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Current Status: Mexican Medicinal Plants with Insecticidal Potential

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1. Introduction

Plants have been used for thousand of year as a source of bioactive substances for therapeutic, agricultural and industrial purpose; in this regard the search for compounds active on these sources is an alternative for development of agrochemicals (Dayane et al., 2009). The plans, their derivatives or extracts have been studied for different biological activities in economically important pests, assessing their toxic effects lethal, antifeedant, repellent, fumigant, growth regulation and deterrent to oviposition, among other (Isman, 2006; Singh and Saratchandra, 2005).

The ecological balance and the organisms of various ecosystems are vulnerable by excessive or careless use of pesticides in agricultural or urban system. In theory, through using these products is to provide enough food and pest control, in contrast, often cause undesirable and dangerous environmental situations. Therefore, before to take a decision on the use of any pesticide, you should be aware that if the use of these substances is performed under controlled conditions and with full knowledge of its adverse properties, the survival of living things and balance of nature can become seriously affected (SEMARNAT, 2011).

The use of plants as a source of active compounds emerged as friendly alternative the indiscriminate use of synthetic products for pest control, which has causes toxicity to human health, biodiversity impoverishment, damage to beneficial organisms and favor the emergence of strains of pests resistant to these product, so it is common to increase the application rate risk to public health and the environment (Siqueira et al., 2000).

The rescue of rudimentary practices used by farmers in pest management is one of the options to find alternatives to the frequent use of synthetic pesticides. This report compiles information about the use of Mexican medicinal plants, native and introduced in the pest control mainly of the system agriculture and livestock primarily, and report an analysis of current status and recommendations for use botanical insecticides.

Currently investigations are conducted to determine the potential pesticide plant (used in herbal medicinal) , its derivatives or extracts, such as several spices of the family Asteraceae, Euphorbiaceae, Solanaceae, Meliaceae,Convolvulaceae, Lauraceae, Piperinaceae, and Anonaceae, among other (López-Olguín et al., 2002; Pereda-Miranda & Bah, 2003; Prakash &

Rao, 1997; Ramos, 2010; Rodríguez et al., 1982). For instance in the family Convolvulaceae, some species of the genus *Ipomoea* such as *I. tricolor*, *I. batata* and *I. murucoides* are traditionally used as nutricional, emetic, diuretic, diaphoretic, purgative (Pereda and Bah, 2003) and pesticidal agents (nematodes, insects, and weeds) (Jackson & Peterson, 2000; Vera et al., 2009; Vyvyan, 2002).

2. Botanic pesticide

In ancient culture and in different parts of the world has existed for thousands of years (~1500 before J. C.) empirical knowledge of the use of plants for pest control, for example, the neem in India, rotenone in East Asia and South America, pyrethrin in Persia (Iran) and sabadilla in Central and South America later botanical insecticides were introduced in Europe and Unite States (Weinzierl, 2000). Since the late 1800s to the 1940s, these products were widely used to protect crops and stored products. It was in the early 1940s and the 1950s which the development and commercial success of synthetic insecticides led to the abandonment of botanical insecticide in agriculture of the industrialized countries, as they won space on the market as products cheaper, effective, long-lasting and readily available. Only the botanical insecticides which remained in use in the Unite States after 1950, were pyrethrins (such aerosol spray and in home and industry) and nicotine (used primarily in the gardens). Already in the 1990s renewed interest stems from the use of botanical pesticides, because it is recognizes the impact on health and environmental that the synthetic insecticides cause, and their presence in food (Weinzierl, 2000).

Botanical pesticides are formulations of organic solvents and aqueous based on different parts of plants (crude extracts) or derivatives thereof, are prepared in powder or liquid concentrates that can be incorporated into talc or clay for application either concentrated or diluted in a solvent such as water, ethanol and petroleum ether, among others (Isman, 2008). These products consist of a group of active ingredients of different chemical nature (Isman, 1997). Preparations from plants such as pyrethroid, rotenone, neem, and citronella, commonly are formulated as liquid concentrates or extracts. The processed form of these products, are purified and isolated substances from plants through a series of extraction and distillation (Weinzierl, 2000).

Through different studies have found that the biological activity of botanical extracts pesticides it is different significantly depending on the species of plants, plant parts used for the preparation of the extracts, the physiological state of the part used, of the solvent extraction, and the insect species under study (Shaalan et al., 2005). Although these products are of natural origin cannot be assumed to be completely safe, some plant-derived compounds, such as nicotine are extremely toxic to humans, or when used several times in continuous time, can affect the natural biotic control of pests by their natural enemies. Therefore, it is important to use correctly the technique and safety equipment when working on the preparation and application of botanical extracts, and recognize the appropriate dose formulation and its use in a program of integrated pest management, which will help efficiently to obtain the benefits of these products. Despite there are many plants and chemical constituents known to have insecticidal properties or insectistatic, few have been used for commercial production. Issue that has been reviewed by several researchers as Graiger and Amhed (1988) and Isman (2008). The Use large-scale commercial of the plant extracts as insecticides began in the 1950s with the introduction of nicotine from *Nicotiana tabacum*, rotenone from *Lonchocarpus* sp, derris from *Derris elliptica,* and pyrethrum from flowers of *Chrysanthemum cinerariaefolium* (Isman, 2008).

