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Morphological, phytochemical, and therapeutic potentials investigation of some species of Cestrum L. (Solanaceae family)

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ABSTRACT **: Medicinal plants have been employed as medication all over the world Since ancient times. Thanks to years of dedication and commitment to research, scientists have made tremendous progress recently in discovering the plethora of therapeutic potentials of medicinal plants. Solanaceae is one of the most prestigious families as its species could be ranked at the top of the most important medicinal plants to human beings in many ways. Solanaceae contains countless bioactive compounds which are used to treat various diseases and disorders, which could be used as anticancer, antimicrobial, antioxidant agents, etc. Additionally, it has many industrial and nutritional benefits. It also gets the most attention from taxonomists because it contains various taxonomic characteristics. In this review, we will concisely display the most remarkable morphological characters, chemical composition, and therapeutic potentials of Solanaceae with a focus on four of the `most essential species named Cestrum diurnum, Cestrum elegans, Cestrum nocturnum, and Cestrum parqui .**

KEYWORDS: Medicinal plants as a natural source of biologically active compounds.

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I. INTRODUCTION

For ages, the traditional herbal medicines have been known for their own designed medical systems such as; Traditional Chinese medicine (TCM) in Asia and China, Korean Chinese medicine in Korea, Japanese Chinese medicine “Kampo” in Japan, Jamu in Indonesia, and Ayurveda in India. Phytotherapy and Homeopathy is the triumphant system in Europe. In America, they follow alternative medicinal systems, where they combine with different herbal therapies (Feher and Schmidt, 2003; Clardy and Walsh, 2004; Piggott and Karuso, 2004; Koehn and Carter, 2005). In South Africa, there are approximately 3000 species of plants, which made the population rely on them in many traditional ways (Vuuren, 2008; Wyk, 2008). The early man depended on these systems for seeking quick recovery from painful diseases and living a healthy life. These systems have been improved till modern medicine has been discovered. Later, integrative medicine (Western medicine) has been brought to the light, which is an integration of Traditional medicines, and modern medicine (Feher and Schmidt, 2003; Clardy and Walsh, 2004; Piggott and Karuso, 2004; Koehn and Carter, 2005). Plants have had an indispensable role in nature as a warehouse of treasures since times immemorial.

Thanks to its secondary metabolites “phytochemicals”, Plants have a notable therapeutic value (Nishtha et al., 2017), and show healing power from diseases and disorders in a tremendously expansive range of health-related applications ranging from treatment of common cold to cancer (Kumar et al., 2007; Punjabi et al., 2015). Thus, in recent times scientists have paid more attention to herbal medicines because of the population increasing numbers and awareness of the harmful effects of synthetic medication on humans’ health. The prevalent admittance and

accessibility of traditional medicine again especially after knowing that natural drug discovery seems so promising thus, recently more pharmaceutical companies have started to show concern (Kate and Laird, 1999).

Among the incalculable plant species, several plants are investigated for their phytochemical and biological screening and had been indicted for their activity against a broad range of diseases (Fabricant and Farnsworth, 2001; Daljit and Kaur, 2008). In our current time, many serious diseases have been contended all over the world by using drugs that have been isolated from plants and have been tested as new pharmacologically active agents (Al-Reza et al., 2010). World health organization (WHO) also has determined that 11% out of a list of 252 medicines are completely plant-based, and more than 65–80 % of the world population used remedies that are based on plants for their primary health care (Arora and Kaur, 1999; Rajasekaran et al., 2008; Shihabudeen et al., 2010). The plants are undiscovered treasures, in which the majority of their therapeutic potential is still not totally explored.

phytochemicals present in any part of the plant, that can be leaves, roots, stem, seeds, etc. These phytochemicals can be alkaloids, saponins, flavonoids, tannins, and many more (Nishtha et al., 2017). Camptothecin, quinine, Penicillin G, Theophylline, Vincristine, Cyclosporin, Morphine, Digoxin, Paclitaxel, and Doxorubicin are some examples of natural drugs, which considered as the bedrock of natural products. Some examples of plant-based drugs are Serpentine which is derived from Rauwolfia serpentina, reduces blood pressure, and can provide quick relief in hypertension. Ephedrine which is derived from Ephedra sinica, is utilized in respiratory ailments (Gazaliev et al., 1988). Codein and morphine are two common drugs that are derived from opium mostly and used in headaches, arthritis, and as sedatives (Huxtable and Schwarz, 2001). Emetine derived from Cephaelis spp. is used as an antiemetic and to cure dysentery (Wiegrebe et al., 1984). Quinine extracted from Cinchona spp. plays a very pivotal role in the treatment of Malaria (Christoforidis and Chang, 2014). A well-known medicine “Digoxin: is isolated from Digitalis purpurea is used to treat cardiac ailments. It is noteworthy that the formation of the fundamental oils and organic extracts of a specific species of plants as sources of natural drug products may differ depending upon the harvesting season, geographical location, the extraction protocol of the plant components, and the isolates from different parts of the same plant may also differ excessively (Burt, 2004).

Down the ages, it has been proved that the aromatic natural products obtained from plants are also a novel source of antimicrobial drugs (Zemek et al., 1987). Antimicrobial activity of the medicinal plants against bacteria is one of the most urgent, and important directions in which the plants have been examined. Trying to get back the traditional antibiotics vitality and develop other divisions of natural antimicrobial products especially after the spreading of drug-resistant pathogens associated with the usage of antibiotics delivered from microorganisms which is one of the most fatal threats in the treatment of microbial diseases (Westh et al., 2004). Thus, Scientists need not spare any effort to extensively screen various more deeply plants with diverse chemical structures and novel mechanisms of action for their potential uses as alternative remedies for the treatment of various microbial infectious diseases.

Cancer is the human burden where it is the second cause of death after heart diseases all over the world in both developed and developing countries as more than six million new cancer cases are reported each year. Thus, the anticancer potentials of medicinal plants have been investigated. In 1957, the US National Cancer Institute (NCI) initiated the attempts to find anticancer agents from higher medicinal plants by screening more than 35,000 plant species. As a result of these attempts plants have been proved to be a novel source of useful anticancer substances (Kaur and Kaur, 2010). Today it turns out that a vast bunch of the most useful and curative anticancer medicines is derived either from plants or their microorganisms such as Vincristine, Vinblastine, Indicine–N-oxide, Etoposide analogs, bleomycin, daunorubicin, doxorubicin, mitomycin, streptozocin, tenoposide (podophyllotoxin derivatives) (Lange et al., 2000; Feher and Schmidt, 2003; Shaikh et al., 2016). Anticancer agents' activities whether natural or synthetic are suppressing or preventing the uncontrolled division of cancerous cells (Shaikh et al., 2016).

