

# Mexican Plants with Teratogenic Effects

Subjects: **Pharmacology & Pharmacy**

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In Mexico, the use of medicinal plants is the first alternative to treat the diseases of the most economically vulnerable population. Some species with teratogenic effects and the main alterations that were found in the nervous system and axial skeleton, induced by compounds such as alkaloids, terpenes, and flavonoids.

traditional medicine

Mexican plants

alkaloids

Teratogenesis

Sacred plants

## 1. From Plants to Drugs

According to the significance that Greece, the cradle of philosophical thought and Western civilization, has held in the sciences and arts, it should not come as a surprise to us that the Greeks were the fathers of Medicine, Botany, and Pharmacology (Hippocrates, Theophrastus, and Pedanius Dioscorides, respectively), who laid the foundations of the therapeutic value of medicinal plants through detailed compilations of the knowledge of medicinal plants during their respective times and in their respective regions [1][2][3], as well as that herbal medicine is denominated phytotherapy, a compound word formed by the Latin prefix *phyto* “plant”, and the Latin word *therapia*, “to treat medically”, in the study of the use of extracts of natural origin as medicines [4].

With the fall of the Western Roman Empire (476 AD), there began a period of time that stretched from the V to the XV century, called the “Middle Ages” or the “Dark Ages”, which involved a notable lag in the development of the sciences [5], despite that knowledge on the use of medicinal plants (and many others) survived during being confined for several centuries inside the walls of monasteries in countries such as England, Ireland, France, and Germany [6], among others. The Arab people were responsible for the preservation of a great part of Greco–Roman knowledge (along with that of the Chinese and the Indians, mainly in terms of plants), and later with the establishment of the first private pharmacies in Baghdad, Irak, at the end of the 8th century [7][8]. Later, the Persian pharmacist and poet Avicena (980–1037 AD) contributed to the dissemination of the knowledge of therapeutic plants with his work “*Canon Medicinae*”, considered the latest translation of all Greco–Roman Medicine [9] and the starting point for the development of medicinal-plant texts throughout Europe, such as “*The Corpus of Simples*” by Ibn al-Baitar, or the Florentine “*Nuovo Receptario Composito*”, which, alongside other manuscripts in England (1518), laid out the concept of “pure compounds” and promoted their development; a century later, these manuscripts would comprise the basis of the emergence of the first pharmacopoeia (First London Pharmacopoeia) [10]. Deriving from this idea, the first natural product to be marketed as isolated and pure was morphine, by Merck in 1826; while the first semi-synthetic medicine based on a natural product was aspirin by Bayer in 1899 [11].

The health needs of the increasing population have intensified the interest in developing more effective chemically synthesized compounds. In this context, since 1910, there was the “magic bullet” (Salvarsan or compound 606) by the German bacteriologist Paul Ehrlich [12], continuing all the way to modern times with the development of drugs used for chronic obstructive pulmonary disease, such as umeclidinium bromide [13]. Despite the good results obtained with chemical synthesis, the therapeutic potential of medicinal plants was not lost from sight. From plants such as meadowsweet (*Spiraea ulmaria*), poppy (*Papaver somniferum*), foxglove (*Digitalis purpurea*), and *barbasco* (*Lonchocarpus utilis*), drugs as remarkable as acetylsalicylic acid [14], morphine [15], digoxin [16], and diosgenin [17], respectively, have been obtained. Currently, this approach has become diversified thanks to the boom in novel processes for the extraction and identification of organic compounds, but mainly due to the increasing use of traditional medicine, which has been the starting point for information obtained throughout scientific research for the development of molecules that, under different conditions, would have been difficult or virtually impossible to conceive. In this regard, nature arises and is constituted, with chemical synthesis [18] and with biotechnology [19], one of the three main ways to obtain biologically active molecules today [20]. This said fact can be observed as reflected in the growing number of studies during the last decades that have provided valuable information to this scientific field, confirming the molecules present in the structures of numerous plants that possess a biological effect against diseases. However, in addition to the development of the knowledge of plant curative properties, the misconception of the safety of natural products has become a health problem that can be confirmed in several epidemiological and experimental assays.