Gaugler (1997), mentioned concerning this that the inconvenient of these products are offset by its lower toxicity, higher levels of security and in addition to generally exhibit lower accumulation in the environment, characteristics that should be used to promote their sales (Silva et al., 2002). These products have the advantage of being generally compatible with other programs acceptable alternative integrated pest management, such as practices, cultivation of plants resistant to pests, pheromone oils, soaps, entomopathogenic, predators and parasitoids, among others (Brechelt, 2008). Botanical pesticides already registered and approved are promoted for organic crop production especially in industrialized countries and for production and postharvest food protection in developed countries (Rodriguez, 1997).

Actually in the Unite States the registration of the botanical insecticides request few requirements, for that reason allows a wide range of these products, including pyretrins, neem, rotenone, sabadilla, ryania, and nicotine. Essential oils are also sold although several of them do not have a complete record (Isman, 2006). In Latin America, it is common that the production of oil and botanical extracts for pest control is done without regulatory system and small scale for local use in low-income populations. As in all developing countries, lack of training of relevant legislations to regulate these products has complicated the registration process, this is the case of Mexico with the insecticide Biocrack® (garlic extract) Berni Labs who have gave the record seven year after starting its activities (Silva *et al.*, 2002). On the other hand, Mexico allows the use of many products sold in the Unite States as the PHC™ NEEEM™ (31.2 g i.a. L^{-1} azadirachtin) and NEEMIX® 4.5 (47.6 g i.a. L^{-1} azadirachtin) and the insecticides approved for their use are pyrethrum, rotenone, nicotine, garlic and capsicum extract and powder the mixture of neem leaf and seed (Grain Protector®, Mexican Fitorganic) (Isman, 2006).

In Mexico, Ultraquimia Group S.A. de C.V., manufactures organic and agrochemicals products used in the control of plant health problems and carry out coordinated studies with researchers from the National Research Institute Forestry, Agriculture and Livestock (INIFAP) to determine the biological effectiveness of botanical insecticides produced, such as BIODI®e, PROGRANIC® CinnAcar and PROGRANIC® Nimicide 80 among others, recommended for control of Diaforina (*Diaphorina citri*), mealybug (*Planococcus citri*), whitefly (*Bemisia tabaci, Trialeurodes vaporariorum),* aphids diver *(Paratrioza cockerelli),* bold *(Phyllocoptruta oleivora),* asian citrus psyllid *(Diaphorina citri),* diamond back moth *(Plutella xylostella),* worm looper *(Trichoplusia ni),* thrips *(Thrips spp., Frankliniella spp., Caliothrips phaseoli, Heliothrips sp.)* and aphids *(Aphis spp, Myzus persicae, Brevicoryne brassicae, Toxoptera spp.).*

Isman (1999) indicated that within 10 to 15 years, specifically the botanical insecticides probably represent about 50% of the total insecticide market. However, the current availability of biopesticides market comprises a small portion of the total volume of pesticides available. According to FAO data, world consumption of bioinsecticides for 2009 represented 0.2 % of the total consumption of insecticides (FAO, 2009). Nevertheless, these products remain important in the insect pest management for the reasons mentioned above.

FAO (1999) indicated that little information exist about the use of botanical pesticide on the crop protection or stored food, also have been few evaluation of the effectiveness of these materials under real conditions of use on field. Currently plant species more recognized and evaluated under laboratory conditions belong to the genus *Azadirachta, Piper, Chenopodium, Ipomoea, Mentha, Annona,* and *Tanacetum*. However, the use of most of these plants has not been divulged due to lack of appropriate programs and properly established of outreach and training. Multinational corporations in western Mexico are implementing alternative pest management in tobacco-growing areas, to try to reduce the amount of synthetic pesticides used; in this sense, botanists become an effective and attractive alternative (Isman, 2008). Several traditionally used plant preparations have found local commercial markets, for example *Ryania speciosa* (Ryania) (Flacourtiaceae) which contains an insecticidal alkaloid, and *Haplophyton* spp. (Apocynaceae) have been used in the West Indies and Mexico for crop protection (FAO, 1999), situation depicted a growing and progressive interest in the use of this alternative in pest management, however the situation is confused, because sometimes ambiguous recommendations are made about the local use of these products without having been previously validated by field investigations and biosecurity. In Mexico and throughout Latin America, this is common, and is manifested in the publication of manuals that describe and encourage the use of botanical pesticides, which usually collect basis of partial observations and reviews established by the people that have empirically determined the effectiveness of certain plants and their formulated in the pest management.

Undoubtedly, it is not strange that in the short term register new plants and compounds with potential usefulness pesticide or plaguistatic with novel modes and sites of action to ensure their gradual distinctiveness in the market and enabling to increase the range of low-risk alternatives for pest management.

3. Modes and sites of action

In the current development of botanical insecticides has increased interest in the characterization of the active compounds. Secondary metabolites of plants with insecticidal or insectistatic properties cause alterations in biochemical and physiological insects (hormonal, neurological, nutritional or enzymatic) when operating with repellent, antifeedant, growth regulation, oviposition deterrent and lethal toxicity, among other activities (Isman, 2006; Singh & Saratchandra, 2005).

Different modes of action are described for many active compounds, for example, when are applied on the crop to be protected, they can act systemically in the plant by penetrating through the stomata and transported through the vascular system, altering its enzymatic complex, transpiration and changes in the composition of sap; other phytocompounds increase plant's energy, promote the synthesis of sucrose to help strengthen your metabolism and immune defense system. In many cases induce repellency and excitement of the nervous system from insect pests hindering the flight and oviposition therefore decrease the populations of insect pests.