The most currently anticancer products used nowadays are belonging to alkaloids. For instance, the Camptothecin (Nyssaceae family) is derived from the bark of Camptotheca acuminata which is considered as topoisomerase I poison and stops its activity. Eventually, leads to death cell (Pu et al., 2013). Vinblastine is isolated from Catharanthus rosesus and is considered one of four major vinca alkaloids that help to cure Hodgkins leukemia in children; non- Hodgkin’s lymphomas, choriocarcinoma, neck cancer, small cell lung cancer, testicular cancer. Paclitaxel (Taxol) was originally derived from the pacific yew tree (Taxus brevifolia) is used in the treatment of many types of cancer such as ovarian and breast cancers. Taxol was supposed to bind the tubulin subunit of microtubules and stabilize the microtubule to normal disassembly (Suffness and Wall, 1995; Fan et al., 1998; Brown, 2003). Phophyllotoxin is isolated from Phodophyllum emodi used to treat lymphomas diseases.

In addition to their medicinal purposes, plants have many uses in other areas, such as in the cosmetics industry, culinary, decoration (Joy et al., 1998; Lange et al., 2000; Debnath et al., 2006; Gairola et al., 2008; Mahesh and Satish, 2008). It is utilized for extending the storage stability period of foods as food preservation from the effect of toxic oxidants. It is a safe way according to the toxicologists and nutritionists from synthetic antioxidants used in

food processing such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA), which have been exhibited harmful side effects, instability, as well as due to a suspected action as inducers of carcinogenesis (Witschi, 1986; Grice, 1988).

Solanaceae: The nightshade family.

Solanaceae has been classified as one of the most important to humanity for possessing countless medicinally, chemically, and nutritious uses (Heywwod, 1993; Shah et al., 2013; Awan and Murtaza, 2016; Almoulah, 2017). Solanaceae has been also known as the nightshade or potato family (Yasin, 1985). Backing to the origin of the words it has been proposed that the word originates from the Latin verb Solari meaning "to soothe". There are two suggested reasons for this name. Firstly, it is believed that it refers to professed soothing pharmacological properties of some of the family species known for its psychoactive. Secondly, the name derives from the notified resemblance between the family flowers, and the sun rays (Almoulah, 2017). Solanaceae has cosmopolitan distribution except in the Arctic area and is predominantly presented in tropical, warmer, and temperate regions of the whole world with centers of diversity in the Southern hemisphere (Willis, 1973; Mabberley, 1987). The major dispersal centers mainly in central and South America, which are considered to be the origin of Solanaceae (Giorgetti and Negri, 2011), Australia was also considered the center of speciation. It can be found also in Africa (Hutchinson and Dalziel, 1963), Europe, and Asia (Hawkes et al., 2000).

Morphological and Phylogenetic character of Solanaceae family.

Members of Solanaceae are extremely diverse. In terms of habit, they range from herbs, trees, rarely small unarmed or prickly trees, to shrubs (Perveen and Qaiser, 2007; Shah et al., 2013). They may be erect or climbing and are usually cultivated annually (Stehmann, 1999). In habitat, they exist from deserts to the wettest tropical rain forests. Morphologically, there is astounding variation in many characters of both flowers and fruits (Knapp et al., 2004). The leaves are simple, petiolate/sub-sessile, or phyllotaxy-alternate/alternate to oppose, exstipulate, or entire. Sometimes they are greatly lobed, and unequal leaf bases, which may be herbaceous, leathery, or modified spines. Inflorescences are mostly cymose and axillary and are usually pentamerous (5-membered) but maybe diminutive to a solo flower. Flowers are single/grouped, medium-sized, regular/irregular. Most species are bisexual (hermaphrodites) and could be hypogynous, actinomorphic, or slightly zygomorphic. Some species are monoecious/dioecious, perianth present (Harisha and Jani, 2013). The ovary is superior with two chambers, each chamber contains from 1-50 ovules and is placed obliquely, it may be anatropous /hemianatropous, placentation axillary (Harisha and Jani, 2013). Fruits are berries, capsules, or drupes. Seeds are compressed, predominantly small, round, or flat (Basu et al., 2014). The calyx consists of five united and persistent petals. Corolla consists of five united gamopetalous, whose shape varies from long to tubular, rotate, or campanulate. Corolla tube length is divided into two styles; it could be a short corolla tube, or long with bell-shaped corolla tube. This is a tool used in the morphological classification of Solanaceae members (Almoulah, 2017). Androecium of five stamens, introduced onto the corolla tube and are opened at apical pores, there are terminal pores to open the anther (Ganguly and Kumar, 1997; Perveen and Qaiser, 2007).

Morphologically, Solanaceae can be classified into two major groups according to their androecium characters. The first includes eminent stamens, the anthers opening with an apical pore and are longer than filaments. The Solanum genus expresses this group clearly. The second group is the opposite in which included stamens with anthers shorter than filament, and the anthers opening is different where it is opened by a longitudinal slit (Almoulah, 2017). Androecium might have two, four, five, or six liberated stamens, crossing with the petals, with flat or filiform filament. The gynoecium is a combined pistil of two carpels “bicarpelary”, and maybe separated by a false septum, with two locules (Basu et al., 2014; Awan and Murtaza, 2016).

Anatomically, Stomata and trichomes play a vital role in the identification of the family characters. In most Solanaceae family species stomatal number, stomatal index, and quantitative microscopy of stomata are more or less similar. According to Metcalfe and Chalk, 1950 the observed dominant stomata types in Solanaceae are cruciferous (anisocytic). The quantitative microscopy also shows ranunculaceous (anomocytic), and caryophyllaceous (diacytic) also has been shown (Inamdar and Patel, 1969; Palei and Harisha, 2012). Solanaceae also exhibit different kinds of trichomes “epidermal hairs”, especially multicellular glandular. The glandular trichomes secret resin and mucilage, which are important secondary products directly or indirectly help in the drug action. Trichomes also mentor the transpiration activity of the plant, hence retaining the chemical constituent of the raw drug. These trichomes protect the plants from microbes, worms, and grazing animals (Harisha and Jani, 2013).

