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An Overview of The Phytochemical and Pharmacological Characteristics of *Aerva lanata*

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Abstract

A. lanata has been utilized as a medicinal remedy for a wide range of illnesses. Moreover, an abundance of inspection studies has demonstrated that its applications in experimental animals extend beyond ethnobotanical ones. According to pharmaceutical analysis, it possesses antibacterial, anti-urolithiasis, anti-ulcer, anti-asthmatic, anti-diarrheal, antioxidant, antihyperglycemic, hypolipidemic, and antiulcer potential healing activities. It also has acute kidney injury healing qualities. Because of its higher antioxidant content and other essential components, it has a favorable potential for the treatment of numerous diseases, including metabolic disorders, supporting improved well-being and health maintenance. It is necessary to thoroughly investigate a variety of these components to make sure they are sufficient for displaying pharmacological activity. To quickly determine the different quantities of chemicals included in the plant's alcoholic extract, analytical methods must be applied. The plant's separated alkaloids and flavonoids are also responsible for its diagnostic properties. Moreover, it is imperative to identify unique bioactive compounds that may be the cause of these effects. The development of phytotherapy will be very helpful in the fight against infectious diseases in many forms of treatment. The current research's findings highlight the value of conventional treatments, and this plant extract can be used to create a useful supply of unique antioxidant components and antibacterial substances. In addition, future research on this plant will need to isolate its active metabolites and structurally reconstruct it to determine which powerful molecule is involved from a pharmacological perspective. Thus, it is clear that *Aerva lanata* cultivation, accumulation, and additional pharmacological research are essential.

Keywords: *Aerva lanata*, Ethnobotanical, Pharmacological Activity, Analytical Methods.

Introduction

The use of medicinal plants for healing dates back as long as humanity. There is substantial proof of the long-standing human link to the hunt for pharmaceuticals in nature from a variety of sources, including written records, preserved monuments, and even the original plant medicines. The many years of fighting diseases have taught us to seek out pharmaceuticals in the bark, seeds, fruit bodies, and other parts of plants. This has led to an awareness of the use of therapeutic plants. Modern science has recognized their potent effects and incorporated a variety of plant-based medications, which have been utilized for millennia by ancient societies, into contemporary pharmacotherapy. Stabilization techniques for fresh medicinal plants were developed in the early

1900s, particularly for those with labile medicinal components. In addition, a lot of work went into researching the circumstances surrounding the production and development of medicinal plants. Many neglected plants and medications produced from them, such as *Aconitum, Punica granatum, Hyoscyamus, Stramonium, Filix mas, Opium, Styrax, Colchicum, Ricinus,* and so on, have been brought back into use in pharmacy due to chemical, physiological, and clinical studies. The most seamless, natural laboratory produces the active ingredients found in therapeutic plants. Given that humans are an essential component of nature, the human body responds to drugs the best. (1) Any plant that has compounds in one or more of its organs that have medical value or that serve as building blocks for the semi-synthesis of chemo pharmaceuticals is considered medicinal. A plant is assumed to be beneficial as a medication, therapeutic agent, or an active component of a medicinal preparation when it is designated as such. For primary healthcare, herbal medicines are highly sought after in both developed and developing nations due to their broad range of biological and therapeutic properties, increased safety margins, and lower cost. (2)

India has a vast array of fragrant and medicinal plants that grow in a variety of environmental situations. India is classified as a region of high plant diversity and endemism due to its geographic location, geomorphology, presence of flora from previous geological eras, coexistence, and interaction of biotic and non-biotic factors. This classification also affects the category of medicinal and aromatic plants (MAPs). It has been discovered by man that an astringent plant may stop diarrhea, an acid plant can stop vomiting, and an aromatic plant can stop nausea. Native American medicine was highly developed in the past, and we have prominent practitioners of homeopathy, allopathy, Siddha, Unani, and Ayurveda. Approximately 70% of India's MAPs are found in tropical forests found in the Himalayas, the Vindhyas, the Chotta Nagpur plateau, the Western and Eastern Ghats, and the Aravalis. This information was obtained by an investigation of MAP distribution in natural habitats. Research also revealed that, in contrast to evergreen and temperate climates, a sizable portion of known MAPs are found in dry and damp deciduous vegetation areas. Approximately 33% of the plants are classified as trees, 32% as herbs, 20% as shrubs, 12% as creepers, and 3% as miscellaneous plants. (3)