The mechanism of action and target sites of the active phytochemicals on insects is diverse. Some cause effects by contact or ingestion being generally difficult their detoxification. The extracts or phytocompounds that acting through contact can penetrate and dissolve the lipoprotein matrix of the cuticle and cell membranes of insects destroying the exoskeleton, disrupting permeability and cellular physiology, causing dehydration and consequently death or reduce the oxygen consumption of nymphs, larvae and adults killing them by asphyxiation, affect the peripheral and central nervous system causing hyperexcitation, hypersensitivity, to external stimuli, seizure, muscle tetanization, effect protein synthesis and cell membranes, causing further death. The hyperexcitation of the nervous system also cause the masking of pheromones responsible for the mating process. The phytochemicals that acting by ingestion alter the physiological rhythm of the digestive system, preventing the contraction of the muscles of the intestine, causing his paralysis and hemolysis. There are components that act as repellents to block and inhibit the ability to search and locate food (antifeedant effect) reducing the amounts ingested and increased parasitism and predation by staying longer exposed to the environment and weak; repellency may be regarding the use of systems of chemical interaction between plant-insect chemical; the alomones, that plants synthesize when interacting with individuals of another species (insect pests, for example) induce them respond with physiological change or behavioral modifying which favors only the plant. The mechanism by which the repellent activity occurs could also be due to a mixed action for an unpleasant effect on the sensory endings as well as a chemical blocking of the perception that insect use for guidance.

The phytochemicals that cause lethal toxicity against insects larvae affect on any of the following target sites: midgut epithelium, gastric caeca, malpighian tubules, and in the nerve axon because disruption of channel sodium whose result in the insect is hyperactivity and seizure. The mechanism of action involves disruption of metabolism both through inhibiting the transport of electrons and uncoupling the ATP transport system, depolarization of the membrane potential, effect on calcium channel with sustained muscle contraction and inhibition of acetylcholinesterase (Shaalan et al., 2005; Weinzierl, 2000). Other phytocompounds asset, have a high effect of "knockdown", causing that the insect to stop feeding, become paralyzed and die of starvation soon after being in contact with the product or treated surfaces.

In experimental tests with sublethal concentrations of the extracts or active compounds of plants, there is often an extension of the period of biological development of the insects under study, making it possible to determine the characteristics effects of botanical extracts classified as regulator of growth, which contain phytoecdysones, phytojuvenoids and juvenile hormone causing prolongation of the stages of development, affecting the size, adult emergence, the physiology of reproduction by disrupting the reproductive system, fertility and hatching of larvae, resulting in effective control (Shaalan et al., 2005). The effect of phytochemicals that cause growth inhibition in various stages of development of insect pests act through inhibiting larval and pupal molt, longer duration of larval and pupal stage, morphological abnormalities and mortality during the molt among other effects (Shaalan et al., 2005).

Morphological abnormalities are observed in different development stage of insect, such as damage in the process of melanization in larvae and pupae, death in the intermediate stage of a larva and pupa (in this case can be observed organisms with the head of a pupa and the abdomen of a larva), death of adults with wings caught in the pupal exuviae and adult difficulties to fully emerge (Shaalan et al., 2005), these anomalies indicate an inhibitor effect on metamorphosis, probably due to disruption of hormonal control, and interference in the synthesis of chitin during the molting process (Pushpalatha & Muthukrishnan, 1999; Saxena & Sumithra, 1985). In the embryonic stage usually observe dehydration on eggs, bleeding, and death of embryo.

The biological effects of the phytocompound mentioned above are manifested individually or in combination depending of the chemical enrichment of plant species with potential pesticide and interactions that exists between the compounds. Many of the botanicals products that exhibit combined effects, such as the simultaneous damage in the larval development time and adult emergence, occasionally extend to the progeny of the larvae exposed to these treatments (Shaalan et al., 2005).

Boeke et al. (2004), validated the toxic and repellent effect of 33 plants used in Africa since the antique of empirical and traditional manner, for beetle *Callosobruchus maculatus* control.

The laboratory evaluation showed that the powders of *Nicotiana tabacum*, *Tephrosia vogelii*, and *Securidaca longepedunculata* significantly reduced the number of beetle progeny and the species *Clausena anisata*, *Dracaena arborea*, *T. vogelii*, *Momordica charantia* y *Blumea aurita* had repellent activity, as reported experimentally that the majority of species assessed, provided effective control against *C. maculatus*.

Certain compounds are well known for their mechanisms of action, as quassin, a triterpene isolated from the wood of *Quassia amara* (Simaroubaceae). The quassin is an insecticide that show effects on the mosquito larval *Culex quinquefasciatus* through the inhibition of tyrosinase enzyme activity and consequently alter the development of the cuticle (Evans & Raj, 1991). This compound has also been tested successfully in cereal crops to control aphids (Sengonca & Brüggen 1991) by the mechanism of inhibition of enzymes of the insect.

Species of the family Meliaceae are source of azadarachtin, a limonoid marketed and appreciated by their biological activities pesticides, such as the antifeedant effect, the regulation of growth, as ovicidal and larvicidal, among others. The main effect of azadirachtin is to inhibit development, especially affecting the molt, by inhibiting the hormone ecdysone. Scott et al. (1999), showed that azadirachtin caused inhibition of voltaje K^+ channel in cultured rat neurons, this compounds has also shows antimitotic affect on *Sf9* insect cell line, resulting in prolongation of repolarization (Salehzadeh et al., 2003). Microscopic studies have indicated that azadirachtin interfere with the formation of the mitotic spindles and in the assembly of microtubules in the axoneme during microgametogenesis of *Plasmodium berghei* (Billker et al., 2002).