## 2. Mexican Plants

Worldwide, Mexico has one of the richest diversities of plants composed of native and introduced species from various parts of the planet [21] that, together with their cultural wealth, constitute Mexican Traditional Medicine. In general terms, the concept of traditional medicine refers to a conventional denomination adopted by researchers to refer to empirical medical systems that are organized and based on various cultures of the world [22]. Thus, traditional medicine is made up of three main types according to the source of the remedy: that obtained from animal products; that of processed minerals, and Botany [23]. With regard to the latter, it is difficult to accurately determine the number of families, genera, or species of existing Mexican plants. Some reports estimate that Mexico has approximately 22,351 species of vascular plants (native and introduced) and calculate that at least 6500 species must be added to this calculation [24][25]. Of this total number ( $\approx 29,000$  total vascular plants), it is suggested that between 3000 and 5000 plants are currently utilized with medicinal purposes in the country [26].

### The Teratogenic Effects of Mexican Plants

During pregnancy, the organogenesis phase is the most critical period for generating birth defects, because it is at this time that the differentiation and specialization of tissues, structures, organs, and systems in the *conceptus* begin, with the grouping of cells in early patterns directed by gene expression toward specific sites in an organ [27]. Thus, during this period, it is most likely (but not exclusively so) that there occurs a multifactorial process known as teratogenesis. The latter, as a result of multiple interactions between environmental (physical, chemical, biological, and maternal diseases, clinical states, etc.) and endogenous (genetic background of the

mother and the embryo/fetus) factors, can produce a wide range of congenital deformities in the developing fetus or in the newborn [28]. Although the mechanisms by which this process occurs are varied, the main ones include oxidative stress, folate antagonism, vascular disruption, neural crest cell disruption, endocrine disruption, and specific receptor- or enzyme-mediated actions, among others [29]. Therefore, the severity and type of alterations will depend, among other things, on the time of the interaction of the teratogenic agent with the embryo/fetus, as well as on the mechanism(s) involved in the disruptive process.

The wide diversity of plants in Mexico allows some of these to be used by humans to alleviate their diseases or as food [30][31], even for livestock. In Mexico, as in other developing countries, the use of medicinal plants remains the first health care available in many rural areas to alleviate the diseases of the most economically vulnerable population, without social security [32][33], as a substantially less expensive and affordable alternative to conventional therapies. Unfortunately, in this practice, quality is generally unproven and is solely based on the population's beliefs. In contrast, insufficient attention is paid to their possible toxicity (unlike what happens with drugs), with the belief espoused for generations, e.g., "the natural remedy" is totally safe, without taking into consideration that plants could contain toxic compounds. Thus, although plants are undeniably an important source of health for vulnerable persons, it is important to make it known to the general population that "natural is not always safe".

The data provided by several investigations demonstrate that an important number of herbs and herbal products have been implicated in poisoning [34], health problems [35], and alterations in embryonic/fetal development in humans [36] and animals [37]. This latter toxic effect of plants comprises an important problem worldwide, not only for public health, where birth defects are one of the main preventable causes of morbidity, mortality, and childhood disability [38], but also in the economic sector, since in different parts of the world, the consumption of teratogenic plants by pregnant females produces a wide variety of congenital anomalies in livestock, generating, in this manner, considerable losses of capital for companies and local ranchers [39].

### 3. Sacred Plants from Mexico

Additionally, it is important to consider that there are some species of Mexican plants that contain considerable amounts of the most common teratogenic compounds in nature, that is, alkaloids, but their teratogenic effect, to our knowledge, has not been investigated. Such is the case of *Borago officinalis* [40], the genus *Senecio* [41], and, of course, an important group of Mexican plants termed "sacred" (Table 1). In ancient Mexico (before the Spanish Conquest), plants with toxic properties were usually considered sacred, because their consumption induces mystical outbursts, fear, and alteration of the human mind in order to experience an elevation in consciousness; for this reason, they were bestowed with the personality of deities based on their effects [42]. In this manner, even today, the act of consuming peyote (*Lophophora williamsii*, America's most famous sacred hallucinogen) is called by an indigenous group, the *Huicholes*, as receiving "hikuri," which means receiving the "heart of the Deer God," who in turn is known as *Tatewari* and represents the grandfather god (God of Fire). This deity, the original shaman, collects peyote every year and guides his followers on a mystical pilgrimage to a sacred place where their ancestors rest: *Wirikuta* [43].

