last four centuries. The extensive botanical knowledge of the Aztecs reached a meaningful nomenclature, giving the Nahuatl name of the plant and several of its characteristics. The recent discovery of the Cruz-Badiano manuscript has furnished color illustrations of a limited number of Aztec medicinal plants. The hieroglyphic symbols with the figurative representation of several parts of the plant add information, but require close examination and careful interpretation. A fair number of the plants have been identified by Reko (23), Emmart (7), and Miranda & Valdés (24), but there are discrepancies within several of them. Others still escape the efforts of the botanists for their classification.

These circumstances should prevent us from making hasty conclusions about the lack of correlation between the activity of a plant claimed by the long empirical knowledge of the Aztecs and our failure to find it in our laboratories. We might be using a different plant.

From the 16th century to present days, many clinical and laboratory studies of supposedly active plants have been made. An institute was founded in Mexico City in 1888, the Instituto Médico Nacional, for the particular purpose of studying the Mexican flora and its medical and industrial applications. The reports of its 27 years of work appeared in four volumes

of a journal entitled *El Estudio* (1889-93) (25) and 12 volumes of *Anales del Instituto Médico Nacional* (1894-1914) (26). An index of both journals, with a short history of the Institute, was published in 1961 (27) by the National University of Mexico. Several monographs were also published by this Institute, among them five volumes of *Datos para la Materia Médica Mexicana* (1894-1908) (28) and *Farmacopea Nacional* (1913) (29). A present day critical review of the abundant literature leaves the general impression of insufficient scientific evidence. However, a valuable amount of information is found in these publications as well as some reliable contributions concerning chemical and pharmacological properties of several plants that were used in precolumbian medicine.

Several books containing abundant bibliographies on Mexican medicinal plants have been published, but the uncritical inclusion of all sorts of papers, even unqualified reports, produces a great confusion. The best known of these works are Martínez' *Plantas Medicinales de Mexico* (30) and Guerra's *Bibliografía de la Materia Médica Mexicana* (31).

From time to time scattered pieces of research on Aztec pharmacology have been carried out. The recent interest in hallucinogenic mushrooms was started by their "rediscovery" by Wasson (32). However, mushrooms having hallucinogenic properties have been in continuous use in Mexico, but because of their esoteric and religious implications there was some secrecy about them. Many other active materials are used and sold on the open market at the present time. Booths of herb vendors are a regular section of every popular market in Mexico where magic, fantasy, and business are mixed with old experience. The way to find the empirical knowledge of Aztec medicine is to study old evidence and to look for data in faraway places where the Indian population has found refuge. Language barriers, distance, mistrust, and concealment are obstacles hampering its discovery, and after great efforts one may reach only degenerated remnants of a lost knowledge without actual value or only of academic interest.

With all the limitations imposed by the mentioned circumstances, a brief description of Aztec pharmacology follows. Short references to several experimental works have given or taken away support to its legendary prestige.

Aztec therapeutics was based on the use of plants, wild or cultivated in their botanical gardens. When a plant is named after its properties or medical uses (*Cihuapahili* from "cihua," women, and "pahli," medicine, drug), it is a strong evidence of its activity. The coincidental references to the uses of a plant in several old sources of information could also be considered a good lead to a genuine medicine. Unfortunately, there are considerable discrepancies in the data. Only 15 out of the 251 plants mentioned by de la Cruz have been found. Among the 123 medicinal plants included by Sahagún some appear with supposedly different properties as shown by del Pozo (33). The indiscriminate description in Hernández' monumental work, in which 3076 plants were included, is caused by the fact that his naturalist interest went beyond Philip II's original assignment. According

to 16th century medical doctrines, Hernández measured the "dry," "humid," "warm," or "cold" degrees of every plant he collected, regardless of its aboriginal use.