The family Piperaceae has been used as sources of pesticides to contain piperamides, several lignans, and derivates of benzoic acid. The piperamides, are molecules with dual biological activity, the amide group is neurotoxic and secondly the group methylenedioxyphenyl (MPD) is an inhibitor of cytochrome P450 in the insect pest, which participates in the metabolism of fatty acids and steroids (Scott et al., 2003).

Commercial botanical insecticide, rhodojaponin-III, islated from *Rhododendron molle* effect on more than 40 species of insect pests being antifeedant, oviposition, ovicidal, inhibitor of growth and change and toxic by ingestion and through contact. Previous studies indicate that this compound inhibits proliferation of *Sf9* insect cell (isolated from pupal ovariantissue of *Spodoptera frugiperda*) dose-dependent effect. Besides interfering with cell division, the concentration of [Ca^{2}+], and intracelular pH (Cheng et al., 2011).

4. Pesticide compounds

Plant extracts and their derivatives are a source of many chemical compounds with potential insecticide or insectistatic and processed forms of botanical insecticides are isolated and purified compounds through extractions and distillation. For instance, nicotine and limonoid are distilled from plant extracts (Weinzierl, 2000).

Plants produce a vast and diverse reserve of secondary metabolites actives on different animals and plants of other species, allowing them to maintain relations of cohabitation (attractants) or defense (toxic or repellent substances) (Kutchan & Dixon, 2005). These secondary metabolites are not essential for growth and development of plants, but they are required for interaction with the environment and to respond to pressures such as scarcity of water and nutrients, extreme temperatures, to deter to the herbivores microorganisms and viruses; also serve as signals to communicate with other organisms (Felton et al., 2008; Wink & Schimmer, 1999).

The demand dynamic of biotic and abiotic environment gives the natural plasticity to the secondary metabolism and encourages the evolution of genetic diversification of the plant and thus generating a abundant group of natural products with variety of chemical structures (Kutchan & Dixon, 2005) many case bioactive (Macías et al., 2007).

The biosynthesis of secondary metabolites and storage of these compounds is regulated in space and time, so the growing tissues are more vulnerable and more protected than the old or senescent tissues. For instance, is usually observed in seeds, latent and period of germination, flower buds and young tissues retain a certain amount of specific compounds or are actively synthesized. The organs that are important for the survival and multiplication, such as flowers, fruits and seeds, are almost always a rich source of chemical defenses (Wink, 1999). In addition, the metabolic profile usually varies between parts of a plant, including developmental stages, sometime during the day, the geographic location of the plant species and between plant species (Wink, 1999).

Many secondary metabolites have biological activities such as insecticides, fungicides, and phytotoxic properties that can be employed in agriculture (Wink, 1999) either alone or in combination with other chemical and biological (Trysyono & Whalon, 1999; Weinzierl, 2000). Particularly during the past 20 years, phytocompounds such as terpenes, alkaloids, rotenone and pyrethrum have gained commercial importance for the development of botanical insecticides (Isman, 2006).

Macías et al. (2007), mention that it was until the twentieth century when the study of plant compounds and their mechanism of action is made relevant. The development of spectroscopic technique allowed the isolation and identification of pure active compounds such as (5E)-ocimenone from *Tagetes minuta* (1978), rotenone from *Derris elliptica* (1983), azadirachtin from *Azadirachta indica* (1981), capillin from *Artemisia nilagirica* (1990), quassin from *Quassia amara* (1991), neolignans from *Piper decurrens* (1996), arborine, a new bioactive compound related to quinazolone alkaloid, from *Glycosmis pentaphylla* (1999) and goniothalamin From *Bryonopsis laciniosa* (2003) (Shaalan et al., 2005).

Kathuria and Kaushik (2005), determinedthe antifeedant effect of etanol extracts of leaves from *Eucaliptus camaldulensis* y *Tylophora indica* en *Helicoverpa armigera* (Hûbner) and found that the alkaloids identified in *T. indica* are responsible for this activity. In another study, extracts were evalued red maple (*Arce rubrum*) resulting assets over *Malacosama disstria* larvae, causing antifeedant affect. Gallates derivatives (1-O-galatoil-L-ramnosa) present in the plant were compounds responsible for this activity (Zaid & Nozzolillo, 2000).

5. Mexican medicinal plants

According to estimates published up to now, Mexico is the third country worldwide with a diversity of vascular plants. Of the 250 000 species located around the world, in the Mexico there are 22 411 (10%), not including nearly a thousand species (Villaseñor & Magaña, 2002; Vovides et al., 2010). Diversification, is back to geological times and have been possible by the variety of soil conditions, climate and topography of the country, as well as plant genetics and anthropogenic activities of conservation, introduction, selection and plant breeding.