Solanaceae family consists of about 98 genera and over 3000 species of flowering plants (Zygadlo et al., 1994; Woodland, 1997; Sterm, 2000; Vidyyarltie and Tripathi, 2002; Olmstead and Bohs, 2007; Basu et al., 2014). This genetic variation has confused the taxonomists and caused “poorly defined taxa”. Thus, Solanaceae plant members are tremendously the topic of taxonomic studies due to their high diversity and beneficial properties to human beings

(Olmstead and Bohs, 2007). Solanaceae is a medium-sized family that exhibits significant flaunt variations in terms of habitats, ecological and morphology characteristics that occur by gene flow during the simultaneous flowering seasons of species.

Previous taxonomic studies consider several other angiosperm families as a part of Solanaceae but later it is considered as a separate family. Most of the recent scientists set it in the order "Solanales" due to its herbs, alternate leaves, and actinomorphic flowers. according to Hutchinson, 1973 Solanaceae consists of two major subfamilies: the first, Solanoideae is a vastly distributed species. Secondly; Cestroideae is bound to America and Australia. Most of the family members are distributed in tropical and temperate regions (fig 1). The largest genus of the Solanaceae family is Solanum (Potato, nightshade) consists of 1500spp approximately half of the total species of the family. Some master genera of Solanaceae are Lycianthes, Cestrum (250spp, mostly American), Physalis (100spp), Nicotiana (tobacco, 100spp), Capsicum (pepper chili, 50spp) (D'arcy, 1992; Zygadlo et al., 1994) Datura (Jimsonweed), Lycium (kaffir thron), Atropa (belladonna), Hyoscyamus (henbane), Lycopersicon (tomato) and Petunia (Perveen and Qaiser, 2007).

Members of Solanaceae are known for their ornamental materials, which are expressed in many species such as species belonging to Nicotiana, Petunia, Nicotiana (Basu et al., 2014), Brunfelsia, Solanum, and Cestrum genus (Inamdar and Patel, 1969). Solanaceae has significant economic, medicinal, floristic, and ethnobotanical importance (Hunziker, 2001). Economically, the species are used as nutritious such as potato (Solanum tuberosum L.), tomato (S. lycopersicum L.), eggplant (S. melongena L.), and red pepper (Inamdar and Patel, 1969; Basu et al., 2014). Characteristically, they are ethnobotanical plants, which are extensively considered as promising sources for medical purposes since early 37 A.D (Kirk, 1927). Medicinally, the remarkable key species of the Solanaceae family belong to the following genera namely: Solanum, Atropa, Capsicum, Datura, Withania, Hyoscymus, Nicotiana, and Miscellaneous (Stanker et al, 1994). The most popular productive species are behaving as drug plants such as; Atropa acuminata (Friedman et al., 1997), Atropa belladonna (deadly nightshade), Datura stromanium (Lynn et al., 1997), Hyocyamus niger, Solanum nigrum, Nicotiana tobacum (tobacco), Henbane, Belladona, rustica L., Mandragora officinarum L., and Duboisia spp (Perveen and Qaiser, 2007). The tremendous range of varieties of secondary metabolites gives the family noteworthy importance (Inamdar and Patel, 1969). For centuries, Tropane alkaloids (Shah et al., 2013), atropine, hyoscyamine, and scopolamine, are among the oldest drugs used in medicine derived from Solanaceae species (Friedman, 2002; Oksman-Caldentey, 2007; Reina et al., 2010). Solanaceae contains also flavonoids, terpenes (Basu et al., 2014), tannins, and steroids (Edeoga et al., 2005; Wollenweber et al., 2005). Alkaloids are found in the whole parts of the plants like leaves, flowers, fruits stems, roots, and seeds. The presence of alkaloids in the Solanaceae member's secondary metabolites is a double-edged sword as although it makes Solanaceae species have a high potential for drug discovery, and makes the leaves of these plants, toxic to humans and animals also range from mildly irritating to fatal in small quantities, for instance, α-tomatine in tomato leaves (Shah et al., 2013).

One of the most important medicinal uses of Solanaceae species is based on its antimicrobial activities, which are attributed to their alkaloid contents (Arunkumar and Muthuselvan, 2009). It's believed that these secondary metabolites give those plants the performance of their natural defense against plant phytopathogens including bacteria, viruses, fungi, insects, and worms (Almoulah, 2017). The followinh is a brief summary of some plants belonging to Solanaceae and their medicinal properties. Cestrum has several species that are used in Chinese traditional medicine (Khaled et al., 2007). For instance, Cestrum diurnum has antimicrobial activity against some bacteria species such as S. aureus and P. aeruginosa. Its antimicrobial oil contains palmitic, stearic, and oleic acid. Its leaves contain a calcinogenic glycoside 1, 25- dihydroxychlocalciferol, which acts by increasing calcium ion Ca^{2+} leading to vitamin D toxicity. Solanum species, such as S. khasianum, S. xanthocarpum, S. nigrum, S. gracile, S. laciniatum have Solasodine, which is a spiroketal alkaloid sapogenin used for the production of steroid drugs in the medical industry.