Plant Profile

Classification

Kingdom: Plantae

Division: Tracheophyta

Class: Magnoliopsida

Order: Caryophyllales

Family: Amaranthaceae

Genus: *Aerva*

Species: *lanata* (4-8)

Common name

Bengali: Chaya

Rajasthani: Bhui

Sindhi: Bhui, Jari

Punjabi: Bui-kaltan

Hindi: Gorkhabundi, Kapurijadi

Marathi: Kapurmadhura, Kapurimadhuri, Kapurphuti, Kumra. (4-8)

Synonym: *Achyranthes lanata, Achyranthes pubescens, Achyranthes villosa, Aerva arachnoidea, Aerva elegans, Aerva pubescens, Aerva sansibarica, Aerva tandalo, Amaranthus aeruoides, Amaranthus lanatus, Illecebrum lanatum, Paronychia lanata.* (4-8)

Description

It is an erect or prostrate dioecious herb that can reach a height of 80 cm. It has many fibrous lateral roots that have a camphoraceous odor, which is yellowish brown on the outside and whitish on the inside. The tap root is cylindrical and branching, measuring 7–2 cm in length and 2–8 mm in thickness. It has branching ends, with pubescent or wolly-tomentose, striate branches at the base. Smooth hairs cover the shoots. The leaves are simple and alternating, with white cottony hairs underneath. The lamina is elliptic, obovate, or suborbicular, with an obtuse or acute apex and tapering base. Axillary heads or spikes make up the inflorescence. Bisexual, tiny, sessile flowers with spikes that are greenish-white in color. The fruit is ovoid in shape with a shiny black seed that resembles a kidney bean, and the perianth is 1.5–1.25 mm long with silky, hairy petals on the back that are oblong and obtuse. (4-8)

Microscopy

Anomocytic stomata with smooth, curved epidermal cells and vein termination numbers of 6-7 make up the leaves. It demonstrates the existence of starch grains, rosette-type calcium oxalate crystals (sphaeraphides), multicellular uniseriate warty trichomes, and rhomboidal calcium oxalate crystals as demonstrated by the plant's powder study. The leaf displays rectilineal cell walls, conic multicellular hairs in the indumentum, anomocytic and hemiparasitic unsubmerged stomata, palisade cells, dorsoventral mesophyll, spongy parenchyma with chlorophyll, conducting bundles, and eight to ten radial chains of vessels. The leaves also include multiarticulate, uniseriate trichomes with spinulated surfaces that taper at the end.

The transverse section of the roots has five to seven rows of cork cells with a secondary cortex that reveals the presence of parenchymatous cells with thin walls and calcium oxalate rosette crystals, three to four alternating rings of secondary xylem and phloem with pitted vessels, and circular pith cells with calcium oxalate rosette crystals. Calcium oxalate crystals, lignified and non-lignified cylindrical fibers, lignified xylem arteries with bordered pits, simple, oval, or spherical starch grains, tricho sclereid, cork cells, parenchyma cells, and secondary phloem are all visible in powdered roots. The thick-walled and small-celled epidermis, thick-walled collenchyma cells beneath the epidermis, parenchyma-containing clusters of pericyclic fibers, primary xylem arteries, radial chains of secondary xylem vessels, resin ducts, and small, spherical cells in the medulla are all visible in the stem. (4-8)

Distribution

The plant's general habitat is found in wastelands in India (Assam, Karnataka, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh); Jawa, Nepal, Philippines, and Sri Lanka. It can also be found on field bunds, under trees, and in damp areas. (4-8)

Traditional uses

The herb is used to treat skin conditions, headaches, kidney and gall bladder stones, uterine clearing following delivery, lactation inhibition, burn healing during pregnancy, and hemorrhage stops. The extract from the plant is used to treat spermatorrhoea, fractures, coughing, nasal hemorrhage, and scorpion stings. It functions as an anthelmintic medication's goal, to soothe irritated and wounded skin. The plant cures dysentery, cholera, and diarrhea in the people of Bihar. In addition to their tonic qualities, the roots are utilized as a diuretic and demulcent. (4-8)