The Mexican sacred plants mentioned in **Table 1** possess an important role in rituals and in their medicinal use due to the presence of psychoactive alkaloids, such as psilocybin, mescaline, and ergotamine, among others [44]. However, an important case that needed to be specified here is that of *Salvia divinorum* or *hierba de la virgen*, which contains a powerful hallucinogenic substance called “salvinorin A,” with a structure similar to that of alkaloids. Nonetheless, it does not contain any nitrogen atom, and, thus, it is not considered as one of these, but rather the first documented diterpene nonalkaloid hallucinogen [45][46][47].

The use of plants with ornamental, nutritional, aromatic, medicinal, and religious purposes is widely extended in Mexico [48]. In this respect, sacred plants with biological effects comprise an important element in indigenous medical and religious practices [49]. According to the lack of studies found in this entry to evaluate the risks of these sacred plants for embryonic and fetal development, which are commonly used in Mexico, it is necessary to emphasize the danger of their use in the indigenous medical and religious systems. Although it is true that Mexico, in subscribing to international treaties, is obliged to prohibit any substance decreed by the World Health Organization (WHO), there is no law in Mexico that punishes the use of these substances. In other words, Mexican legislation sanctions the possession, but not the consumption, of illegal substances, including sacred plants. Therefore, the consumption of hallucinogenic plants such as *peyote* is legal with only certain restrictions (trafficking) that do not apply to indigenous groups because “it is an issue of rights regarding the culture and native communities of our country” [50].

**Table 1.** List of Mexican sacred plants without studies of teratogenicity.

Scientific Name	Common Name	Compound	Type	Cite
<i>Ariocarpus retusus</i>	Peyote cimarron	Alkaloids	Cactaceae	[51]
<i>Argemone mexicana</i>	Chicalote	Alkaloids	Plant	[52]
<i>Conocybe</i>	Teonanácatl	Alkaloids	Mushroom	[53]
<i>Coryphantha compacta</i>	Biznaga Partida Compacta	Alkaloids	Cactaceae	[54]
<i>Datura ceratocaula</i> Ortega	Torna loco	Alkaloids	Plant	[55]
<i>Datura inoxia</i> Mill	Toloache	Alkaloids	Plant	[56]
<i>Echinocereus triglochidiatus</i>	Alicoche Copa de Vino	Alkaloids	Cactaceae	[57]
<i>Epithelantha micromeris</i>	Ikuli mulato	Alkaloids	Cactaceae	[58]
<i>Erythrina americana</i> Mill	Zumpantle	Alkaloids	Plant	[59]
<i>Heimia salicifolia</i>	Sinicuichi	Alkaloids	Plant	[60]
<i>Ipomoea violacea</i>	Quiebra platos	Alkaloids	Plant	[61]
<i>Lophophora williamsii</i>	Peyote	Alkaloids	Cactaceae	[62]

Scientific Name	Common Name	Compound	Type	Cite
<i>Lycoperdon mixtecorum</i>	Hongo de primera clase	Alkaloids	Mushroom	[63]
<i>Mammillaria senilis</i>	Biznaga cabeza de viejitos	Alkaloids	Cactaceae	[54]
<i>Pachycereus pecten-aboriginum</i>	Cardón Barbón	Alkaloids	Cactaceae	[64]
<i>Panaeolus sphinctrinus</i>	Toshka	Alkaloids	Mushroom	[65]
<i>Psilocybe caerulescens</i>	Quélet	Alkaloids	Mushroom	[65]
<i>Rhynchosia phaseoloides</i>	Ojo de cangrejo	Alkaloids	Plant	[42]
<i>Solandra brevicalyx</i>	Tecomaxóchitl	Alkaloids	Plant	[66]
<i>Sophora secundiflora</i>	Mezcal frijol	Alkaloids	Plant	[67]
<i>Stropharia cubensis</i>	San Isidro	Alkaloids	Mushroom	[68]
<i>Tagetes lucida</i>	Yauhtli	Alkaloids	Plant	[69]
<i>Turbina corymbose</i>	Ololiuhqui	Alkaloids	Plant	[61]
<i>Turnera Diffusa</i>	Damiana	Alkaloids	Plant	[70]
<i>Ungnadia speciosa</i>	Monilla	Alkaloids	Plant	[71]

## References

Information is shown on the alkaloid-rich main Mexican sacred plants that do not, to our knowledge, have scientific studies that evaluate their toxicity on embryo-fetal development.