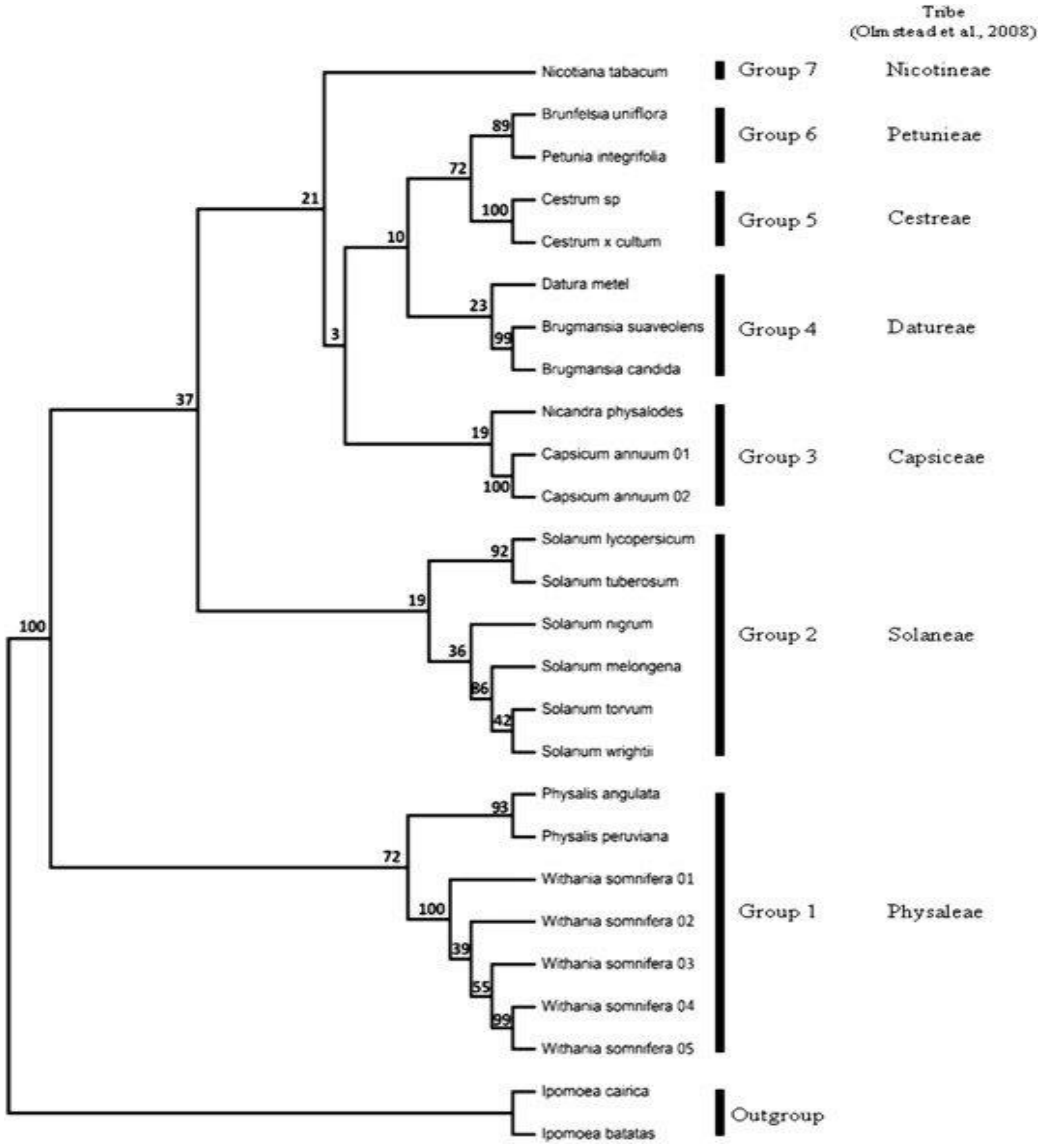

Figure 1: Phylogenetic tree of Solanaceae based on the internal transcribed spacer region (Hidayat et al., 2016).

antiaccelerator cardiac activities, and antioxidant activities (Thongchali et al., 2010). Solanum and Datura have narcotics properties. Recently, Solanum steroidal alkaloids have been represented as potential antimycotic agents, antiviral, and have cytotoxic properties. Species identified with a significant antimicrobial activity were Solanum pennellii, Solanum habrochaites, Nicotiana rustica, Solanum palinacanthum. They have antimicrobial activities against S. aureus and contain the isolated compounds rutin and 3,5-dicaffeoylquinic acid which have activity against S. aureus (Pereira et al., 2008). Solanum tomentosum shows antimicrobial activity against Gram-negative bacteria and Gram-positive bacteria (Aliero and Afolayan, 2006). Jimson weed (Datura stramonium) contains saponins, tannins, rich glycosides, and a source of tropane alkaloids (Berkov et al., 2006). Tropane alkaloids are used in the chemotaxonomy of Solanaceae and it has represented an antimicrobial activity against Pseudomonas aeruginosa, Klebsiella pneumonia, and Escherichia coli (Banso and Adeyemo, 2006). The antimicrobial compounds in these plants are produced from their trichomes, which also have been reported to produce steroidal saponins and glycoalkaloids (Munien, 2014). potato and tomato glycoalkaloids exhibit inhibition of human colon and liver cancer cells. Tomato also largely contributes to dietary nutrition worldwide with beneficial effects mainly attributed to its antioxidant compounds contents (Friedman and Chromatogr, 2004). As described in Gazetas Médicas, Physalis

angulata L. showed depressor activity on the central nervous system (CNS) (Giorgetti and Negri, 2011), and it has Physalin B that shows inhibition of S. aureus and N. gonorrhoeae (Silva et al., 2005).

History of Cestrum L. as one of the most important genera of Solanaceae.
Kingdom Plantae: Plants
Subkingdom Tracheobionta: Vascular plants
Super division Spermatophyta: Seed plants
Division Magnoliophyta: Flowering plants
Class Magnoliopsida: Dicotyledons
Subclass: Asteridae
Order: Solanales
Family Solanaceae: potato family
Genus Cestrum L.: Jessamine

Cytologically, Cestrum is the sister genus to Sessea (Sykorova et al., 2003). Cestrum is one of the most important genera in the family Solanaceae. In 1753, Linnaeus embodied Cestrum to conform material of two species, Cestrum nocturnum L. and Cestrum diurnum L. Full revisions of Cestrum have occurred by (Dunal, 1852; Francey, 1935; Francey, 1936). The Cestrum name is assumed to have been derived from the Greek word 'kestron', for similarity to a plant of that name, or 'kestrum', which is a tool used for engraving, which looks like in several plant's member's anthers (CABI, 2017). Cestrum is native to tropical Central and South American, with major concentrations in Brazil and the Andean region, and is widely distributed in tropical and subtropical areas around the world like Bangladesh, India, Australia, the Bahamas southwards to Chile northern Argentina, Bangladesh, United States, and southern China (Begum and Goyal, 2007; Prasad et al., 2013).

Inhabitant and distribution of Cestrum L.