PHYTOCHEMISTRY

The plant is home to biologically active canthin-6-one alkaloids, including 10-methoxy-canthin-6-one, 10-hydroxy-canthin-6-one, 10-O-β-D-glucopyranosyloxycanthin-6-one, 10-hydroxycanthin6-one (ervine), 10-methoxycanthine-6-one (methyl ervine), 10-β-D-glucopyranosyloxycanthin-6-one (ervoside), aervine (10-hydroxycanthin-6-one), methyl aervine (10-methoxycanthin6-one), and aervoside (10-β-D-glucopyranosyloxycanthin-6-one). Aervolanine (3-(6-methyoxyβ-carbolin-1-yl) propionic acid) and β-carboline-1-propionic acid, as well as 6-methoxyβ-carboline-1-propionic acid and 6-methoxyβ-carbolinl-ylpropionic acid, are also alkaloids found in plants. Flavonoids including kaempferol, quercetin, isorhamnetin, isorhamnetin 3-O-β-[4-p-coumaroyl-αrhamnosyl (1→6) galactoside and flavanone glucoside persinol, persinosides A and B, etc. are abundant in *Aerva lanata*. Apigenin 7-O-β-D-glucoside and 7-O-β-D-glucopyranoside are examples of 5, 4'-hydroxy-3, 6, 7-tri methoxy flavone, 5-hydroxy-3, 6, 7, 4-tetramethoxy flavone, 5-hydroxy 2', 3,5', 6,7-pentamethoxyl flavone, 3,3',5,7-trihydroxy-4'-methoxy flavone. Moreover, methyl grevillate, benzoic acid, β-sitosteryl acetate, lupeol, lupeol acetate, and tannic acid are found in Aerva lanata. It was discovered that *Aerva lanata* leaves have significant levels of ash, crude protein, and carbohydrates (31.2 g/100g). The mineral content (mg/100g) of the leaves showed that they were low in Mn and relatively high in K, Ca, Mg, Zn, and Fe, as well as high in PO_4^{3-}. (4-8)

Reported Pharmacological Activities

M. Al-Ansari et al. (2019) reported the phytochemical components, microbial inhibitory, and antioxidant properties of *Aerva lanata* plant extracts. The entire plant demonstrated a variety of therapeutic uses in traditional medicine and folklore across the globe. Various phytochemical tests were performed on the organic extracts, including ethanol, ethyl acetate, chloroform, acetone, water, and methanol, to establish the presence of flavonoids, glycosides, terpenoids, and alkaloid-containing components. As an alternative, the extracts work extremely well against E. coli and E. aerogenes at dosages ranging from 5 mg/ml to 40 mg/ml. By using the DPPH technique, the extracts also demonstrated encouraging antioxidant activity. (9)

Manik Ghosh et al (2018) investigated the antioxidant, antimicrobial, and anti-urolithiatic activity of *Aerva lanata* Flowers. In comparison to normal BHT, the extract in chloroform (68%), ethyl acetate (92%), and aqueous (65%) demonstrated similar DPPH free radical scavenging capabilities at both low and high doses.

BHT > methanolic extract > ethyl acetate > chloroform > aqueous is the sequence in which test samples (0 and 500 ppm) and the standard are scavenged by free radicals. When tested against both Gram-positive and Gram-negative bacteria, including *S. aureus* and *Acinetobacter, E. coli*, and *R. planticola*, the methanolic extract showed strong antibacterial activity. Additionally, the levels of calcium, phosphate, uric acid, oxalic acid, protein, and citrate in the kidney homogenate of the calculi-induced animal group were dramatically reduced by a high dose of methanolic extract and cystone treatment. (10)

Arivalagan Pugazhendhi et al (2021) evaluated the antibacterial, antioxidant, and nephroprotective proficiency of the methanol extract of *Aerva lanata* flowers. Concerning *Staphylococcus aureus* (3–20 mm), *Pseudomonas aeruginosa* (9–25 mm), *Salmonella* (10–23 mm), *Streptococcus pneumoniae* (3–16 mm), and *Escherichia coli* (10–24 mm), the methanol extract demonstrated exceptional antibacterial activity at a concentration of 40 mg mL^{-1}. In addition, the *A. lanata* methanol floral extract exhibits remarkable antioxidant activity, measuring 1.48 ± 0.12 mg mL^{-1}. When applied at a 20 µg mL^{-1} concentration to HEK 293 cells exposed to 8 µg mL^{-1}, the methanol extract demonstrated remarkable nephroprotective action (97.04%) and was nearly equivalent to the standard nephroprotective medication quercetin (8 µg mL^{-1}). (11)

