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# Cruz-Badiano codex and the importance of the Mexican medicinal plants

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**ABSTRACT**

Plants have been used by human for thousands years as natural curative products. Ancestral populations from China, Egypt, India, and México, among others, are cultures that found the curative effects of different plants. A very invaluable document is the Cruz-Badiano codex. This codex was written in 1552 and presented as a gift to the King of Spain, the codex deals with herbolary and traditional Mexican medicinal plants. The main goal of this study is to show the importance of the Cruz-Badiano codex which is based on the native and traditional medicinal Mexican plants used for treatment or as cure in the ancient times. A brief historical overview of the Cruz-Badiano codex, his origin and the round trip between México-Spain-México is described. Some of the beautiful handmade illustrations of Mexican medicinal plants are shown. And a brief review of plants that have been subject of pharmacological studies is given.

**Key words:** Martin de la Cruz, Juan Badiano, Mexica, traditional herbolary, curative plants.

## INTRODUCTION

The *Mēxihcah* (Mexica, or Aztecs) are herbs used to treat illnesses typical of México over hundred of years. Later on, after the Spanish conquest of México in 1521, the information about these medicinal herbs that was transmitted by generations orally and was contained in pre-Columbian Aztec codices was transferred to other codices including the Matritense, Florentine, and Cruz-Badiano (Espinosa et al., 2016).

Several native Mexican cultures were known for their extensive use of native herbs for medicinal purposes. The Mixtec and the Zapotec in the south, the Maya in the southeast of México, the Teotihuacan and the Purépecha in the center, and the Mexica across a large part of the country, used a wide variety of medicinal herbs years before the arrival of the Spanish conquerors, and continued using them years after the conquest. These herbs or medicinal plants were classified in the Matritense, Florentine, Toscano and Cruz-Badiano codices. The last of these, called *Amate Cehuatl Xihuitl Pitli* in Nahuatl, *Libellus de Medicinalibus Indorum Herbis* (Native medicines and herbs notebook) in Latin, or Codex Barberini and dating from 1552, is a pictorial compilation of medicinal plants and different remedies used by the natives to cure various physical ailments in New Spain in the XVI century, and is considered to be a masterpiece of world medical literature (García and Blanco, 2004). According to Jesus Kumate (1992) (former Mexican Secretary of Health), it is "the summary description of the medical practice of the Aztecs, not only for herbal medicine but also for its mineral, animal and psychological matter". Beginning from around 1550-1600, Spanish and other European scientists analyzed the basic chemical contents of these traditional Mexican herbs; their analyses were of course severely limited by the knowledge and technology available at the time. At present, international institutions and laboratories use modern science and technology to carry out sophisticated analyses of medicinal plants for a wide variety of purposes, including deriving new drugs. Such research has obvious potential benefits for humanity.

The aim of the present study is to present the Cruz-Badiano codex that is based on the native and traditional use of medicinal Mexican plants. A brief historical overview

of the Cruz-Badiano codex, his origin and the round trip between México-Spain-México is shown. Additionally, some handmade illustrations of Mexican traditional medicinal plants that are used till today are shown and a brief review of plants that have been subject of pharmacological studies is given.

## MATERIALS AND METHODS

This study is a product of a bibliographical investigation where books, specialized articles and databases were consulted. Documentary information, the term codex (lat. codex) applies to ancient manuscripts prior to the origin of the printing. The Cruz-Badiano codex was written 31 years after the fall of Tenochtitlán, ancient capital of the Aztec Empire, by the native Martín de la Cruz and translated into Latin by the indigenous Juan Badiano in 1552 in El Colegio de la Santa Cruz (The College of the Holy Cross) in Tlatelolco, being the first book of medicine written in America (Del Pozo, 1964). The codex was commissioned and transported to Spain by Don Francisco de Mendoza, son of the first viceroy of New Spain, Don Antonio de Mendoza, as a gift to the King of Spain Carlos V (García and Blanco, 2004; de la Cruz, 1964), with the intention of obtaining permission from the Spanish Crown to trade with spices and medicinal plants of America (Aranda et al., 2003).

There is little knowledge about the lives of the authors before and after the writing of the codex, but it is known that both belonged to El Colegio de la Santa Cruz. Martín de la Cruz was born in Tlatelolco, herbolary man, member of the indigenous nobility, healer of the viceroy Don Antonio de Mendoza and the native student's children of that college. Juan Badiano was born in of Xochimilco and was teacher of the El Colegio de la Santa Cruz. For the authors, the preparation of the codex represented the opportunity to recommend the college to the King of Spain, in order to avoid its closure and obtain financial support (Viesca, 1992).