In general terms, the biological, ecological and cultural diversity of Mexico has led to the generation of empirical and scientific knowledge, the first has its origins in ancient times with the practices of observation to the nature and experimentation through trial and error, inheritance transmitted from generation to generation through texts or stories. Through the inventory made under the empirical system made were possible the first classifications of plants with data on their ecology, biological importance and usefulness (Gómez-Pompa, 2010). In Mexico the codices written by important pre-Hispanic groups are transcendental. With regard to the Azteca codex De la Cruz-Badiano is a record conceptual and illustrative of the medicinal plants used in New Spain of the Sixteenth Century, regarded worldwide as one of the best collections of Mexican folk medicine, this wealth of literature has fractured and disrupted on several occasions, however, has been rescued, preserved and expanded by the country's ethnic groups and has now increased interest to validate through experimental science (Bye & Linares, 1999). Scientists from Mexico and other countries have used the codices, herbal, picked and general ethnobotanical practices for various purposes, among these, botanists have been interested in reviewing corroborated and enrich the etnoflora catalogs, describing the location, uses regional and popular names of plants and the phytochemical have used ethnobotanical studies as a reference for the location of plants with biological significance and the search for new phytocompounds useful in protecting, and preserving food un pre- and post-harvest either as pesticides and botanical repellents, as well as raw materials for pharmaceutical, cosmetic, chemical, beverage, food and bioprocesses. A current record, provides that Mexico has about 7 000 species of vascular plants with some use for various purposes (Caballero & Cortés, 2001).

Importantly, there are still many regions of Mexico to explore thoroughly, to have an updated inventory of plants, a situation that reflects the potential in the many uses of these resources. In these sense, diversity and identification of endemic, native, and introduced strengthen several areas of research, local and foreign plant extracts or their derivatives. Of the plants with some kind of use, 3 300 species have medicinal use (Pérez, 2001); in addition to its therapeutic properties, many of these plants have the potential to be used in the management of pests and phytopathogens of agricultural and livestock importance, ancient practice that originated with the beginning of agricultural activities. The global ecological problem that exists in modern times, mankind has created demand for residue-free agricultural products and alternatives to reduce agrochemicals use, so that the development of conservation and sustainable agriculture was necessary and this favors the development and commercialization of these botanical pesticides.

6. Ethnobotanical study of Mexican medicinal plants with insecticide potential

Traditionally, the plants located in each geographic region of Mexico, are used for different purposes. Many have multiple applications and properties, the literature quotes are cite both for its medicinal properties as insecticides and antiparasitic properties. It is estimated that in Mexico there are about 7 000 useful plant species, representing 31% of vascular plants located in the country (Caballero & Cortés, 2001).

Ethnobotany is considered as a source for research of phytopesticides of interest to the agricultural and livestock with production sustainable and alternative.

This paper conducted a literature search and review of the publications on ethnobotanical studies in the country, plants that farmers and people in general routinely used to protect crops, stored grain, and ornamentals (Table 1). To confirm the medicinal use of plants

PLANT	Common name	Other use	Municipality or Community/ Reference	Plant part used	Preparation	Application forms	Species/location of control
ASTERACEAE							
Senecio salignus	Chilca	Remedy (foliage) andornamental	Tzental Region, Chiapas/Miranda, 1952				Corn and bean weevil (*Acanthoscelides obtectus* y *Zabrotes subfasciatus*)/store
Artemicia ludoviciana	Mugwort wormwood	Medicinal and pesticide (CONABIO, 2009)	Ixtapan de la sal/Rodríguez, 2008	Whole plant	Drying	Among the sacks of corn	Weevil/store
CAPRIFOLIACEAE							
Sambucus mexicana	Elder	Ceremonial, medicinal	Santos Reyes Nopala, Oaxaca	Fresh or dried leaves	Pulverized leaves	Arrange altérnate layers of leaves, then corn	Pest of stored maize and beans
FABACEAE							
Eritryna americana	Zompantle	Insect repellent, living fence, medicinal, ceremonial	/Hasting, 1990; Rodríguez, 2008	Seed	Combustion	Use of smoke	Corn and bean weevil /store

Table 1. Plants with potential pesticide used in different regions of Mexico

PLANT	Common name	Other use	Municipality or Community/ Reference	Plant part used	Preparation	App f
MELIACEAE						
Cedrela spp.		Timber Medicinal	Cuetzálan, Puebla y Chicontepec, Veracruz/ Rodríguez, 2008	Leaves and seed	Dust	Mix v beans
Melia azedarach	Tree of Paradise	Medicinal	Martínez de la torre, Veracruz/ Rodríguez 2008	Dried leaves	Dust	Mixe corn
Trichilia havanensis	Xopiltetl		Tuzamapan de Galeana, Puebla/Rodríguez, 2008; López-Olguín, 1997	Leaves and fruit	Dust	Muxe corn beans
PIPERACEAE						
Piper auritum Kunth	Mumo, yerba santa	Medicinal	Chatino territory, Oaxaca/ Miranda, 1952	Whole plant	Dried and ground	
			Tepetate, Veracruz/ Ortega & Rodríguez, 1991	Whole plant	Powdery	

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Piper sanctum	homeoquelite	Medicinal	Cuetzálan, Santiago Yancuitlalpan y San Miguel Zinecapan, Puebla/ Rodríguez, 2008	Leaves	Dried	Cover the soil with a thin layer of partially dehydrated leaves, then a layer of corn and so on to accommodate the entire crop	
POLYPODIACEAE							
Pteridium aquilinum		Medicinal	Los Altos de Chiapas, México/ Ramírez *et al.*, 2006	Whole plant	Aqueous extracts by infusion 5%	Infusion applied to cabbage plants infested with larvae	Larvae of the second stage of *Leptophobia aripa* Elodia. Cause 27% mortality
RUTACEAE							
Zanthoxyllum liemmanianum	Colopahtle (tongue grass)	Remed for amoebiases and helminthic	Valle de Tehuacán, Puebla				Wood