1. Ríos, J.L.; Recio, M.C. Medicinal plants and antimicrobial activity. *J. Ethnopharmacol.* 2005, 100, 80–84.
2. Madsen, H.L.; Bertelsen, G. Spices as antioxidants. *Trends Food Sci. Technol.* 1995, 6, 271–277.
3. Staub, P.O.; Casu, L.; Leonti, M. Back to the roots: A quantitative survey of herbal drugs in Dioscorides' *De Materia Medica* (ex Matthioli, 1568). *Phytomedicine* 2016, 23, 1043–1052.
4. Singh, N.; Savita, S.; Rithesh, K.; Shivanand, S. Phytotherapy: A novel approach for treating periodontal disease. *J. Pharm. Biomed. Sci.* 2016, 6, 205–210.
5. McIntyre, L. *Dark Ages: The Case for a Science of Human Behavior*; The MIT Press: Cambridge, MA, USA, 2006; p. 15.
6. Guthrie, L.S. Monastic cataloging and classification and the beginnings of “class b” at the library of congress. *Cat. Classif Q.* 2003, 35, 447–465.
7. Cragg, G.; Newman, D.J. Natural product drug discovery in the next millennium. *Pharm. Biol.* 2001, 39, 8–17.
8. Hamarneh, S. The rise of professional pharmacy in Islam. *Med. Hist.* 1962, 6, 59–66.

9. Newman, D.J.; Cragg, G.M.; Snader, K.M. The influence of natural products upon drug discovery. *Nat. Prod. Rep.* 2000, 17, 215–234.
10. Dunlop, D.M.; Denston, T.C. The history and development of the British Pharmacopoeia. *Br. Med. J.* 1958, 2, 1250–1252.
11. Grabley, S.; Thiericke, R. Bioactive agents from natural sources: Trends in discovery and application. *Adv. Biochem. Eng. Biotechnol.* 1999, 64, 101–154.
12. Thorburn, A.L. Paul Ehrlich: Pioneer of chemotherapy and cure by arsenic (1854–1915). *Br. J. Vener. Dis.* 1983, 59, 404–405.
13. Gu, J.; Zhang, J.; Wang, X.; Wang, G. Convenient new synthesis of umeclidinium bromide. *Synth. Commun.* 2018, 48, 995–1000.
14. Tsoucalas, G.; Karamanou, M.; Androutsos, G. Travelling through time with aspirin, a healing companion. *Eur. J. Inflamm.* 2011, 9, 13–16.
15. Bulduk, I.; Gezer, B.; Cengiz, M. Optimization of ultrasound-assisted extraction of morphine from capsules of *Papaver somniferum* by response surface methodology. *Int. J. Anal. Chem.* 2015, 2015, 796349.
16. Whayne, T.F., Jr. Clinical use of digitalis: A state of the art review. *Am. J. Cardiovasc. Drugs* 2018, 18, 427–440.
17. Colorado, I.R. Obtaining diosgenin from the barbasco. *Rev. Inst. Salubr. Enferm. Trop.* 1962, 22, 71–73.
18. Blakemore, D.C.; Castro, L.; Churcher, I.; Rees, D.C.; Thomas, A.W.; Wilson, D.M.; Wood, A. Organic synthesis provides opportunities to transform drug discovery. *Nat. Chem.* 2018, 10, 383–394.
19. Tandon, S.; Sharma, S.; Rajput, R.; Semwal, B.; Yadav, P.K.; Singh, K. Biotech drugs: The next boom in pharmaceutical market. *JPRP* 2011, 1, 76–79.
20. Shen, B. A new golden age of natural products drug discovery. *Cell* 2015, 163, 1297–1300.
21. Juárez, A.; Carranza, C.; Alonso, A.; González, V.; Bravo, E.; Chamarro, F.; Solano, E. Ethnobotany of medicinal plants used in Xalpatlahuac, Guerrero, México. *J. Ethnopharmacol.* 2013, 148, 521–527.
22. Consejo Estatal Para el Desarrollo Integral de los Pueblos Indígenas del Estado de México (CEDIPIEM). (S.F.). La Medicina Tradicional. Available online: <http://portal2.edomex.gob.mx/cedipiem/pueblosindigenas/cultura/medicinatradicional/index.html> (accessed on 6 May 2015).

23. Lee, J.W.; Lee, W.B.; Kim, W.; Min, B.I.; Lee, H.; Cho, S.H. Traditional herbal medicine for cancer pain: A systematic review and meta-analysis. *Complement. Ther. Med.* **2015**, *23*, 265–274.