Cruz-Badiano codex description, the codex book front and back cover are in red velvet; the paper for the 140 pages used for the text and illustrations came from Genoa Italy. The writing of the texts was done by hand, and two types of ink were used: brown for all the texts, descriptions and remedies; and red for the names of the plants and the chapters of the manuscript. The red color, originally from México, came from the cochineal *Dactylopius coccus* that parasitizes plants of the genus *Opuntia*. The 185 handmade color illustrations were done by Mexican native artisans called *Tlacuilos* (the one who write or paint; painters of the codices, maps and murals) in Nauahtl (Stols, 1964; González, 2015).

One of the most notable features of the codex are the 185 paintings of the plants that illustrate it, some of which are complemented by images of animals, rocks and water bodies. The latter do not only serve as decorative elements, in some painting they are indicators of environmental and ecological characteristics of the place where the plants grow (Somolinos, 1964). For example, Figure 1 shows the plant *Nonochton azcapan ixhua* (unidentified species) growing close to the ants. These images capture the natives pictorial tradition and mix it with the concept of western art, with which the codex represents the union of indigenous art, ideography and symbolism with European science, giving the codex an aesthetic and scientific value (Fernández, 1964).

Codex structure, the codex has 13 chapters where the remedies for the treatment of different diseases, infections and wounds are described. The first seven chapters mention the cures for specific parts of the body such as head, which includes: hair, eyes, ears, nose, mouth (and its internal structures), face, throat and neck; parts of the thorax like: chest, heart and abdomen; and the upper extremities (de la Cruz, 1964).

In chapters eight, nine and ten, the cures for the pubis area of the human body, urinary diseases, armpits odor, feet problems and joint problems are mentioned; also include the treatment for: the fatigue, body burns, struck by lightning, against fear, hit by the gale, among others (de la Cruz, 1964).

Chapter eleven is dedicated to treat women period(menstrual) problems, childbirth and breastfeeding. Chapter twelve is devoted to the treatment of burns in children, and for infants who don't want breast milk. And chapter thirteen focuses on signs of the proximity of death, and some remedies for the dying (de la Cruz, 1964; Viesca, 1992).

The diseases and treatments described in the codex are arranged following a sequence that starts in the head and ends in the feet (Sanfilippo, 1992). This classification is in accordance with the native vision of the correspondences to the 13 heavens and the nine regions of the underworld, ruled by the forces and beings that reside in each one (Viesca, 1992). Another very interesting and important classification in the Cruz-Badiano codex is the cold and hot nature of the different parts of the human body, related to the cosmic equivalences. The entire human body can be characterized by the temperature and together all the parts must be in balance for the proper functioning of the organism (Viesca, 1992).

Journey to Spain and return to México, after his arrival in Spain, the codex was presented to the future King of Spain Felipe II (son of King Charles V), who ordered it to be archived in the Royal Library in 1553 (Viesca, 1992). In the beginning of the XVII century, the codex was passed into the custody of Diego Cortavila and Sanabria, apothecary of King Felipe IV. Later, around 1625, the codex was obtained by Cardinal Francisco Barberini, the nephew of Pope Urban VII, and was included in the Barberini library for the next three centuries. In 1902, this library was acquired by the Vatican (Kumate, 1992; García and Blanco, 2004), and in 1929, the codex was discovered by Charles Upson Clark, a


**Figure 1:** Plant *Nonochton azcapan ixhua* growing close to the ants and its way of use written in Latin.

professor of history at Columbia University. Ten years later, it was published in English by William Gates, and also in the same year, in Spanish by Demetrio S. García (García and Blanco, 2004). In the year 1990, the Cruz-Badiano codex returns to México as a gift from Pope John Paul II to the Mexican, and since then it is under the safekeeping in the library of the *Instituto Nacional de Antropologia e Historia* (INAH). Finally, thanks to scanning technologies, the codex was totally digitized and the entire images are available on the INAH website (INAH, 2018).

As regards Mexican medicinal plants today, the botanical diversity in México is the result of the physical complexity of the territory (territorial extension, diversity of climates, altitude, topography, geographic location, geology, etc.) (Durand and Neyra, 2010). The country has 23,314 species of vascular plants (Villaseñor, 2016), many of which have been used in ornamental, food and medicinal aspects.