The first chroniclers agree on the presence of true physicians (*ticitl*) in old Mexico. They are described as well trained in the applications of plants without any magical implications, because magic and sorcery were in the charge of different men. However, de la Cruz, the only Aztec "physician" who has left us any written information, includes several magical resources, even excluding those cases in which there is more ignorance than magic. This seems to show that de la Cruz was not a true *ticitl*. Hernández' complaint about the lack of mixtures in medicines as being a failure of Aztec physicians, does not correspond to the de la Cruz prescriptions. In one, there appears a mixture of 11 plants, 4 gems, and 11 different bezoars. This is additional evidence of Western contamination.

In this review, it would be meaningless to give a long list of Indian (Nahuatl) names of plants, animal products, and minerals used in Aztec medicine. Even when these materials have been identified according to modern nomenclature, we cannot include any of them without some proof of activity.

Evidently, Aztec medicine could not be very advanced without anatomical, physiological, and pathological knowledge. However, therapeutics based on experience compares favourably with the Western uses at that time based on complex doctrines and philosophical lucubrations.

Quite often, the plants contained in the Aztec materia medica are pharmacologically active, but this does not mean that the medical uses were correct. Sometimes, the same plant was used for very different diseases and quite often the same name was applied to different plants as the name could refer to a common characteristic such as shape, color, taste, etc. However, any pharmacological activity is a valuable clue for detecting a plant worthy of study. In the literature, there are several cases of important discoveries being made while a plant was being tested for other uses. The findings of Johnson et al. with *Catharantus roseus* G. Don is a good recent example (34).

Several Aztec plants have justified their old prestige when tested in our present-day laboratories. *Peyotl*, *teonanacatl*, and *ololiuhqui* have been substantiated in modern research as having the same pharmacological properties discovered by the Aztecs. *Peyotl*, identified with *Lophophora williamsi* (Lem.) Coult., is a small cactus well described in old chronicles as producing hallucinations and being used in religious and medical practices. In 1888, Lewin (35) confirmed the action of this plant on the central nervous system and since then it has received exceptional attention in pharmacology and ethnology. "Mezcal buttons" are misnomer that gave origin to the name "mezcaline," an alkaloid isolated by Heffter in 1896 (36). Among the several plants called *peyote* in Mexico, reviewed by Shultes (37), mezcal or *mexcalli* is not included. *Teonanacatl*, the sacred mushroom of the Aztecs has been tested, identified, and analyzed recently by the intensive work of Wasson

(38), Heim (39, 40), and Hofmann (41). The universal interest in this new pharmacological agent is shown by the large number of papers that appear in Wasson's bibliography (42). No less than 24 hallucinogenic mushrooms used in Mexico have been identified. All of them are called *teonanacatl* (Nahuatl: God's flesh) because of the religious and divinatory use. Some of them are the following: *Psilocybe aztecorum* Heim, *Psilocybe mexicana* Heim, *Psilocybe zapotecorum* Heim, *Psilocybe semperviva* Heim et Cailleux, *Panaeolus sphinctrinus* (Fr.) Quetelet Fries (38, 43). *Ololiuhqui* have been identified with the seeds of *Rivea corymbosa* L. by Shultes (44). The name refers to the seeds. The plant is called *coaxihuitl* or *coatlxouhqui* in Nahuatl and *xtabentum* in Maya. Ximenez (10) said in 1615 about *ololiuhqui*: "When it is drunk, provokes lasciviousness . . . the priests of the idols used to eat of this plant when they wanted to deal with the devil and to have answers to their doubts. They became mad and saw a thousand phantoms that appeared to their eyes. . . It is not a great mistake to leave unsaid where it grows because it is not important. . . that the Spaniards know this plant." The 16th century chroniclers agreed on the generalized use of these seeds and the Spanish priests tried very hard to suppress it. Recently, Wasson has done research on this plant (45) and Hofmann (46) has isolated active principles. Perezamador and his colleagues (47, 48) have also worked recently on the chemical analysis of this plant.