24. Villaseñor, J.L. Checklist of the native vascular plants of Mexico. *Rev. Mex. Biodivers.* **2016**, *87*, 559–902.

25. Villaseñor, J.L. Diversidad y distribución de las magnoliophyta de México. *Interciencia* **2003**, *28*, 160–167.

26. Palma-Tenango, M.; Miguel-Chávez, R.S.; Soto-Hernández, R.M. Aromatic and Medicinal Plants in Mexico. Chapter 7: Aromatic and medicinal plants in Mexico. In *Aromatic and Medicinal Plants*; InTech: London, UK, 2017.

27. McAleer, I. Renal Development. In *Avery's Diseases of the Newborn*, 10th ed.; Elsevier Inc.: Amsterdam, The Netherlands, 2018; pp. 1238–1249.

28. Vargesson, N.; Fraga, L. Teratogenesis. *eLS* **2017**, a0026056, 1–7.

29. Cassina, M.; Cagnoli, G.A.; Zuccarello, D.; Di Gianantonio, E.; Clementi, M. Human teratogens and genetic phenocopies. Understanding pathogenesis through human genes mutation. *Eur. J. Med. Genet.* **2017**, *60*, 22–31.

30. Jacobo-Herrera, N.J.; Jacobo-Herrera, F.E.; Zentella-Dehesa, A.; Andrade-Cetto, A.; Heinrich, M.; Pérez-Plasencia, C. Medicinal plants used in Mexican traditional medicine for the treatment of colorectal cancer. *J. Ethnopharmacol.* **2016**, *179*, 391–402.

31. Bautista-Cruz, A.; Arnaud-Viñas, M.R.; Martínez-Gutiérrez, G.A.; Sánchez-Medina, P.S.; Pacheco, R.P. The traditional medicinal and food uses of four plants in Oaxaca, Mexico. *J. Med. Plants Res.* **2011**, *5*, 3404–3411.

32. Laveaga, G.S. Mexico's Historical Models for Providing Rural Healthcare. In *Health for All: The Journey of Universal Health Coverage*; Medcalf, A., Bhattacharya, S., Momen, H., Saavedra, M., Jones, M., Eds.; Orient Blackswan: Hyderabad, Indian, 2015; Chapter 4. Available online: <https://www.ncbi.nlm.nih.gov/books/NBK316259/> (accessed on 12 November 2021).

33. van Gameren, E. Health insurance and use of alternative medicine in Mexico. *Health Policy* **2010**, *98*, 50–57.

34. Govea-Salas, M.; Morlett-Chávez, J.; Rodriguez-Herrera, R.; Ascacio-Valdés, J. Some Mexican Plants Used in Traditional Medicine. In *Aromatic and Medicinal Plants—Back to Nature*; InTech: London, UK, 2017; Chapter 10.

35. Valdivia-Correa, B.; Gómez-Gutiérrez, C.; Uribe, M.; Méndez-Sánchez, N. Herbal Medicine in Mexico: A Cause of Hepatotoxicity. A Critical Review. *Int. J. Mol. Sci.* **2016**, *17*, 235.

36. Alonso-Castro, A.J.; Ruiz-Padilla, A.J.; Ruiz-Noa, Y.; Alba-Betancourt, C.; Domínguez, F.; Ibarra-Reynoso, L.; Maldonado-Miranda, J.J.; Carranza-Álvarez, C.; Blanco-Sandate, C.; Ramírez-

Morales, M.A.; et al. Self-medication practice in pregnant women from central Mexico. *Saudi Pharm. J.* 2018, 26, 886–890.

37. Cortinovis, C.; Caloni, F. Alkaloid-Containing Plants Poisonous to Cattle and Horses in Europe. *Toxins* 2015, 7, 5301–5307.

38. Almli, L.M.; Ely, D.M.; Ailes, E.C.; Abouk, R.; Grosse, S.D.; Isenburg, J.L.; Waldron, D.B.; Reefhuis, J. Infant Mortality Attributable to Birth Defects—United States, 2003–2017. *Morb. Mortal. Wkly. Rep.* 2020, 69, 25–29.