Many of the pre-Hispanic medicinal plants are in current use till now, such as the *chicalote* (*Argemone ochroleuca* Sweet) which is used to treat eye conditions, and the *pericon* (*Tagetes lucida* Cav.) that is used to treat digestive disorders (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018; García et al., 2012).

Some examples of the plants mentioned in the codex are shown in Figures 2 to 7. These plants are sold commercially and are still used, although the current use is not always related to its original use.

***Quauhtlaxoxocoyolin* (*Begonia gracilis* Kunth) (Figure 2):** The Cruz-Badiano codex (XVI century) indicates that the juice of this plant was used for the treatment of baldness and dandruff (de la Cruz, 1964; INAH, 2018). Currently, it is used as a purgative (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018).

***Xaltomatl* (*Jaltomata procumbens* (Cav.) J.L.Gentry) (Figure 3):** The Cruz-Badiano codex indicates that when the eyes are warmed by an illness, they are treated with a distillate of the root of this plant (de la Cruz, 1964; INAH, 2018). Currently, it is used to treat ulcers, bile, nerves,


**Figure 2:** Plant *Quauhtlaxoxocoyolin* (*Begonia gracilis* Kunth).


**Figure 4:** Plant *Azcapan yxhua tlahcolpahtli* (*Datura stramonium* L.).

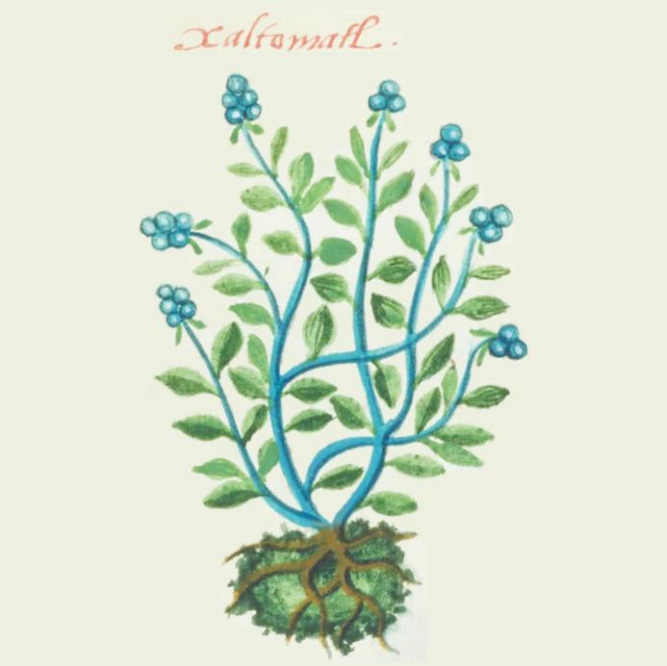


**Figure 3:** Plant *Xaltomatl* (*Jaltomata procumbens* (Cav.) J.L.Gentry).


**Figure 5:** Plant *Tememetla* (*Echeveria gibbiflora* DC.).

diarrhea, among others (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018).

***Azcapan yxhua tlahcolpahtli* (*Datura stramonium* L.) (Figure 4):** This plant, which is born next to the anthills, was used to reconcile or attract sleep (de la Cruz, 1964; INAH, 2018). In different states of the country, it is currently used for its analgesic qualities, as an anti-inflammatory of the womb, to treat vaginal infections, to lessen the pain of childbirth, in skin problems, among many others (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018).

***Tememetla* (*Echeveria gibbiflora* DC.) (Figure 5):** In the XVI century, the leaves of this herb, ground in water and mixed with other plants and white soil, were used as part of

**Figure 6:** Plant *Tlalhaueuetl* (*Agastache mexicana* (Kunth) Lint & Epling).

**Figure 7:** Plant *Yolloxochitl* (*Talauma mexicana* (DC.) G. Don.).

the treatment or to cure an inflamed mouth (de la Cruz, 1964; INAH, 2018). Currently, it continues to be used to cure oral ailments, in addition to dermatological treatments (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018).

***Tlalhaueuetl* (*Agastache mexicana* (Kunth) Lint & Epling) (Figure 6):** The root of this plant was used to treat wounds (de la Cruz, 1964; INAH, 2018). Currently, it has a variety of uses: to treat scares and nerves, in treatments related to gastric problems, cardiovascular disorders, and when mixed with other plants are used to treat different diseases (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018).