Cestrum species are popular with their ornamental features because of their strongly fragrant flowers that bloom at night and day. Seeds germinate mainly in autumn with young plants taking two or more years to flower and set seed. Mature plants flower and seed each year. Seeds are delivered after 18 months of establishment and can remain dormant in the soil for many years. Sections of the fleshy root, which remain after digging or dragging out the plants are also suitable for regrowth (Croft and Holding, 2004). Vegetative reproduction is another way to reproduce also by using cut roots or buds from creeping roots and this makes the plant escapes from cultivation to some other areas such as road edges, forest gaps, gardens, fencerows, pastures, vacant lots, and abandoned farmland as they invade aggressively colonies and forming heavy impenetrable clumps in the forest understory and shrubland and resulting in competition with and displacement of native ecosystems services (Liogier, 1995). Cestrum nocturnum and Cestrum parqui is the most extremely difficult member to be controlled. Cestrum prevalence is back to its poisonous berries that affect the native fauna (Weedbusters, 2017). Although the leaves and fruit have medicinal purposes, Cestrum species don't only affect the surrounding plants, but also their fruits are poisonous and shouldn't be eaten by humans and other mammals, as they affect the nervous system. All other parts of Cestrum species are toxic to mammals, especially to cattle. The death of humans by these plants' poisons is not confirmed. Their poisoning effect becomes optimum especially during the winter months of June, July, and early spring. Consumption of a huge amount of Cestrum species may cause fatalities of animals. The less acute poisoning presents some symptoms such as watering of the eyes, salivation, unsteady gait, weak pulse, accelerated breathing, increasing debility caused by a disease commonly known as the "Chase valley Disease, respiratory problems from the scent, and feverish symptoms following ingestion (SAPIA, 2001). Their leaves are toxic because of the action of atropine-like alkaloids that are running in the Solanaceae family.

Morphological characterization of Cestrum L. species.

Cestrum contains more than 300 species of flowering plants in many forms as a moth, butterfly and hummingbird pollinated small trees, shrubs, vines with sympodial and robust herbs. Cestrum is mostly found in Asia, Europe, Africa as well as in warm 'subtropical' and 'tropical regions (Sarkar et al., 2016). The mature plants are semi-deciduous, their leaves fall off in the winter and reproduce rapidly again a new growth in spring which carries on truncated side branches subtended by a leaf at each node which can give the superficial appearance of an opposite arrangement of unequal leaves. It may be polyaxial, or monochasial branching. Members of this genus are classified by solitary or clustered flowers with five fused sepals and petals. Flowers could be nearly actinomorphic also. Fruits are fleshy succulent berries and are easily eaten and dispersed by birds through the consumption, and deposit of feces (Atkinson and James 1979). The flowers are prominent and are pollinated at most by insects. Cestrum species are also characterized by a superior ovary composed of two fused carpels with five stamens and

small, persistent calyces, long tubular corollas, small longitudinally dehiscent anthers held close to the corolla mouth, and few-seeded berries (Beckett, 1987).

Phytochemical description of Cestrum L.

Cestrum species are well-known for their ornamental, chemical, and pharmacological properties (Beckett, 1987; Backhouse et al., 1996). They have an old history in folk medicine for the treatment of health disorders (Al-Raza et al., 2009). Some Cestrum species were previously investigated for their chemical constituents, and it has been found that they contain Caffeic acid, cestric acids, many spirostanol saponins, steroidal saponins, parquine, carboxyparquine, lignans, flavonoids, phenolic compounds (Begum and Goyal, 2007; Mohamed et al., 2007; Nasr et al., 2018), volatile oils, as well as amounts of alkaloids from alcohol extracts of the leaves. Glycosides that possess calcinogenic potential were also identified in C. diurnum. whereas, saponins were identified in C. parqui (Ikbal et al., 2007). Cestrum nocturnum is used for many medicinal purposes as the plant has been shown noticeable biological activities. Cestrum elegans flowers extract is a potential remedy for fighting infectious diseases as it had been affirmed to produce compounds that were classified as saponins and flavonoids. These isolated compounds showed ratable in vitro antimicrobial activity against pathogenic microbial strains in comparison with standard antibiotics such as high antibacterial effect against Gram-positive “S. aureus”, Gram-negative “P. aeruginosa”, and against pathogenic dimorphic yeast “C. albicans”, and anti-fungal against mycotoxins fungus “A. Niger”. Alongside its antimicrobial activity, it has also been confirmed to have antiviral activity against the hepatitis A virus (Nasr et al., 2021).

In folk medicine, most Cestrum species have several medicinal usages. Especially in Chinese traditional medicine, Cestrum species have been used for the treatment of burns and swelling. In the West Indian Islands, Cestrum species have been used for treating epilepsy (Ntonifor et al., 2006).

Cestrum diurnum L.

Cestrum diurnum (Day Jasmine), (fig, 2a) also known as “Din ka Raja”, blooms during the daytime. Cestrum diurnum is native to Cuba, Jamaica, and Puerto Rico (Hanachi et al., 2009; IUCN, 2017). It has been delivered as an ornamental shrub to dry soils from mostly tropical and subtropical regions of the world. Now, it can be found naturalized on many islands in the Pacific Ocean, in India and South Africa, and across tropical and subtropical America. It does not prosper on exposed subsoil nor grow on the swampy ground, it grows in disturbed sites, pastures, along roadsides, and in secondary forests (FLEPPC, 2001).

The average annual temperature that Cestrum diurnum could tolerate is between 15˚C to 30˚C. Cestrum diurnum is an attendant to precipitation, where its colonization becomes more aggressive when increasing the amount of rain. It is also salt tolerant (FLEPPC, 2001). The species have two styles to inhabit even as individual plants or in thickets. It has been mentioned in the Global Compendium of Weeds as an environmental weed. It is also listed as an invasive or potentially invasive species in some areas outside its native range areas as Mexico, Tonga, South Africa, Marianas Islands, the Dominican Republic, Hawaii, Bahamas, Guam, and Florida (CABI, 2017). It has become a serious problem, where it is replacing native vegetation. as it is a trimmer species that invades mostly disturbed areas and establishes itself easily and reproduces quickly.

Cestrum diurnum L. is an erect evergreen woody shrub. It can grow up to the height of 2 meters with numerous trunks that are often densely branched and branches arching. These trunks are green with well-marked white lenticels when young, and become fawn with age (CABI, 2017). The younger parts are covered with very sparse glandular scruff. The leaves are alternate, simple, and short with a petiole that can extend to 1.2 cm (Bor and Raizada, 1954). The flowers are fragrant in the daytime, and also have a sweet scent during the nighttime. They have creamy white color and are trumpet-shaped in several-flowered. The clusters are short-stalked at upper leaf axils. The fruits are black, nearly globular berry. Corolla tube length extends to 1.8 cm, with tiny petal lobes curled back. Because of its fragrant flowers and its moderate size, it has been planted as an ornamental plant (Hanachi et al., 2009).