D. Anantha et al. (2010) reported the invitro anti-helminthic activity of aqueous and alcoholic extracts of *Aerva lanata* seeds and leaves tested against a tapeworm and an earthworm. At room temperature, the time of death and/or total paralysis were recorded. To determine if the worm was dead, it was placed in a beaker filled with 50ºC hot water, which would have caused the worm to move if it was still alive. To verify the findings, five separate tests were conducted for every observation. When compared to the effect produced by the reference standard drug albendazole, the alcoholic extract at normal concentrations (2.5, 5, 10, 20 mg/ml) only demonstrated good anti-helminthic activity, whereas the aqueous extract of *Aerva lanata* at high concentrations (2.5, 5, 10, 20 mg/ml) showed good anti-helminthic activity. (12)

Renata Nowak et al. (2021) investigated the chemical composition of phenolic acid (PA)-rich fractions isolated from methanolic extracts of *A. lanata* using the liquid/liquid extraction method and their potential antioxidant, anti-inflammatory, and anti-diabetic properties. Tri-quadrupole mass spectrometry (LC-ESI-MS/MS) was used to evaluate the free PA fraction (FA), the PA fraction (FB) that was released following acid hydrolysis, and the PA fraction (FC) that was acquired following alkaline hydrolysis. Every sample's phenolic profile revealed a significant PA content. The amount of PA in fraction A was minimal as compared to fractions FB and FC. Phenolic acids found in Fraction B were also found in FC; however, syringic, vanillic, gentisic, sinapic, 4-hydroxybenzoic, salicylic, and protocatechuic acids (mostly derivatives of hydroxybenzoic acid, except synapic acid) were generally present in higher concentrations than in FC. The concentration of gentistic, vanillic, and syringic acids showed the biggest variations between fractions B and C. High levels of 2ABTS (2.88 mM TE/g) and DPPH (2.85 mM Trolox equivalents (TE)/g) scavenging activity were found in bioactivity experiments conducted on all fractions. Fraction FB demonstrated the greatest inhibitory capacity for both lipoxygenase (LOX) (EC_{50} = 1.88 mg/mL) and xanthine oxidase (XO) (EC_{50} = 1.77 mg/mL), in addition to having the best antiradical activity. With minor inhibition of α-amylase (EC_{50} = 7.46 mg/mL) and substantial inhibition of α-glucosidase (EC_{50} = 0.30 mg/mL), the fraction exhibited the strongest anti-diabetic

characteristics. The presence of PA components and the overall PA content were highly correlated with the activities of all the studied samples. (13)

Irfan Anjum et al (2022) evaluated the Immunomodulatory and anti-inflammatory effects of *Aerva lanata* in ovalbumin-induced allergic asthmatic mice. The ethyl acetate extract *of A. lanata* was shown to be the most effective in reducing the number of inflammatory cells in both blood and broncho-alveolar lavage fluid (BALF). IgE antibodies and the inflammatory modulator TNF-α were both reduced by the *A. lanata* extract. In asthmatic mice, it also decreased interleukin 4, 5, and 13 and increased AQP1 and AQP5 expression levels. GC-MS analysis revealed the presence of several phytoconstituents that are antioxidants. Inflammation, goblet cell score, and alveolar thickening were all improved by the extract. Therefore, the suppression of edema, pro-inflammatory cytokines, and IgE antibodies, as well as the rise of aquaporin expression levels, may contribute to *A. lanata* anti-asthmatic impact. This suggests that further research and clinical trials may be necessary to support *A. lanata* candidacy for treating allergic asthma. (14)

Raphael Eguono Uwejigho et al. (2023) investigated the testicular toxicity of the testes of offspring of Wistar rats (Dams) treated with crude aqueous extract of *Aerva lanata* leaves. Six weeks after giving birth, the puppies (delivered by the dams) were weighed, examined, and slaughtered. The male pups' testes were removed for histological analyses, and the testis histology was looked at. When compared to the control, the treated pup testes tissues displayed different levels of disruption and distortion in the cellular architectures of the germinal epithelium on a dose-dependent basis. The study therefore demonstrated the toxicity of *Aerva lanata* on the testicles and its potential antifertility effect on the pups of dams. (15)