***Yolloxochitl* (*Talauma mexicana* (DC.) G. Don.) (Figure 7):** In the codex Martín de la Cruz notes that as part of the treatment for mental stupor, the person, before eating, should drink the juice of flowers and ingest the bark and roots of this plant (de la Cruz, 1964; INAH, 2018). It is currently used for heart conditions, and when mixed with other plants are used to treat different diseases (Biblioteca Digital de la Medicina Tradicional Mexicana, 2018).

## DISCUSSION

Several of the codex plants, whose biological identification is currently known, have been the subject of pharmacological studies to identify the chemical compounds they possess and the real effect they generate. An example of the above is the work carried out by Estrada-Reyes et al. (2014), who found that low concentrations (from 0.1 to 10.0 mg/kg) of aqueous extracts of *A. mexicana* ssp. *mexicana* and ssp. *xolocotziana* have an inhibitory activity on anxiety, while high concentrations (over 100 mg/kg) induce a sedative action that affects general activity and motor action. In addition, they found that these *A. mexicana* subspecies do not have a significant health risk because of their low toxicity. In these studies, the authors used a high performance liquid chromatography-electro spray ions-mass spectrometry (HPLC–ESI-MS) method to determine and compare the chemical composition of both *A. mexicana* subspecies, and found: Luteolin7-O-β-D-glucoside, Luteolin7-O-β-D-(6″-O-malonyl)-glucoside, Diosmetin 7-β-O-glucoside, Diosmetin 7-O-β-D-(6″-O-malonyl)-glucoside, Acacetin, 7-O-β-glucoside, Acacetin 7-O-β-D-(6″-O-malonyl)-glucoside, Acacetin-7-O-β-glucoside-D-(2″-acethyl-6″malonyl), Acacetin, Diosmetin, GardeninAþNa, 5,6,7,8,3-Pentahydroxy,4-methoxyflavone and 8-Hydroxy-salvigenin.

Also, Juárez et al. (2015) studied the *A. mexicana* ssp. *xolocotziana* essential oil extract to evaluate their antifungal activity efficacy as a substitute for synthetic chemical fungicides. Using Hydro-distillation and GC–MS, they extracted and identify the components of the oil and found that estragole and methyl eugenol were the major components. This essential oil shows a strong antifungal activity against a panel of eleven fungal strains isolated from wheat grains during storage. The minimal inhibitory

concentration determined for all the strains tested range from 0.3 to 30 µg/mL and showed no toxicity when exposed to neither human-derived macrophages nor brine shrimp.

In the search for novel molecules with therapeutic properties for treating asthma, especially those which involve a contractile process of the smooth muscle cells, the Mexican medicinal plants *A. mexicana* and *T. mexicana* organic extracts were evaluated *exvitro* to determine their relaxing activity on the contractions induced by carbachol in isolated rat tracheal rings. Extracts were obtained by maceration at room temperature using hexane, dichloromethane and methanol for each plant material, and the results showed that the extracts with more significant effects were dichloromethanic extracts of *T. mexicana*, while the extracts obtained from *A. mexicana* were fully effective but less potent than *T. mexicana* (Sanchez et al., 2014).

Reyes et al. (2002) used the purified fraction from the plant from the Crassulaceae family named *E. gibbiflora* (which is popularly used as a vaginal postcoital rinse to prevent pregnancy without side effects), to evaluate whether the effect on the modification of human sperm plasma membrane and metabolism is adequate for a male contraception. The results showed that an enhanced activity of the immobilizing and agglutination effects was induced instantaneously after the addition the purified fraction of *E. gibbliflora* in sperm. Also, the hypotonic-like effect included a distension of the plasma membrane over the acrosome region and in some occasions around the sperm middle piece. In a similar study, Cordero et al. (2016) employed the aqueous crude extract of *E. gibbliflora* to evaluate the functional parameters of mouse sperm, to evaluated its effect on $Ca^{2+}$ influx and to determined the acute toxicity. They found that the capacitation and acrosome reaction suffered a significant decrease in a concentration-dependent manner, coinciding with the reduction of $Ca^{2+}$ influx, however, the sperm viability was not affected by the presence of different concentrations of the aqueous crude extract. Finally the aqueous crude extract showed an $LD_{50}$ of 3,784.42 mg/kg and can be classified as a low toxic substance.