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PLANT	Common name	Other use	Municipality or Community/ Reference	Plant part used	Preparation	App fo
SAPINDACEAE						
Dondonaea viscosa			/ Lagunes *et al.*, 1984			
SMILACEAE						
Smilax aristolochiaefolia	*Sarsaparrilla*	Medicinal	/ Martinez, 1983			
			/ Lagunes *et al.*, 1984	Whole plant	Maceration	
S. morarense	*sarsaparrilla*	Medicinal	/ Martinez, 1983			

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PLANT	Common name	Other use	Municipality or Community/ Reference	Plant part used	Preparation	Application forms	Species/location of control
S. morarense	*sarsaparrilla*	Medicinal	/ Lagunes *et al.*, 1984	Whole plant	Maceration		Cause 40% mortality and reduces weight more than 50% in larvae of *S. frugiperd*a
SOLANACEAE							
Capsicum spp.	Chile	Insect repellent, dye, medicinal, cosmetic	Oaxaca/ Rodríguez H. C. 2008	Dried fruit	The fruit is roasted	The smoke is passed through the corn stored, locally know as "mats" to repel insects	Weevil /store
Cestrum anagyris	Huele de noche	Medicinal	/Ortega & Rodríguez, 1982	plant, leave, flower and the mix of leaf-flower	Infusion and maceration		Mortality of fourth instar larvae of *Culex quinquefasceatus*// Laboratory tests
			Lake Texcoco (laboratory and field test) / Rodríguez & Lagunes, 1987	Leave	Maceration	Bioassay and application of macerated in trays distributed later in southeast shore of lake	Field: mortality of fourth instar larvae of *Culex quinquefasceatus* (75%)

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PLANT	Common name	Other use	Municipality or Community/ Reference	Plant part used	Preparation	App f
Cestrum roseum		Medicinal	Lake Texcoco (laboratory and field test) / Rodríguez & Lagunes, 1987	Leave	Maceration	Bioas appli mace trays distri later south shore
Cestrum thyrsoideum		Medicinal	Lake Texcoco (laboratory and field test) / Rodríguez & Lagunes, 1987	Leave	Maceration	Bioas appli mace trays distri later south shore
Datura stramonium	Toloache	Medicinal	/Rodríguez, 2011	Whole plant		Interc speci cultiv *Nicot tabacu*
Solanum cervantesii			/ Lagunes *et al.*, 1984		Maceration	

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PLANT	Common name	Other use	Municipality or Community/ Reference	Plant part used	Preparation	Application forms	Species/location of control
STERCULIACEAE							
Guazuma tomentosa	Cuahulote	Medicinal, craft, cosmetics, fuel, fodder, fiber, ceremonia, flavoring, and sugar industry	Laboratory tests/ Lagunes *et al.*, 1984	Whole plant	Macerated		Cause 40% mortality and reduces weight more than 50% in larvae of fall armyworm (*S. fugiperda)*
TROPAEOLACEAE							
Tropaeolum majus	*Capuchina* Mastuerzo	medicinal	Tarahumara of México Region/ Rodríguez, 2011	Fresh plant	Macerated aqueous 10% with paste soap 0.1%		Whitefly control in vegetables
TURNERACEA							
Turnera diffusa			Field trials/Jiménez &Villar, 1990		Infusions	Tests with one and three applications per week	Significant *S. fugiperda* control, compared to grain yield

Table 1. Plants with potential pesticide used in different regions of Mexico

concerned are consulted databased of Plant Atlas of Traditional Mexican digital library of Mexican Traditional medicine of the National Autonomous University of Mexico with access at www.medicinatradicionalmexicana.unam.mx, as well as the book "The scientific investigation of the Mexican medicinal herbs" (Aguilar et al., 1993) and publications with information ethnobotany.

7. Studies of insect pests of agricultural importance

In Mexico and many parts of the world, people field for various decades have been consistently observed in their environment, and empirically they have selected plants that are not attacked by diseases and pests, many of which can be used as repellents and pesticides. Among the more promising botanical insecticides from the standpoint of its regulation, marketing and use, are products derived from plants that have already been validated by their pharmacological activity and insecticide, as the powdered of leaves and seed from neem (Grain Protector®) and garlic extract (Biocrack®) (Silva et al., 2002).

According to Dev and Koul (1997) worldwide about 2 000 plant species have insecticidal active compounds with significant, mainly distributed in 61 families, of which we have identified for Mexico around 14 families of vascular plants by the number times cited in total publications consulted in this review, they are Asteraceae, Meliaceae, Convolvulaceae, Flacourtiaceae, Liliaceae, Solanaceae, Euphorbiaceae, Fabaceae, Lamiaceae, Rutaceae, Myrtaceae, Verbenaceae Burceraceae, Caricaceae (Table 2), despite diversity of resources with propierties worldwide, only a few of these species have commercial value in the market phytoinsecticides. Some authors like Isman (2006) mention that in modern times should restructure the search for new species with insecticidal or insectistatic activity and concentrate on the validation, regulation and marketing of phytoinsecticides already known for their potential. In developing countries like Mexico, is possible that the search of species with potential for pest control play an important role in food production (agricultural and livestock) and public health and livestock, because of empirical and traditional in several regions have been using some native species with this potential, either in the form of hedges, crude extracts, combustion products, powders, resins, latex, sap, poison baits or live plants interspersed throughout the orchards.