The qualitative and quantitative analysis of Cestrum diurnum revealed the presence of nicotine and nornicotine as major alkaloids in large quantities (Nishtha et al., 2017). other alkaloids had been detected also as 3, anor-lignan glycoside- cestrumoside 2, ursoloic acid, and some steroidal saponins in rich amounts named diurnoside and cesdiurinsI-III5 (Burt, 2004). It was extracted from the leaves some types of saponin like spirostane-type saponins, furostane-type saponins, and three new furostanol steroidal saponins named cesdiurins I–III (Fouad et al., 2008). The evaluation also showed the presence of xylose, glucose, galactose, and tigonin. According to Fouad et al., 2008 (1.25-dihydroxy vitamin D3- (1.25-(OH)2D3) which has a similar activity of vitamin D3 existed in Cestrum diurnum extraction, and it has been declared to be responsible for increasing calcium absorption.

In many parts of the world, practitioners had used Cestrum diurnum for many medical treatments such as; patches on the skin, controlling itching, and topical psoriasis therapy. Cestrum diurnum leaves contain several active compounds which possess medicinal properties such as antioxidant, hepatoprotective (Begum and Goyal, 2010),

larvicidal, and cardioactive activities (Wadsworth, 1974). Moreover, many African countries have used the plant's oil to treat malaria. The antimicrobial activity has been confirmed also, as it exhibits inhibition of the mycelial growth of some fungus species such as Absidia ramosa, A. brassicae, A. solani, A spergillus flavipes, A. fumigatus, A. terrius, Pyricularia oryzae, A. L'aricolar, C. gloeosporides, C. tinospore, H. orvzae, Absidia ramosa, H. turcicum, Paecilomyces sp., Penicillium decumbans, Rhizoctonia bataticola, R. solani, Chaetomium globossmn, Chaetomium fidcatum, Paecilomyces sp., A. temds, Trichoderma viride, and Penicillium decumbans (Renu et al., 1979). However, in Egypt, this species is cultivated for their ornamental purposes and isn't used medicinally (Fouad et al., 2008).

Cestrum Elegans L.

Cestrum elegans (Brongn. ex Neumann) Schltdl (Fig, 3b) or red Cestrum is a woody shrub, native to Mexico and introduced to Asia as an ornamental plant. Cestrum Elegans leaves are solitary, simple, petiolate, or entire. The stem is copious pubescent; the calyx is narrowly campanulate; with red, pink, or violet corolla, which conspicuously narrowed at the throat. The flowers are 5-merous, odorless with dark pink or globose berry. The inflorescence is erect, terminal or axillary, congested racemose panicles. It grows in moist or wet forests, and open areas both naturally and disturbed (Zuhri, 2017). C. elegans distributes rapidly and had a negative impact on native plant communities, as Its seeds are dispersed by birds (Moktan and Das, 2013). Furthermore, C. elegans was reported as invasive species and was found as exotic species in South Africa, the mountain forest of Reunion (Mascarene Archipelago), South-East Australia, fully naturalized in New Zealand, and In Cibodas Botanic Gardens (Indonesian) (Muyt, 2001; Clayson and Sawyer, 2006; Fourie, 2011). Cestrum elegans has a large genome size and few chromosomes (1C 9.76 pg; n = 8) (Zuhri, 2017).

According to HPLC fingerprint analysis, a steroidal saponin, named as (25R)-6α-[(β-D-glucopyranosyl) oxy]-5α-spirostan- 3β-yl β-D-glucopyranosyl (1"→3')-O-β-D-glucopyranosid was detected in the flowers of Cestrum elegans. Also, leaves and flowers of Cestrum elegans possess some phenolic compounds namely; Caffeic acid, coumaric acid, vanillin, rutin, syringic acid, catechin, quercetin, cinnamic acid, and gallic acid (Nasr et al., 2018). Many studies have been reported that there is a positive relationship between the existence of total phenolic content (TPC) in medicinal plant extracts and their biological activities, especially the total antioxidant capacity (TAC) (Huang et al., 2007). As the phenolic compounds exhibited potent antioxidant potential due to the presence of the characteristic structural criteria for effective free radical scavenging activity like; extended conjugation system heavy hydroxylation pattern, and ketonic groups (Wojdyło et al., 2007; Gengaihi et al., 2014). The antimicrobial action of these phenolic compounds depends on cell walls damage as a specific mode of action (Puupponen-Pimiä et al., 2001; Sousa et al., 2006; Hayriye, 2011; Nitiema et al., 2012; Madkour et al., 2017).

Cestrum elegans extracts exhibit biological and chemical activities. The tested extracts showed weak to moderate cytotoxicity against the Vero cell line. Furthermore, C. elegans leaves and flower extracts exhibit antimicrobial activity. The extract of C. elegans leaves exhibited moderate activities against S. aureus, P. aeruginosa, C. albicans, and A. niger. The extract of the flowers showed strong to moderate antimicrobial activities against S. aureus, P. aeruginosa, C. albicans, A. niger, and S. aureus. It has been demonstrated also that C. elegans is considered a natural source of antioxidant compounds with a low cytotoxic effect on the mammalian cell line (Nasr et al., 2018).

Cestrum nocturnum L.

Cestrum nocturnum Linn. (Fig, 2c) is one of the most important garden shrub species of Cestrum, also known with many other names as Night- Cestrum, Lady of the Night (Ghosh and Chandra, 2006), Queen of the Night, and Night-blooming Jasmine, as its flowers exude a special sweet fragrance that blooms at night (WGB, 2007; Fatema et al., 2019). It is also called "Hasnuhana" as a popular name, and "Raat ki Rani" (Shah et al., 2013; Fatema et al., 2019). It is mainly popular for its ornamental fragrant flowering and traditional medicinal purposes. Cestrum nocturnum has been used in traditional Chinese medicine (TCM) to treat digestive diseases for centuries. Due to the ornamental characteristics of Cestrum nocturnum, it has been used in many industries for making Perfumes, Soaps, Candles, Body Oils, Essential Oils, etc (Sarkar et al., 2016).

Cestrum nocturnum is an evergreen shrub growing to about 4 meters with simple, smooth, narrowly lanceolate, and glossy leaves with an entire margin (Khan et al., 2011, Chaskar et al., 2017; Fatema et al., 2019). The leaves are ovate-oblong, petiolate, and obtuse, and mostly 7 to 20 cm long, with vine-like stems. Cestrum nocturnum is characterized by sparsely pubescent flexuous branches, with crisped simple and glandular hairs. The flowers are greenish-creamy white tubular or pale greenish-yellow (Khan et al., 2011; Chaskar et al., 2017) with 5 stamens, which are puberulent at their bases (CABI, 2017). flowers emit a strong sweet scent at night. Corolla has obtuse, erect, or spreading lobes that are 5 to 6 mm long. The berries are small and white, about 8-10 mm long. The fruit is a berry of aubergine color. Seeds are few, prismatic, inner faces concave, outer face convex, hilum scar elliptic, minutely reticulate and the birds help to disperse it.

