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REVIEW ARTICLE

A comprehensive review on antiepileptic properties of medicinal plants

Muhammad Faheem [a,1], Sara Ameer [a,1], Abdul Waheed Khan [b,*], Muhammad Haseeb [c], Qurratulaen Raza [b], Fawad Ali Shah [a], Ameer Khusro [d,*], Chirom Aarti [d], Muhammad Umar Khayam Sahibzada [e,*], Gaber El-Saber Batiha [f], Niranjan Koirala [g,*], Muhammad Adnan [b], Saad Alghamdi [h], Hamza Assaggaf [h], Naif O. Alsiwiehri [i]

[a] *Riphah Institute of Pharmaceutical Sciences, Riphah International University, Islamabad, Pakistan*
[b] *Department of Pharmacy, Ibadat International University Islamabad, Islamabad, Pakistan*
[c] *Department of Molecular Science and Technology, Ajou University, Suwon 16499, South Korea*
[d] *Research Department of Plant Biology and Biotechnology, Loyola College, Chennai, Tamil Nadu, India*
[e] *Department of Pharmacy, Sarhad University of Science and Information TTechnology, Peshawar 25100, Khyber Pakhtunkhwa, Pakistan*
[f] *Department of Pharmacology and Therapeutics, Faculty of Veterinary Medicine, Damanhour University, Damanhour 22511, AlBeheira, Egypt*
[g] *Department of Natural Products Research, Dr. Koirala Research Institute for Biotechnology and Biodiversity, Kathmandu 44600, Nepal*
[h] *Laboratory Medicine Department, Faculty of Applied Medical Sciences, Umm Al-Qura University, Makkah , Saudi Arabia*
[i] *Department of Clinical Laboratory Sciences, College of Applied Medical Sciences, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia*

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KEYWORDS

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Medicinal plants;
Prevalence;

Abstract Pakistan has large variety of medicinal plants distributed throughout the country. Due to the unavailability and high cost of allopathic medicines, herbal therapists, especially in rural areas, prescribe phytomedicine for Epilepsy. The native people consider such treatments most effective for seizures. The data of the effective antiepileptic medicinal plants of Pakistan were collected from the

* Corresponding authors.
E-mail addresses: waheedmarwat31@gmail.com (A.W. Khan), armankhan0301@gmail.com (A. Khusro), umar.sahibzada@gmail.com (M. Umar Khayam Sahibzada), koirala.biochem@gmail.com < /em.
[1] Authors have equal contribution.

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Phytochemicals;
Pakistan;
Seizures

published research articles by exploring article search engines like PubMed, Medline, Web of Science, Google Scholar, and ScienceDirect. Additional information such as mode of preparation and application of medicinal herbs were acquired from folk medicine users, traditional healers, and local people enriched in knowledge of herbal medicines. Total 97 families were uncovered to be used in epileptic and seizure disorders, of which, the foremost use belonged to Lamiacea 19 (18.56%), Asteraceae and Fabaceae 16 (16.5%) each, Fabaceae 11 (11.34%), Rubiaceae, Rutaceae, and Apocynaceae 6 (2.4%) each, Caesalpiniaceae, Solanaceae, Byrtaceae and Anacardiaceae 5 (2%) each, and Liliaceae, Mimosaceae, Ranunculaceae and Combretaceae 4 (1.6%) each. According to the plants habit, of 241 plants, herbs were 102 (42.15%), trees were 72 (29.75%), shrubs were 54 (22.31%), climbers were 12 (4.96%), and bulbs were 2 (0.83%). According to the part used, 105 (43.39%) plants were found to have antiepileptic potentials in leaves, 51 (31.07%) plants in roots, 20 (8.36%) plants in stem, 8 (3.31%) plants in rhizome, 4 (1.65%) plants in bulb, 32 (13.22%) plants in bark, 6 (2.48%) plants in gum, 19 (7.85%) plants in flowers, 18 (7.44%) plants in fruits, 24 (9.92%) plants in seeds, and 29 (11.98%) plants as a whole. This review provides foundation for researchers to understand the pivotal role of certain medicinal plants towards the treatment of epilepsy and seizures.