Soundararajan et al. (2007) reported the hypolipidemic activity of aqueous extract of aerial parts of *Aerva lanata* on ethylene glycol-induced calcium oxalate urolithiasis in rats. Rats with calcium oxalate urolithic kidneys had significantly higher blood, liver, and kidney levels of total lipids, total cholesterol, and triglycerides. In addition, calcium oxalate urolithic rats had changed amounts of phospholipids (PL), high-density lipoproteins (HDL), low-density lipoproteins (LDL), and very low-density lipoproteins (VLDL). The aqueous suspension supplementation brought the aforementioned alterations back to almost normal. These findings suggest that in calcium oxalate urolithiasis, *A. lanata* aqueous suspension functions as a hypolipidemic agent. (16)

M Johnson et al. (2011) reported the terpenoid profile of *Aerva lanata* using HPTLC. As a mobile phase for terpenoids, n-hexane: ethyl acetate (7.2: 2.8) was used. 27 distinct terpenoids with a range of R_f values between 0.06 and 0.97 were found in the methanolic extract of A. lanata's stem, leaves, roots, flowers, and seeds. Simple, accurate, and precise, the established HPTLC method for terpenoid profiles can be applied to identification and business applications. (17)

Manokaran S et al. (2008) evaluated the hepatoprotective activity of the hydroalcoholic extract of *Aerva lanata* against paracetamol-induced liver damage in rats. The animals were given the extract orally at a dose of 600 mg/kg, while the reference standard was supplied as 25 mg/kg of silymarin. By suspending the test medications in a 0.5% carboxymethyl cellulose solution, they were all given orally. Rats' livers were effectively shielded from the damage caused by paracetamol by the plant extract. The serum enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and bilirubin

significantly decreased, which was indicative of this. Based on the results, it was determined that rats' hepatotoxicity caused by paracetamol was prevented by the hydroalcoholic extract of *Aerva lanata*. (18)

R. Rajesh et al. (2011) evaluated the Anticancer activity of methanol (MEAL) and aqueous extracts (AEAL) of the aerial parts of *Aerva lanata* against intraperitoneally injected Dalton's Ascitic Lymphoma (DAL) cell lines in Swiss albino mice. The reference dosage was 5-fluorouracil (20 mg/kg). At 200 mg/kg, both MEAL and AEAL lowered the average rise in body weight, packed cell volume, and viable tumor cell counts, and lengthened the survival of mice given DAL treatment. They also restored the lipid profile, serum enzyme, and hematological parameters to levels that were almost normal. According to these findings, extracts may be protective against Dalton's ascitic lymphoma (DAL). (19)

Girija Kuttan et al. (2011) reported the Immunomodulatory and antitumor activity of *Aerva lanata* ethanolic extract. At 10 mg/kg body weight, the ethanolic extract of the entire A. lanata plant was observed to increase the number of α-esterase-positive cells (1276 cells/4000 cells), bone marrow cellularity (22.33×10^6 cells/femur), and total WBC count (14,238 cells/mm^3). In vitro and in vivo, its therapy has also shown increased proliferation of bone marrow cells, thymocytes, and splenocytes in the presence and absence of particular mitogens. Both the circulating antibody titer and the number of plaque-forming cells (PFC) in the spleen (243.33 PFC/106 spleen cells) were elevated. At 500 µg/mL, the extract was 100% cytotoxic to Ehrlich ascites carcinoma (EAC) and Dalton's lymphoma ascites (DLA) cells. Additionally, it was discovered that at higher concentrations, it was cytotoxic to L929 and HELA cells, whereas the nontoxic amounts decreased the rate of cell growth. Concurrent delivery of the extract has the potential to significantly reduce the growth of solid tumors produced by DLA in mice and extend the survival of animals harboring EAC tumors by 53.47%. (20)