Although Mexico exist isolated investigations on the search for plants with insecticidal activity (in some case having as antecedent pharmacological activity),there are well established research groups from different institutions of the country, for several years, have established this area as its research. A clear example is found in the Postgraduate College (Montecillo, Texcoco, State of Mexico) where Dr. Cesáreo Rodríguez Hernández, Dr. Laura D. Ortega Arenas and the group of contributors, since 1981 have worked consistently for the validation of plans that have traditionally been used since ancient times in rural communities across the country. About 30 rears, Dr. Rodríguez has collected and documented information from various parts of the country about the type local vegetation, plants with properties, uses, controlling pest species and forms of preparation. Generally, the information is recorded as prescription practices used among rural workers, agricultural technicians and promoters of organic farming, which details the use of local flora for the preparation of powders, baits or extracts, using materials available in the field. These research ranging from the intensive search for potential plant species present in a community insecticide and conducting toxicity tests on one or more species of insect pests of worldwide importance such as *Spodoptera frugiperda* and the complex of while fly, or a local impact, such as *Leptophobia aripa elodea* (Table 3). The evaluations have been conducted in species of insect pests warehouse, public health and agricultural, using different parts of the candidate plants for preparations carrying out tests in laboratory and field level in several states. The information that Dr. Rodríguez and other working groups with whom he has worked, is recorded in different memories of the event "national and international symposium on plant and mineral substance in pest control" performed periodically in Mexico and is also published in scientific journals.

In this sense, Villavicencio-Nieto and colleagues (2010), have determined that the State of Hidalgo there is much dependence on farmers for the local flora, the Autonomous University of Hidalgo State investigated the traditional use of 124 species of plants in the region, specifically for the pest control, only 97 of them being medicinal and 11 are used as insecticides. This research found that these plants have different uses in other regions of Mexico, including pharmacologic, as is the case *Galphimia glauca,* which have been used all its parts in different products (extracts, powders, essencial oils and resins) used in the management of pests of livestock agriculture, and health, such as human lice. Plant species most used in the communities of Hidalgo were *Trichilia havanensis*, *Psidium guajava*, *Nicotiana tabacum*, *Tagetes erecta*, *Mentha rotundifolia*, *Ipomoea stans*, *Tagetes lucida*, *Parthenium hysterophorus,* and *Schinus molle*. As a result of surveys conducted in this investigation, Villavicencio-Nieto and colleagues found that the plants with insecticide potential under study, are used to control 29 different pest species such as lice, fleas, weevils, ants, mosquitoes, cockroaches, among others, and are toxic to vertebrates such as dogs, squirrels, rats, snakes, and raccoons. This marks the importance of promoting the proper use of botanicals among communities.

At the Center of Development of Biotic Products (CEPROBI) National Polytechnic Institute, Dr. Camino Lavín, developed his research on finding alternatives to the use of synthetic pesticides and in 1985 founded the department of plant-insect interactions, which among other line, encourages the development of phytoinsecticides. Currently, this line of research continues the group of collaborators and has evaluated *Ficus goldmanii, Ficus petiolaris* (Moraceae), *Cochlospermun vitifolium* (Bixaceae), *Croton ciliatoglanduliferus* (Euphorbiaceae), *Crescentia alata* (Bignoniaceae), *Phitecellobium dulce*, species of the genus *Tagetes* (Asteraceae) and also species in the Sierra Huautla, at the State of Morelos, as *Prosopis laevigata* (Fabaceae) and species of the genus *Bursera* (Burseraceae) *and Lupinus* (Fabaceae), which is known that several species have compounds with insecticidal and medicinal activity. They have also evaluated the biological activity of seeds of different varieties of *Carica papaya* (Caricaceae), which present effect insecticide e insectistatic against *Spodoptera frugiperda* (Franco et al., 2006).

In the Autonomous University of San Luis Potosi, have been assessed by laboratory tests, powdered of leaves and flowers from 81 plant species belonging to the Asteraceae family, the selection was made considering that this family includes many species with insecticidal activity or deterrent and also because they have pharmacological activities, the evaluations were conducted on *Sitophilus zeamais*. Of the 169 powder tested 50 were promising, highlighting the powder of leaves from *Zinnia acerosa* and *Z. peruviana*, in terms of insectistatic activity highlighted *Bahia absintifolia*, *Stevia pilosa* and *Jefea brevifolia* (Juárez-Flores et al., 2010).

Trichilia havanensis (Meliaceae) is a species found from southern Tamaulipas to Tabasco and Chiapas, in considered native to Mexico and given its relationship with *Azadirachta indica* and *Melia azaderach* belonging to the same family, has been studied for over 15 years in the Benemerita Autonomous University of Puebla. The assessments are aimed at finding alternatives to control *Ceratitis capitata*, fruit pest species with cosmopolitan distribution and quarantine regulations in several countries, his control is restricted to the use of insecticidal organophosphates and pyrethroids. Other insects that have been used for the evaluations are *Spodoptera exigua*, especies del género *Phyllophaga*, *Leptinotarsa decemlineata*, *Thrips tabaci*, *Helicoverpa armígera*, *Spodoptera litorali* and *Hypotenemus hampei*. Actually, after years of experimentation and validation is likely to be patented and marketed a bioinsecticide obtained from the fruit species (López-Olguin et al., 1997; López-Olguin et al., 1998; López-Olguin et al., 2002).