Cestrum nocturnum is native to Mexico, Australia (Al-Reza et al., 2010), New Zealand, El Salvador, Guatemala, Belize, Costa Rica, Panama Honduras, Nicaragua, Cuba, and widely distributed all over as well as tropical, and subtropical areas of the World (Punjabi et al., 2015; Nishtha et al., 2017). It has been found also in Asia: southern China (Al-Reza et al., 2010; Wu et al., 2017), India, Ogasawara Islands (Japan), and in the southernmost United States: California, Louisiana, Hawaii, Georgia, Texas, Florida; the Caribbean: Puerto Rico, US Virgin Islands; the Pacific Islands: Cook Islands, Galapagos Islands, American Samoa, Federated States of Micronesia, Fiji, Guam, Kiribati, French Polynesia, Marshall Islands, Nauru, Samoa, Tonga, New Caledonia, Niue, Pitcairn, Wallis and Futuna, Midway Islands (ISSG, 2017). generally, Cestrum nocturnum grows in all types of soils. However, the best adaption is in the rich loamy, irrigated soil, or dry sandy (Sarkar et al., 2016). It has low salt and waterlogging tolerance. Cestrum nocturnum produces long-lived seeds with high reproductive potential which makes the species widely dispersed. Cestrum nocturnum is considered an aggressive invader as it distributes in many sites such as forest gaps, trail sides, and landslides (ISSG, 2017), which cause a negative impact on native ecosystems. Cestrum nocturnum may form dense, shady thickets that outcompete indigenous flora of the area, where it occurs and may prevent natural regeneration of the flora and may prevent the establishment of native plant seedlings. (Weedbusters, 2017). The species can also have a negative impact on human and animal health if ingested due to the toxic alkaloids that its parts contain, which are capable of resulting in the death of livestock and causing hay-fever-like symptoms in some people (ISSG, 2017).

The chemical composition of Cestrum nocturnum is responsible for its therapeutic potentials and industrial benefits. Phytochemical screening has manifested the presence of important bioactive compounds in different parts of the plant, such as the presence of alkaloids, carbohydrates, fatty acids, spirostanol, steroidal saponins (Ahmad et al., 1991; Mimaki et al., 2002), flavonoids glycosides, tannins, ursolic acids, essential volatile oils, phenol compounds which are responsible for their biological activities, terpenes, (Jawale and Dama, 2010), and trisesquiterpenoid (Sridevi et al., 2015), and chlorogenic acids as the major chemical (Chaskar et al., 2017). According to chemical analysis (HPLC), It has been found that Cestrum nocturnum extract contains coumaric acid and vanillin are major constituents, while caffeic acid, rutin, catechin, quercetin, syringic acid, and cinnamic acid were detected as minor components (Nasr et al., 2018). In Flowers, the major compounds detected from the extract in different solvents were L-arabinitol, trans-Z-α-bisabolene epoxide, isoeugenol, diosgenin, 3-tetradecynoic acid, D-mannitol, methoxyeugenol, eicosane, phenyl ethyl alcohol, nonadecene, diacetylglycerol, D-mannitol, heneicosane, vanillic acid, and n-tetracosane (Jawale et al., 2010).

Some phytochemical analysis studies helped to recognize some compounds in the leave of C. nocturnum extract which have medicinal and industrial benefits, 1) ethyl citrate, is employed as a pseudo-emulsifier in e-cigarette juices, food products, and as a plasticizer (Park et al., 2004). 2) phytol has been tested and found to be a potent antimycobacterial agent and used in cosmetics, shampoos, household cleaners, toilet soaps, and the detergents industry (Sahoo et al., 2016). 3) 4-isobutylmorpholine is widely being used as a reagent in the pharmaceutical industry (Chaskar et al., 2017). 4) n-hexadecanoic acid produced hypocholesterolemic, nematicide, Antioxidant, insecticide, lubricant, and hemolytic properties (Selvarani and Bai, 2014). 5) α-amyrin is reported to have an ameliorative influence on infectious diseases (Venkatachalapathi et al., 2016). Mature foliage contains a ‘calcinogenic glycoside’ that leads to vitamin D poisonousness and is responsible for increasing serum calcium level (Mello, 2003). Cestrum nocturnum has several glycosides for instance ‘(25R)-spirost-5-ene-2R, 3 ,-diol pentaglycosides (nocturnoside A), (25R)-spirost-5-en-3,ol tetraglycoside (nocturnoside B)’ as well as phenolic glucosides (cesternosides A as well as B) (Sahai et al., 1994).

Cestrum nocturnum leaves extract has various therapeutic potentials such as an anti-inflammatory, analgesic (Mazumder et al., 2010), antimicrobial (Khan et al., 2011), anticancer (Zhong and Zhao, 2008), CNS depressant (Zeng et al., 2003), insecticidal, mosquito repellant especially against the mosquito Aedesa egypti, and as a treatment for night sweats (Savchenko et al., 2000; Patil et al., 2010; Patil et al., 2011; Kamboj et al., 2013), anticonvulsants, antiepileptic, (Pérez-Saad and Buznego, 2008) a local anesthetic (Zeng et al., 2002), antihyperglycemic, anti-hyperlipidemic, (Sahane et al., 2014) pesticidal (Al-Reza et al., 2010; Punctatus, 2012), wound healing (Khan et al., 2011; Kumar et al., 2016; Nagar et al., 2016), anti-arrhythmic (Zou et al., 2009), anti-tumor (Zhao et al., 2013), larvicidal (Jawale and Dama, 2010), insecticidal (Patil et al., 2011), anticonvulsant, cytotoxic (Mimaki et al., 2001), antidiabetic (Mimaki et al., 2001; Kamboj et al., 2013), antiviral, diuretic, abortive properties, anti-malarial, (Mimaki et al., 2006; Ntonifor et al., 2006; Nishtha et al., 2017) epilepsy (Punjabi et al., 2015), painkilling, inhibitory influence on the central nerve system, and local anesthetic effect (Zeng et al., 2003). It has a cardiac arrhythmic effect, and obtain negative inotropic as well as chronotropic actions (Pérez-Saad and Buznego, 2008). Also, it is used to treat arterial hypotension, dyspeptic, antispasmodic, smooth muscle relaxant (Raj et al., 2010; Jawale et al., 2012). Cestrum nocturnum could be used externally for skin disorders as it has an effect on burns and swellings (Roig and De noche, 1988; Xiao, 1989; Punjabi et al., 2015). The previous study has revealed that the essential oil and various organic extracts from the flower extract of Cestrum nocturnum also possess antioxidant activities that

might be a source of natural potential for use in food and other allied industries (Al-Reza et al., 2010; Nasr et al., 2018). The chemical contents are also used in the perfumes industry.