Contents

1. Introduction

The burdens of mental illnesses like depression, epilepsy, Alzheimer, Parkinson, alcohol dependence, and schizophrenia have been considered a serious conditions worldwide (Chang et al., 2013). The global epidemiology of epilepsy and its prevalence in Pakistan and neighboring countries are shown in Table 1. Epilepsy is one of the most common and serious disorders of the brain (Beghi, 2020). About 1% of the population suffers from epilepsy, and about one-third of patients have refractory epilepsy (i.e., seizures are not controlled by appropriate antiepileptic medications). Approximately 75% epilepsy begins during childhood, reflecting susceptibility of the developing brain to seizures (Stafstrom and Carmant, 2015). However, the incidence in childhood has fallen over the past three decades in the developed countries with subsequent increase in geriatric populations.

A clinical syndrome often has many possible causes that can lead to various epileptic syndromes (Beghi, 2020). Epilepsy syndrome refers to a group of clinical characteristics; occur together with similar seizures' types, age of onset, ECG findings, triggering factors, genetics, natural history, prognosis, and responses to antiepileptic drugs (Stafstrom and Carmant, 2015). The common epilepsies are complex traits depending on inherent variation in particular gene (Beghi, 2020). In term of mechanism, an epileptic seizure can be defined as "a state produced by an abnormal excessive neuronal discharge within the central nervous system" (Penfield and Erickson, 1941). Seizures are paroxysmal alteration of neuronal function caused by the excessive and increased synchronous discharge of the neurons in the brain. Epileptic seizure is actually used to distinguish a seizure caused by abnormal neuronal firing from a non-epileptic event, such as psychogenic seizures (Shorvon et al., 2011; Stafstrom and Carmant, 2015). Not all epilepsies are recognized as electro-clinical syndromes (Robinson et al., 2002; Breakspear et al., 2006). Uncommon epilepsy syndromes that have monogenic inheritance are associated with mutations in genes that encode subunits of voltage-gated ion channel and ligand gated ion channel. In voltage gated ion channels, mutation of Na^+, K^+, and Cl^- channels are associated with forms of generalized epilepsy and infantile seizures syndromes (Scheffer and Berkovic, 2003; Berg et al., 2010). Absence seizure is associated with the dysfunction of

Table 1 Global epidemiology of epilepsy and its comparative prevalence in Pakistan and neighbouring countries.

Epilepsy	Prevalence	References
Worldwide	0.5–1%	Hussain et al., 2017
Asia	0.49%	Khan et al., 2019
Africa	1.13%	Khan et al., 2019
Australia	0.44%	Bellon et al., 2015
Europe	0.82%	Khan et al., 2019
North America	0.8%	Theodore et al., 2006
South America	0.98%	Khan et al., 2019
Pakistan	2%	Awan et al., 2017
Afghanistan	8.9%	Ventevogel et al., 2012
China	0.3%	Ebrahimi et al., 2012
India	0.39%	Ebrahimi et al., 2012
Iran	1.8%	Ebrahimi et al., 2012

Table 2 Medicinal plants used traditionally for the treatment of epilepsy.