These three psychotropic plants were used in precolumbian Mexico primarily as hallucinogens for religious and divinatory purposes, but also for the treatment of diseases. It is surprising that they have only recently received scientific attention as for four centuries references to the action of these plants have appeared in all sorts of papers in Mexico. Furthermore, *peyotl*, *teonanacatl*, and *ololiuhqui* are still in use in remote Indian villages, but the people are afraid of the white man's hindrance and persecution because they have been accused of heresy or witchcraft in the past.

The modern requirements for complete identification of a plant, laboratory proof of activity, and isolation of the active principles are difficult to fulfill. Many drawbacks are found; only poor descriptions of the plants are available; usually, only the Nahuatl name is known, and quite often the same is used for different species. The first step should be to evaluate the historical background, and then test the product under the same conditions (preparation, source, way of administration, dose) that were used in the old times.

In the same group of hallucinogens, there are other plants of marked activity which have not received great attention. *Toloache* is used all over Mexico, mainly for the evil purpose of forcing the love of an elusive man. The Aztec *pizietyl*, identified as *Nicotiana rustica* L., was used in sorcery and medicine. The *tlitlilzen* described in old chronicles, with the same hallucinatory properties as *ololiuhqui*, is believed by Wasson (45) to be *Ipomoea violacea* L. Other plants referred to as "satanic," together with *teonanacatl*, are *poiyomatli* and *pipiltzintli*. Wasson (49) suggested that *poiyomatli* could be a Labiatae plant found by him in the Sierra Mazateca in the State

of Oaxaca, Mexico. It is used by the Indians as divinatory, a substitute for *teonanacatl*, and has been classified by Epling & Játiva as *Salvia divinorum* (50).

Toloatzin, *tolouaxihuitl*, or *toloache* has been identified with several species of *Datura* which are found in different regions of Mexico (*Datura stramonium* L.; *Datura meteloides* DuRoi.; *Datura quercifolia* H.B.K.; *Datura villosa* Fern.; *Datura ceratocaula* Ort.; *Datura innoxia* Mill) (30). All these species are said to produce similar effects which are supposed to be caused by the atropine, hyoscyamine, and scopolamine content of the plants. I am not aware of any systematic pharmacological study of the groups of plants called "toloatzin" or "toloache" in Mexico. The complexity of the *Datura* genus has been shown by Safford (51) and Matuda (52).

Tzompantle or *tzompacuahuil* are the Aztec names for the tree now called "colorin" or "patol" in Mexico. This tree has been identified as *Erythrina americana* Mill. The red seeds of this plant were known as a poison producing paralysis and also erotic dreams. The first action was experimentally studied by Altamirano & Domínguez in 1877 (53). They discovered the curarizing action of this plant. These authors observed the "rupture of the physiological continuity between the muscles and their motor nerves" in their experimental dogs, and proposed the name of "eritrina" for the active principle. This principle, an alkaloid, was isolated in 1877 by Río de la Loza who gave it the name "eritrocoraloidina" (54). It is well known that after the study in 1937 by Folkers & Major (55) and their isolation of the alkaloid "erythroidine," this plant was used for the production of curarizing agents used nowadays in surgery, shock therapy, and physiological laboratories. It is interesting to mention that the flowers of *Erythrina americana* are eaten fried in Mexico as a dish without any toxic effects.

Cochitzapotel or *Iztuczapotel*, Nahuatl names meaning "sleep zapote" or "white zapote" (zapotel: sweet fruit), refer to a tree (*Casimiroa edulis* La Llave et Lex.) whose seeds have been used in popular medicine as a hypnotic and tranquilizer since Aztec times. Hernández (56) and Ximenez (10) mentioned this property of the fruit, but they warned against the poisonous effect of the seeds. The powder obtained from burned seeds is claimed by them to be effective for the treatment of ulcers. The hypnotic properties of the seeds were tested at the Instituto Médico Nacional and positive results were reported by Flores (57). Recently, an extensive chemical work has been done on the isolation of the constituents of this plant by Kincl and his colleagues (58) and Iriarte and his colleagues (59).