*Montanoa tomentosa*, known as zoapatle in México is a plant that has been used in traditional medicine for the last five centuries and is appreciated for its medicinal properties. Its phytochemical studies have shown that it contains several classes of chemical constituents including flavonoids and terpenoids, and is well recognized that many of these compounds produce anxiolytic-like effects. Sollozo et al. (2015) tested the anxiolytic-like effect at different concentrations (1.5, 3.0, 6.0 and 12.0 mg/kg) of *M. tomentosa* in male Wistar rats and they found that at 3.0 mg/kg, the anxiolytic-like effects were induced without producing locomotor impairments; however, at higher doses, sedative effects were observed. Another compounds obtained from the leaves of *M. tomentosa* are the diterpenoid oxepanes zoapatanol, montanol, tomentanol and tomentol, which have been on use for centuries to prepare tea to induce menses, labor, and terminate early pregnancy (Cossy et al., 2008).

Another contribution of the Cruz-Badiano codex, is the first illustration and record of the *Tlilxochitl* (Black Flower), now known as vanilla (*Vanilla planifolia* Andrews) (Gómez, 2008). This species of orchid is a very important Mexican present to the world, first was taken to Europe by Spaniards, and currently is known all over the world. It is one of the most popular spices and is found in the third place after saffron and cardamom as flavorings (Baquiero and Guerrero, 2017). Currently, the vanilla has been used: a) in medicine, their extracts are used in aromatherapy to diagnose Alzheimer, as cancer inhibitor; b) in pharmacy, to mask unpleasant taste medicines, especially for children; c) as antioxidant, the vanillin has antioxidant capacity, also it is used in the food area as preservative; d) as antimicrobial, the vanilla properties can inhibit the growth of *Escherichia coli*, *Lactobacillus plantarum*, and *Listeria innocua*; e) in perfume industry, owing to its aromatic characteristics, vanilla was added to products for beauty care such as soaps, shower gels, among others and f) in foods and drinks (Baquiero and Guerrero, 2017).

In a different kind of study, Espinosa et al. (2016) determined by gamma spectrometry the natural and artificial radioactivity concentration in 30 Mexican medicinal plants and found different contents of natural $^{40}K$ , low concentration levels of natural radioactivity and no artificial radionuclides. A few of the analyzed plants are know since the times of the codex, as such *A. mexicana*, *D. stramonium*, *T. mexicana*, *Selaginella lepidophylla* and *Montanoa tomentosa*. In this study, the radiological content of the plants analyzed does not represent a risk to the health of the consumers.

**Economic importance of the Mexican medicinal plants**

In México, around 3,352 species of plants are used to treat illnesses (Bye, 1998) of the nervous, vascular, respiratory, digestive, urinary, reproductive system, among others. Due to their low cost and easy access, many doctors and health specialists in México prescribe various medicinal plants, ingested mainly in the form of infusion, for the treatment of not very severe diseases of the respiratory and digestive system (Alonso et al., 2017). About 90% of the Mexican population consumes traditional herbs, for 45% of the country's population (in part because their economical situation), it is the only medicinal resource they can have access to, while the other 45% uses medicinal plants in combination with allopathic medicines (Muñeton, 2009). Just in México City around nine tons of medicinal plants are sold in a single day in different markets, and up to ten tons can be sold in the most well-known market in the city (Sonora Market) (Muñeton, 2009). The market for

medicinal plants is thus surprisingly large and very important economic spill in the country. From a socioeconomically point of view, the Mexican herb industry gives employment to several thousand families, both urban and rural area.

Final comment, the Cruz-Badiano codex is a compendium of the remedies used by the natives to cure various ailments and is the result of the knowledge generated by the interaction of the natives with their environment and their religious beliefs. Its elaboration was possible thanks to the interest of Spaniards who sought to obtain benefits from the medicinal plants of the new world, and a group of natives who wished to save the *El Colegio de la Santa Cruz*; and unlike the Mayan culture, whose codices were destroyed on July 12 in 1562 by Diego de Landa Calderon, the knowledge embodied in the Cruz-Badiano codex opens a window to the culture and traditional medicine of the Mexicas. In recent years, several plants mentioned in the codex have been the subject of pharmacological studies with the aim of obtaining new drugs for medicine.

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