According to Qadir, 2014 the leaves extract of Cestrum nocturnum has hepatoprotective activities against the paracetamol-induced hepatotoxicity in albino mice as confirmed histopathologically. It is believed that this activity is due to the presence of flavonoids and phenolic components as Most flavonoids have hepatoprotective activity (Ali et al., 2013). The nephroprotective and nephrocurative activity of the leaves extract of Cestrum nocturnum have been evaluated also on rabbit kidneys and it exhibited significant results (Saleem et al., 2017).

The antimicrobial activity of the whole plant of Cestrum nocturnum L against pathogenic organisms was performed and the result had been revealed that C. nocturnum has antibacterial activity against some species such as Shigella flexenari, Staphylococcus aureus, Salmonella paratyphi A, Salmonella paratyphi B, Pseudomonas aeruginosa (Punjabi et al., 2015), Klebsiella. pneumoniae, Escherichia coli, Bacillus subtilis (Khan et al., 2011). Its antifungal activity had been affirmed also against Candida albicans, Aspergillus niger, Trichoderma, Proteus vulgari (Nasr et al., 2018).

Previous studies had proved that the isolated extract from the flowers of Cestrum nocturnum produced an inhibitory effect on the proliferation of human gastric hepatocellular carcinoma Bel-7404, cervical cancer HeLa cells, and carcinoma SGC-7901 in a dose-dependent manner with low immune toxicity (Lu et al., 2010). The mode of action of the extract fraction is to attenuate proliferation and trigger apoptosis at G0/G1 and G2/M phases in Bel-7404 cells through inhibiting topoisomerase II relaxation activity, which eventually causes DNA damage. According to phytochemical analysis, steroidal saponins contents are responsible for the plant bioactivity as most steroidal saponins were reported to produce great cytotoxicity towards cancer cells (Podolak et al., 2010). These results suggest that Cestrum nocturnum may represent important sources of potential antitumor agents.

Cestrum parqui L.

Cestrum parqui L´Hér (Fig, 2d) is usually known as “green or Chilean Cestrum” (Chenni et al., 2015). It is recognized by its fetid fragrance crushing leaves (Ragonese and Milano, 1984). However, it is used as an ornamental plant. Cestrum parqui is a shrub native to South America and found in the southern part of Italy (Stavolone et al., 2003; Fiorentino et al., 2008). Cestrum parqui contains a rich amount of alkaloid compounds which give the plant its toxic properties for animals (Ahmed et al., 2012). The plant is used fundamentally to protect the surrounding cultivated fields because it repels goats and has strong resistance to bacterial and cryptogamic diseases (Stavolone et al., 2003).

Figure 2: Four species of cestrum “Solanaceae family”, a) Cestrum diurnum. b) Cestrum elegans. c) Cestrum nocturnum. d) Cestrum parqui.

The organic extracts obtained from fresh leaves of the plant have been evaluated by phytochemical analysis and it has been found richness of secondary metabolites belonging to the lignans, phenyl propanoids, terpenes, oxylipins, which protect it from herbivore attacks or in the cases of pathogenic infections (Howe and Schilmiller, 2002). Also, saponins had been detected, which are responsible for the plant’s several biological activities such as a potent insecticidal, spermicidal (Chaieb et al., 2009), antimicrobial activity (Ahmed et al., 2012), and antifeedant activity especially against three insect pest species (Spodoptera littoralis, Schistocerca gregaria, Tribolium confusum) and a phytophagous mollusc spice (Theba pisana) (Chaieb et al., 2009). The chromatographic and mass spectrometric analysis also indicated the presence of oleanolic, and ursolic acids as biologically active compounds (Chenni et al., 2015).

A previous study reported insecticidal activity against Culex pipiens larvae. The plant extract resulted in insect malformation (Chaieb et al., 2001) as it causes a change in the color and size of the fat body cells, destruction of the cuticle structure, becoming denser because of losing its contents, and damage of the digestive walls with a separation of its peritrophic membrane (Chaieb et al., 2009; Ahmed et al., 2012).

The spermicidal activity of the plant exhibits many modifications, especially in the head's plasma membrane (Lohiya et al., 2000). According to Maikhuri, 2003 these compounds belong to a group that affects the sperm surface as it expanded and separated from the nucleus and the acrosome appeared interrupted (Kammoun et al., 2007). Also, the Plant derivatives cause severe inhibition in sperm membrane-specific enzymes, such as acrosin and hyaluronidase, the most important enzymes involved in the fertilization process (Chakrabati et al., 2003).

The antimicrobial activity of the saponins extracted from Cestrum parqui leaves had been examined. According to Ahmed, 2012 the results demonstrate, that it hasn't any antibacterial activity against the tested bacterial strain, two gram-positive (Pseudomonas aeruginosa, and Escherichia coli) and two gram-negative (Staphylococcus aureus, and Enterococcus faecalis) even with the highest concentration or against the two tested phytopathogenic fungi tested (Fusarium solani and Botrytis cinerea) probably due to their ability to synthesize detoxification enzymes. On the contrary, Trichoderma viride exhibited very high sensitivity and it's a good impact that can be used to check in the saponins mode of action as an antifungal agent.

Moreover, it has been demonstrated that the leaves extract of Cestrum parqui has anticancer activity as it showed remarkable inhibition on the growth of the HL-60 cell line. The mode of action of the inhibition was identified as cell cycle arrestation and apoptosis induction (Chenni et al., 2015). Several scientific reported that C. parqui has a wide spectrum of pharmacological activity based on administered systemically manner or in isolated organ preparations. Traditionally, Cestrum parqui was used as antifebrile and for treating inflammation and fever in Chilean folk medicine (Backhouse et al., 1996; D'Abrosca et al., 2005). Over since, its medicinal uses are expanded to treat dermatosis, rheumatic pain, headache, scabies, diarrhea, and metrorrhagia (D'Abrosca et al., 2004).

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