Cihuapahitli is the name of a plant used by the Aztecs for the activation of labor. It appears in almost every 16th century document on Aztec materia medica. De la Cruz (8) included the illustration of this plant and prescribed it for cases in which "a woman has difficulty in elimination of the fetus or just to facilitate delivery." At the present time, it is sold by herb vendors at the popular markets and is used very widely. Mexican physicians have seen women suffering from tetanization of the uterus because of an overdose of *cihuapahitli*. It has been identified with *Montanoa tomen-*

tosa Cerv. and is found in many parts of the country. Clinical activity has been noted by many physicians (60, 61, 62). Experimental work has been done by Ramírez (63) and Derbez, Pardo & del Pozo (64). They obtained good, positive results on "spontaneous" activity and on provoked responses of the uterus of cats and guinea pigs, both pregnant and nonpregnant. Chemical isolation of active principles has been tried by Armendáriz (65, 66), García Colín (67), Hidalgo (68), and others.

Yoloxochitl is another plant commonly used in precolumbian times as a medicine for several diseases. Some chronicles say "it gives comfort to heart." *Yoloxochitl* means "heart flower" from Nahuatl "yolotl," heart, and "xochitl," flower. This name seems to come from the shape of the flower which resembles a heart, and not from its action (69). It was used by Aztec nobles as an ornamental flower because of its beauty and perfume. It was held in great esteem and was cultivated at the botanical gardens. This plant (*Talauma mexicana*) is still used in popular medicine for heart diseases. It is found at the booths of herbalists and it is represented at the center of the emblem of the Mexican Cardiological Institute. Pérez Cirera & Roca (70) found that the extract of the leaves produced positive inotropic effects on the frog heart and eventual systolic standstill. Pardo, García Tellez & del Pozo (71) obtained improvement on ischemic muscle contraction similar to that produced by digitalis. Finally, Pardo (72) studied the effects of the plant on the electrocardiogram of the cat and detected changes similar to those seen after the administration of digitalis bodies (73). However, no cardioactive compounds have been isolated.

The plant *Thevetia nerifolia* was known in precolumbian times under the name of *yoyotl*. Nowadays it is called "codo de fraile" (friar's elbow) and is used in popular medicine. Méndez, Sodi-Pallares & Nava (74) have isolated a crystalline substance for which the name "thevetoidin" has been proposed. The pharmacologic testing revealed a marked digitalis-like action.

The fascinating field of Dioscoreas is not strictly Aztec medicine as the present use of these plants is based on elaborate chemical procedures. However, "cabeza de negro" (*Dioscorea mexicana*) and "barbasco" (*Dioscorea composita*), the main sources of diosgenine, were used by the Indians for medical purposes. Plants of the genera *Dioscorea* and *Smilax*, both sources of sapogenins, are illustrated in the Cruz-Badiano manuscript (8). In his interesting book, Krieg has described many details of the Dioscoreas story (75).

Several pharmacologically active plants have been studied in Mexico without reference to Aztec medicine. We know that their use comes from old times but we lack historical data. The "tullidora" or *Karwinskia humboldtiana* is a very interesting plant whose ingestion produces a progressive paralysis in man and animals. This appears after several days of latency. Castillo Nájera (76) observed a group of soldiers intoxicated and with extreme paralysis; several died. Padrón (77) studied clinical and experimental cases. Escobar & Nieto (78) demonstrated the axonic degeneration produced by this herb. Del Pozo (79) analyzed evolution of paralysis in numerous animals.

There are many old references to plants that are described as very active pharmacologically. There are also recent studies of numerous plants, but without sufficient scientific observations. This reviewer prefers to leave the subject at this point, in which the facts are still reasonably proven, instead of continuing with a great number of medicinal plants used by the Aztecs, which have not been subjected to modern studies.

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