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
1	*Aristolochia rotunda* L.	Smearwort	Aristolochiaceae	Shrub	Root	Powder	Sahranavard et al., 2014
2	*Aristolochia longa* L.	Dutchman's pipe	Aristolochiaceae	Herb	Root	Decoction of roots to make tea	Sahranavard et al., 2014
3	*Allium sativum* L.	Garlic	Liliaceae	Herb	Bulb	Extract	Sharma et al., 2013
4	*Asparagus racemosus* Willd	Satavar	Liliaceae	Climber	Root	Powder	Jalalpure et al., 2009; Sharma et al., 2013
5	*Achyranthes aspera* L.	Chaff-flower	Amaranthaceae	Herb	Root	Powder	Gawande et al., 2017; Sharma et al., 2013
6	*Abrus precatorius* L.	Jequirity bean	Leguminosae	Climber	Leaves	The leaves are boiled with water	Moshi et al., 2005
7	*Anacyclus pyrethrum* L.	Spanish chamomile	Asteraceae	Herb	Root	Ethanolic extract	Gautam et al., 2011
8	*Areca catechu* L.	Areca nut	Arecaceae	Tree	Root	Extract	Lodge et al., 1977
9	*Albizia coriara* Welw. ex Oliv	West African albizia	Mimosaceae	Tree	Bark	Mixture of pulverized bark and *Ternstroemia* species is inhaled	Focho et al., 2009
10	*Allium cepa* L.	Onion	Liliaceae	Bulb	Bulb	Decoction with *A. sativum* and *Nicotina tobaccum* is taken orally.	Focho et al., 2009
11	*Annona diversifolia* Saff.	Ilama	Annonaceae	Tree	Leaves and flower	Ethanolic extract	González-Trujano et al., 2015; González-Trujano et al., 1998
12	*Aloe vera* (L.) Burm.f.	Aloe	Liliaceae	Herb	Leaves	Aqueous extract	Rathor et al., 2014; Shah and Khan, 2006
13	*Annona senegalensis* Pers.	Wild soursop	Annonaceae	Shrub	Leaves and Root	Infusion	Bum et al., 2011
14	*Acorus calamus* L.	Sweet flag	Acoraceae	Herb	Rhizome and root	Methanolic, aqueous, and alcoholic extracts	Samleti et al., 2012
15	*Anastatica hierochuntica* L.	Rose of jericho	Brassicaceae	Shrub	Whole plant	Decoction	Abouri et al., 2012
16	*Albizzia berteriana* (DC.) M.Gomez	Flea tree	Fabaceae	Tree	Leaves and seed	Ethanolic extract	Kasture et al., 2000
17	*Annona squamosa* L.	Sugar apple	Annonaceae	Tree	Seed	Ethanol extract	Saluja and Santani, 1994
18	*Ambrosia paniculate* Michx.	American wormwood	Asteraceae	Herb	Leaves	Decoction	Buznego and Pérez-Saad, 2004
19	*Artemisia vulgaris* L.	Mugwort	Asteraceae	Herb	Stem and leaves	Aqueous extract	Abdul-Ghani et al., 1987
20	*Anisomeles malabarica* (L.) R. Br. ex Sims	Malabar catamint	Lamiaceae	Herb	Leaves	Ethanolic extract	Choudhary et al., 2011
21	*Anthocephalus cadamba* (Roxb.) Miq.	Burflower-tree	Rubiaceae	Tree	Bark	Ethanolic extract	Nagakannan et al., 2011
22	*Acalypha fruticose* Forssk.	Birch leaved acalypha	Euphorbiaceae	Shrub	Stem	Extract	Govindu and Adikay, 2014
23	*Afrormosia laxiflora* (Benth. ex Baker) Meeuwen	East African afrormosia	Leguminosae	Tree	Root	Decoction	Haruna, 2000
24	*Artemisia dracunculus* L	Tarragon	Asteraceae	Shrub	Whole plant	Essential oil	Sayyah et al., 2004
25	*Aeollanthus suaveolens* Mart. ex Spreng.	Suavis mart	Lamiaceae	Herb	Leaves	Essential oil	Elisabetsky and Coelho de Souza, 1997
26	*Artemisia*	Chinese	Compositae	Herb	Whole	Hydroalcholic extract	de Lima et al., 1993