39. Soares, M.C.; Pupin, R.C.; Guizelini, C.C.; Gaspar, A.O.; Gomes, D.C.; Brumatti, R.C.; Lemos, R.A.A. Economic losses due to *Vernonia rubricaulis* poisoning in cattle. *Pesq. Vet. Bras.* 2018, 38, 2217–2223.

40. Vacillotto, G.; Favretto, D.; Seraglia, R.; Pagiotti, R.; Traldi, P.; Mattoli, L. A rapid and highly specific method to evaluate the presence of pyrrolizidine alkaloids in *Borago officinalis* seed oil. *J. Mass Spectrom.* 2013, 48, 1078–1082.

41. Langel, D.; Ober, D.; Pelser, P.B. The evolution of pyrrolizidine alkaloid biosynthesis and diversity in the Senecioneae. *Phytochem. Rev.* 2001, 10, 3–74.

42. Barba, B. Las plantas sagradas mexicanas. *Ciencia* 2015, 66, 48–59.

43. Schultes, R.E.; Hofmann, A. Plants of the Gods: Their Sacred, Healing, and Hallucinogenic Powers, 2nd ed.; Healing Arts Press: Rochester, VT, USA, 2001; p. 148.

44. Díaz, J.L. Ethnopharmacology of sacred psychoactive plants used by the Indians of Mexico. *Annu. Rev. Pharmacol. Toxicol.* 1977, 17, 647–675.

45. Rossi, A.; Pace, S.; Tedesco, F.; Pagano, E.; Guerra, G.; Troisi, F.; Werner, M.; Roviezzo, F.; Zjawiony, J.K.; Werz, O.; et al. The hallucinogenic diterpene salvinorin A inhibits leukotriene synthesis in experimental models of inflammation. *Pharmacol. Res.* 2016, 106, 64–71.

46. Roth, B.L.; Baner, K.; Westkaemper, R.; Siebert, D.; Rice, K.C.; Steinberg, S.; Ernsberger, P.; Rothman, R.B.; Salvinorin, A. A potent naturally occurring nonnitrogenous kappa opioid selective agonist. *Proc. Natl. Acad. Sci. USA* 2002, 99, 11934–11939.

47. Valdés, L.J., 3rd. *Salvia divinorum* and the unique diterpene hallucinogen, Salvinorin (divinorin) A. *J. Psychoact. Drugs* 1994, 26, 277–283.

48. Reimers, E.A.L.; Fernández, E.C.; Reimers, D.J.L.; Chaloupkova, P.; Del Valle, J.M.Z.; Milella, L.; Russo, D. An Ethnobotanical Survey of Medicinal Plants Used in Papantla, Veracruz, Mexico. *Plants* 2019, 8, 246.

49. Heinrich, M.; Ankli, A.; Frei, B.; Weimann, C.; Sticher, O. Medicinal plants in Mexico: Healers' consensus and cultural importance. *Soc. Sci. Med.* 1998, 47, 1859–1871.

50. Cámara de Diputados del Congreso de la Unión, LXIV Legislatura. Necesario Legislar Sobre Plantas Sagradas; Boletín 3979; son Patrimonio Nacional: Nava Palacios. México, 2017. Available online: <http://www5.diputados.gob.mx/index.php/esl/Comunicacion/Boletines/2017/Agosto/29/3979-Necesario-legislar-sobre-plantas-sagradas-son-patrimonio-nacional-Nava-Palacios> (accessed on 24 August 2020).

51. Rodríguez, R.G.; Morales, M.E.; Verde, M.J.; Oranday, A.; Rivas, C.; Núñez, M.A.; González, G.M.; Treviño, J.F. Actividad antibacteriana y antifúngica de las especies *Ariocarpus kotschoubeyanus* (Lemaire) y *Ariocarpus retusus* (Scheidweiler) (Cactaceae). *Rev. Mex. Cienc. Farm.* 2010, 41, 55–59.

52. Singh, S.; Verma, M.; Malhotra, M.; Prakash, S.; Singh, T.D. Cytotoxicity of alkaloids isolated from *Argemone mexicana* on SW480 human colon cancer cell line. *Pharm. Biol.* 2016, 54, 740–745.

53. Reingardiene, D.; Vilcinskaite, J.; Lazauskas, R. Haliucinogeniniai grybai . *Medicina* 2005, 41, 1067–1070.

54. Mandujano, M.C.; Gulovob, J.; Reyes, J. Lo que usted siempre quiso saber sobre las cactaceas y nunca se atrevio a preguntar. CONABIO. *Biodiversitas* 2002, 40, 4–7.