The National Autonomous University of Mexico there is also consolidated groups of researchers in this area. The Department of Naural Products Chemistry Institute have among their line of validation of natural products with antifeedant and insecticidal activity, particularly plant species of the Labiatae, Burseraceae and Verbenaceae family. Have evaluated the activity of the purified active compounds are present in species such as *Vitex hemsleyi*. The tests were done in neonate larvae of *S. frugiperda* (Villegas *et al*., 2009). In the Faculty of Sciences, is studying the antifeedant activity of plant extracts from *Acacia cornigera*, *Bursera* species and some species of Solanaceae, the evaluations are performed on neonate larvae of *S. frugiperda*, and is also looking for alternatives to control *Boophilus microplus*.

Northern Sierra of Oaxaca, community groups have received government support for production to tomatoes and other vegetables, have been advised by engineers and technician from the Institute of Technology in the Oaxaca Valley, the presence of whiteflies in the crop has been controlled with the use of extracts and infusions of garlic, onions, marigolds, basil, pepper, rue, chamomile, and others, the advantages are clear as reduces the investment cost and the food product developed under the organic system can be sold at higher prices.

In the highlands of Chiapas cultivation of cabbage (*Brassica oleracea*) is of economic importance are usually affected mainly by the cabbage worm *Leptophobia aripa elodia* to control in these communities have used synthetic pesticides, to reduce costs, health problems and pollutation, El Colegio de la Frontera Sur has sought alternative biological control. This region has recorded around 1650 medicinal plant species, however, there are no studies on the effect of extracts of these species at different developmental stage of *L. aripa elodia*, a situation that prompted the selection of 15 wild species of insecticidal activity history ethnobotanical and medicinal use. The results showed no significant activity on *L. aripa elodia* although some of the species tested showed activity against *Locussta migratoria* and *Trichoplusia ni*, therefore should continue investigating the potential of these species in pest management (Ramírez-Moreno, et al., 2001). There has also been collecting traditional knowledge of indigenous Tzeltal farmers of Chiapas highlands, on the management of agricultural pests (ants, *Phyllophaga* spp., *S. frugiperda*, *Doru taeniatum*, *Diphaulaca wagnerii* y *L. Aripa elodia*) four of the most common crops in the region, this led to the evaluation of the sensitivity of these pest species and 64 medicinal wild plants belonging to the basic list of useful plants from this ethnic group, the idea to promote local and regional control ecological these pests (Trujillo-Vázquez & García-Barrios, 2001).

In the Biological Control Laboratory, Biotechnology Research Center, of the Autonomous University of Morelos State (UAEM), for 15 years under the initial coordination of Dr. Eduardo Aranda Escobar+, we have developed the research of plant extracts with biological activity on insect pests. Most plants have been collected in the State of Morelos, many of which have pharmacological properties (Table 4). Among the species tested include the genus *Ipomoea* (Convolvulaceae) bioassays have been done on *S. frugiperda* y *Bemisia tabaci* at different stages and we have observed different biological activities of the extracts, some *Ipomoeas* cause lethal toxicity against larvae and nymphs between 2-100% mortality (*I. carnea, I. pauciflora, I. intrapilosa, I. cuernavacensis, I. murucoides*), others cause decrease in weight of the larvae of *S. frugiperda* between 90-15% reduction (*I. murucoides*, *I. carnea* e *I. pauciflora*) and others affect the life cycle (*I. carnea*: cause malformation of pupae and adult difficulty to emerge, *I. pauciflora*: prolonged pupal development time). We also conducted tests on the establishment *in vitro* of Ipomoeas with potential, as an option to develop biotechnological technique for various purposes; one is to optimize the use of phytocompounds responsible for biological activity on insect pests (Toledo, 2001; Aguirre, 2008; Gaona, 2009; Vera et al., 2009; Guzmán-Pantoja et al., 2010).

Although they are abundant records of plants with insecticidal potential, before recommending its use should be tested for biosafety and formulation, it is important to the safety of these products in non-target species and the health of domestic animals and humans. Although most species with a history of drug use in communities has an apparent safety backup, remember the legacy of Paracelsus (1567) "the dose makes the poison". Another factor to consider is the stock of plants because it could jeopardize the survival of these species in the ecological environment, in this regards is necessary to implement strategies for the compounds responsible for biological activity according to the phenological stage of the plant and seasonality is needed to establish the dates of collection and, if possible, establish community gardens for intensive planting of these plants with potential insecticide would have continuous availability of phytoinsecticides.

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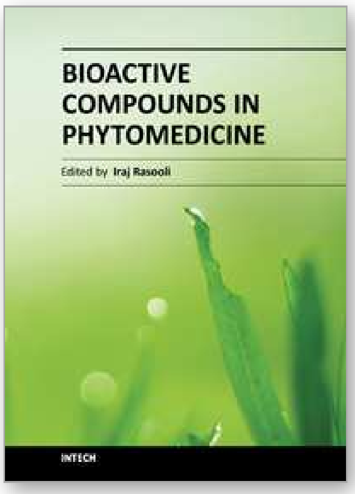

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There are significant concerns regarding the potential side effects from the chronic use of conventional drugs such as corticosteroids, especially in children. Herbal therapy is less expensive, more readily available, and increasingly becoming common practice all over the world. Such practices have both their benefits and risks. However, herbal self-therapy might have serious health consequences due to incorrect self-diagnosis, inappropriate choice of herbal remedy or adulterated herbal product. In addition, absence of clinical trials and other traditional safety mechanisms before medicines are introduced to the wider market results in questionable safe dosage ranges which may produce adverse and unexpected outcomes. Therefore, the use of herbal remedies requires sufficient knowledge about the efficacy, safety and proper use of such products. Hence, it is necessary to have baseline data regarding the use of herbal remedies and to educate future health professionals about various aspects of herbal remedies.

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