Sunder et al. (2011) investigated the anti-diarrheal Activity of *Aerva lanata* in Castor oil-induced diarrhea, Charcoal meal test, and PGE2-induced enteropooling in rats. Loperamide (2 mg/kg) and atropine (0.1mg/kg) were used as standard drugs. Significant protection against PGE2-induced enteropooling was demonstrated by alcoholic extract at doses of 400 and 800 mg/kg p.o. This protective effect may have been caused by the reduction of prostaglandin synthesis, which is the cause of diarrhea. Because alcoholic extract inhibits prostaglandin synthesis and reduces gastrointestinal motility, it has an antidiarrheal effect. The extract may contain alkaloids and flavonoids, which could explain the reported effects. (21)

Mangala Gunatilake et al. (2012) investigated the toxic effects of dried infusion of *A. lanata* 25g/200ml (low dose), and 100g/200ml (high dose) on the structure and function of the urinary tract of a rat model (Sprague-Dawley rats). The findings showed that there was no statistically significant difference between the test groups' urine flow rate (UFR) and creatinine clearance (Ccr) compared to the control group. Studies using light microscopy (LM) did not reveal any histological alterations that would indicate toxicity. However, significant ultrastructural alterations were observed in the proximal convoluted tubular epithelial cells of the rats in both test groups according to electron microscopy (EM) examinations. Therefore, it can be said that giving rats dried Aerva lanata for a month had no appreciable impact on their kidney function. On the other hand, the proximal convoluted tubular epithelial cells had notable ultra-structural alterations as a result of treatment throughout the same period. (22)

Vivek et.al. (2015) evaluated the invitro anti-inflammatory activity of methanol extract of *Avera lanata* leaves by HRBC lysis and protein denaturation. To evaluate the extract's anti-inflammatory properties, it was incubated at various doses with HRBC and egg albumin under carefully monitored experimental circumstances. The absorbance of the mixture was then measured. Diclofenac sodium served as the benchmark medication. The current results showed that the extract inhibited HRBC lysis and protein (albumin) denaturation in a concentration-dependent manner. When compared to the extract, diclofenac sodium was found to have less of an effect. The polyphenols and flavonoids found in *A. lanata* may have had an impact. (23)

Estari Mamidala et al. (2014) evaluated the anti-HIV activity and cytotoxic effects of *Aerva lanata* root extracts. Extracts were made using the sequential maceration method in hexane, chloroform, ethyl acetate, acetone, and methanol solvents. The filtered mass was then collected at low ambient temperature under pressure in a rotating vacuum evaporator. Using the Retro Sys HIV-1 RT activity kit, the extracts' anti-HIV activity was assessed. PBMCs obtained from whole blood were used to conduct cytotoxicity research utilizing the MTT test on all extracts. The chloroform extract of Aerva lanata had the highest (91.0%) HIV-RT inhibition at 2 mg/ml concentration among all the extracts, with the highest activity among them all. At a concentration of 2 mg/ml, the extractions of hexane, ethyl acetate, and acetone also demonstrated the maximum inhibition of HIV-RT (86.9, 85.2, and 77.5, respectively). At a concentration of 2 mg/ml, the control medication, AZT, displayed 91.7%. Every extract's IC_{50} value was found to be less than 40 mg/ml. This finding implies the presence of bioactive chemicals with potential medical value in Aerva lanata root extracts. (24)

Conclusion

Aerva lanata is a perennial undershrub that grows prostrate or succulent on mountain slopes up to 900 meters above sea level. It is a member of the Amaranthaceae family. Due to its many therapeutic benefits, it is commonly known as Mountain Knotgrass in English or Gorakhabooti in Hindi. It is a gift from nature. It is a member of the Pashanbheda family of plants, which is used to treat kidney stones. It has several therapeutic uses in traditional and folklore medicine in different regions of the world. Its broad spectrum of pharmacological actions is attributed to the enormous range of phytochemicals it contains, including terpenoids, flavonoids, phenolic acids, steroids, canthin-6-one and β-carboline alkaloids, and many other classes of phytoconstituents. Its pharmacological properties include anti-urolithiatic, diuretic, hepatoprotective, immunomodulatory, anticancer, antioxidant, and antibacterial properties. Consequently, it is a natural treasure. The plant's infinite variety of phytochemicals is responsible for its diverse pharmacological properties. Regarding the biological activities and potential mechanisms of action of the different separated phytoconstituents, more investigation is necessary. To advance to additional clinical research in people, toxicological investigations in animals must also be completed. There is still room for formulating new products that are marketable and useful in treating a range of illnesses.

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