55. Berkov, S. Alkaloids of *Datura ceratocaula*. *Z. Naturforsch. C. J. Biosci.* 2003, 58, 455–458.

56. Malinowska, I.; Studziński, M.; Niezabitowska, K.; Gadzikowska, M. Comparison of TLC and Different Micro TLC Techniques in Analysis of Tropane Alkaloids and Their Derivatives Mixture from *Datura inoxia* Mill. *Extract. Chromatographia* 2013, 76, 1327–1332.

57. Ferrigni, N.R.; Nichols, D.E.; McLaughlin, J.L.; Bye, R.A. Cactus alkaloids. XLVII. N alpha-dimethylhistamine, a hypotensive component of *Echinocereus triglochidiatus*. *J. Ethnopharmacol.* 1982, 5, 359–364.

58. Štarha, R. Alkaloids of *Epithelantha micromeris*. *Fitoterapia* 1995, 66, 375.

59. Garín-Aguilar, M.E.; Luna, J.E.; Soto-Hernández, M.; Valencia del Toro, G.; Vázquez, M.M. Effect of crude extracts of *Erythrina americana* Mill. on aggressive behavior in rats. *J. Ethnopharmacol.* 2000, 69, 189–196.

60. Rumalla, C.S.; Jadhav, A.N.; Smillie, T.; Fronczek, F.R.; Khan, I.A. Alkaloids from *Heimia salicifolia*. *Phytochemistry* 2008, 69, 1756–1762.

61. Steiner, U.; Leistner, E. Ergot Alkaloids and their Hallucinogenic Potential in Morning Glories. *Planta Med.* 2018, 84, 751–758.

62. Cassels, B.K.; Sáez-Briones, P. Dark Classics in Chemical Neuroscience: Mescaline. *ACS Chem. Neurosci.* 2018, 9, 2448–2458.

63. Schultes, R.; Farnsworth, N. Ethnomedical, botanical and phytochemical aspects of natural hallucinogens. In *Botanical Museum Leaflets*; Harvard University: Cambridge, MA, USA, 1980; Volume 28, pp. 123–214.

64. Strömbom, J.; Bruhn, J.G. Alkaloids of *Pachycereus pecten-aboriginum*, a Mexican cactus of ethnopharmacologic interest. *Acta Pharm. Suec.* 1978, 15, 127–132.

65. Mahmood, Z.A. Bioactive Alkaloids from Fungi: Psilocybin. In *Natural Products*; Ramawat, K., Mérillon, J.M., Eds.; Springer: Berlin/Heidelberg, Germany, 2013.

66. Qu, J.; Hu, Y.C.; Li, J.B.; Wang, Y.H.; Zhang, J.L.; Abliz, Z.; Yu, S.S.; Liu, Y.B. Structural characterization of constituents with molecular diversity in fractions from *Lysidice brevicalyx* by liquid chromatography/diode-array detection/electrospray ionization tandem mass spectrometry and liquid chromatography/nuclear magnetic resonance. *Rapid Commun. Mass Spectrom.* 2008, 22, 755–765.

67. Izaddoost, M.; Harris, B.G.; Gracy, R.W. Structure and toxicity of alkaloids and amino acids of *Sophora secundiflora*. *J. Pharm. Sci.* 1976, 65, 352–354.

68. Bogusz, M.J.; Maier, R.D.; Schäfer, A.T.; Erkens, M. Honey with *Psilocybe* mushrooms: A revival of a very old preparation on the drug market? *Int. J. Legal Med.* 1998, 111, 147–150.

69. Salvaña, F.R. Morphological and Histochemical Characterization of Callus from Leaf Explant of *Tagetes lucida* Cav. (Asteraceae). *JNBR* 2019, 8, 172–178.

70. Esquivel-Gutiérrez, E.R.; Alcaraz-Meléndez, L.; Hernández-Herrera, R.; Torres, A.; Rodríguez-Jaramillo, C. Effects of damiana (*Turnera diffusa*; var. *diffusa* and var. *aphrodisiaca*) on diabetic rats. *Acta Univ.* 2018, 28, 84–92.

71. Dayton, W.A. Important Western Browse Plants; Miscellaneous Publication, 101; U.S. Department of Agriculture: Washington, DC, USA, 1931; Volume 214, p. 768.

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