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Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
	verlotorum Lamotte	mugwort			plant		
27	*Acorus gramineus* Aiton	Japanese sweet flag	Acoraceae	Herb	Rhizome	Methanolic extract	Duy and Trang, 2015; Yang et al., 2006
28	*Balsamodendron myrrha kaunth.*	Myrrh	Burseracea	Shrub	Seed and gum	Powder of seeds and dry gum	Sahranavard et al., 2014
29	*Bryonia dioica* Jacq.	Red bryony	Cucurbitaceae	Tree	Fruit and leaves	Leaves powder, while fruits are taken as such	Sahranavard et al., 2014
30	*Bryonia alba* L.	Wild hop	Cucurbitaceae	Herb	Fruit and leaves	Ethanol extract	Jäger et al., 2006
31	*Boerhavia diffusa* L.	Punarnava	Nyctaginaceae	Herb	Roots	Powder	Adesina, 1979; Sharma et al., 2013
32	*Bacopa monnieri* (L.) Wettst.	Water hyssop	Scrophulariaceae	Herb	Leaves	Ethanolic extract	Balamurugan et al., 2009; Kaushik et al., 2009
33	*Biophytum petersianum* Klotzsch.	Life plant	Oxalidaceae	Herb	Whole plant	Powder	Focho et al., 2009
34	*Butea monosperma* (Lam.) Kuntze	Flam of the forest	Fabaceae	Tree	Flower	Petroleum ether extract	Kasture et al., 2000
35	*Berberis integerrima* Bunge	Barberry	Berberidaceae	Shrub	Root	Methanolic extract	Hosseinzadeh et al., 2013
36	*Brassica nigra* (L.) K.Koch	Black mustard	Brassicaceae or Cruciferae	Herb	Seed	Hydro-alcoholic extract	Kiasalari et al., 2012
37	*Balanites aegyptiaca* (L.) Delile	Thron tree	Balanitaceae	Shrub	Whole Plant	Decoction	Bum et al., 2005
38	*Bixa orellana* L.	Annatto	Bixaceae	Tree	Leaves	Methanolic extract	Shilpi et al., 2006
39	*Bridelia micrantha* (Hochst.) Baill.	Coastal golden-leaf	Phyllanthaceae	Tree	Leaves	Decoction	Bum et al., 2012
40	*Cuscuta epithymum* Murray.	Love vine	Convolvulaceae	Climber	Stem	Hydro-ethanol extract	Mehrabani et al., 2007; Sahranavard et al., 2014
41	*Caesalpinia bonducella* (L.) Roxb.	Bonduc nut	Caesalpiniaceae	Shrub	Seed	Powder	Balamurugan et al., 2009
42	*Commiphora opobalsamum* Engl.	Mecca myrrh	Burseracea	Tree	Seed and gum	Powder of seeds and dry gum	Sahranavard et al., 2014
43	*Cedrus deodara* (Roxb. ex D.Don) G.Don	Deodar	Pinaceae	Tree	Leaves	Alcoholic extract	Viswanatha and Nandakumar, 2009
44	*Coriandrum sativum* L.	Cilantro	Apiaceae	Herb	Seed	Aqueous and ethanol extract	Hosseinzadeh and Madanifard, 2000
45	*Celtis integrefolia* L.	Nettle tree, African hackberry	Asteraceae	Herb	Bark and leaves	Methanol extract	Muazu and Kaita, 2008; Musa and Adam, 2017
46	*Cassia fistula* L.	Golden shower	Fabaceae	Tree	Seeds	Decoction and aqueous seed fraction	Sharma et al., 2013; Tan and Castillo
47	*Clerodendrum viscosum* Vent.	Hill glory bower	Verbenaceae	Shrub	Leaves	Powder	Sharma et al., 2013
48	*Chlorophytum borivillianum* Santapau & R.R. Fern.	Safed musli	Lilliaceae	Herb	Leaves	Tincture of leaves	Balamurugan et al., 2009
49	*Curcuma longa* L.	Turmeric	Zingiberaceae	Herb	Rhizome	Essential oil	Balamurugan et al., 2009; Oyemitan et al., 2017
50	*Cannabis sativa* L.	Marijuana	Cannabaceae	Herb	Leaves	Decoction	Oyemitan et al., 2017

Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
51	*Clausena anisate* (Willd.) Hook.f. ex Benth.	Perdepis	Rutaceae	Shrub	Root, bark, and leaves	Extract boiled with water	Kenechukwu et al., 2012; Moshi et al., 2005
52	*Clematis hirsute* Guill. & Perr.	Clemitite	Ranunculaceae	Climber	Leaves	Leaf juice	Focho et al., 2009
53	*Craterocapsa tarsodes* Hilliard & B.L.Burtt.	Wahlenbergia montana	Campanulaceae	Herb	Whole plant	Crude methanol extract	Van Heerden et al., 2002
54	*Cestrum nocturnum* L.	Night-blooming jasmine, lady of the night	Solanaceae	Shrub	Leaves	Decoction	Pérez-Saad and Buznego, 2008
55	*Citrus sinenis* L.	Sweet orange	Rutaceae	Tree	Leaves, bark, root, and flower	Decoction and infusion	Bum et al., 2011
56	*Colebrookia oppositifolia* Sm.	Pansre	Lamiaceae	Shrub	Leaves and roots	Extract	Murad et al., 2011
57	*Convolvulus arvensis* L.	Bindweed	Convolvulaceae	Herb	Whole plant	Extract	Murad et al., 2011
58	*Cuminum cyminum* L.	Cumin	Umbelliferae	Herb	Fruit	Essential oil	Samleti et al., 2012; Sayyah et al., 2002a
59	*Centella asiatica* (L.) Urb.	Asiatic pennywort	Apiaceae	Herb	Whole plant	Powder plant extract	Samleti et al., 2012; Visweswari et al., 2010
60	*Cymbopogon winterianus* Jowitt ex Bor.	Citronella	Poaceae	Herb	Leaves	Essential oil	Quintans-Júnior et al., 2008
61	*Cotyledon orbiculata* L.	Round-leafed navel-wort	Crassulaceae	Shrub	Leaves	Methanolic and aqueous extract	Amabeoku et al., 2007
62	*Calotropis procera* (Aiton) W.T. Aiton.	Apple of Sodom	Asclepiadaceae	Shrub	Leaves	Powder	Abouri et al., 2012
63	*Crocus sativus* L.	Saffron	Iridaceae	Herb	Stigma	Aqueous and ethanolic extract	Hosseinzadeh and Khosravan, 2002
64	*Cyperus articulates* L.	Priprioca	Cyperaceae	Herb	Rhizome	Methanolic extract	Bum et al., 2001; Bum et al., 2011
65	*Calliandra portoricensis* (Jacq.) Benth.	Powder puff	Liguminoseae – Mimosoideae	Shrub	Root and stem	Aqueous extract	Akah and Nwaiwu, 1988
66	*Canscora decussata* (Roxb.) Schult. & Schult.f.	Kambumalinee	Gentianaceae	Herb	Whole plant	Crude powder and alcoholic extract	Dikshit et al., 1972
67	*Carum copticum* (L.) Benth. & Hook. f.	Ajwain	Apiaceae	Herb	Seed	Aqueous extract	Rezvani et al., 2011
68	*Cyperus rotundus* L.	Java grass	Cyperaceae	Herb	Rhizome	Hydro-alcoholic extract	Khalili et al., 2011
69	*Cynanchum wilfordii* (Maxim.) Hemsl.	Keunjorong	Apocynaceae	Herb	Root	Decoction	Li et al., 2016
70	*Caesalpinia sappan* L.	Brazil wood	Fabaceae	Tree	Leaves	Methanolic extract	Baek et al., 2000
71	*Carissa edulis* (Forssk.) Vahl	Currant Bush	Apocynaceae	Shrub	Root and bark	Aqueous and ethanolic extract	Ya'u et al., 2008
72	*Calotropis gigantea* (L.) Dryand.	Crown flower	Asclepiadaceae	Shrub	Root	Alcoholic extract	Argal and Pathak, 2006
73	*Casimiroa edulis* La Llave	White sapote	Rutaceae	Tree	Leaves	Aqueous extract	Ruíz et al., 1995
74	*Cymbopogon citratus* (DC.) Stapf	West Indian lemon grass	Poaceae	Herb	Leaves	Essential oil	Blanco et al., 2009

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Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
75	*Cymbopogon proximus*	Halfabar	Poaceae	Herb	Whole plant	Volatile oil	El Tahir and Abdel-Kader, 2008
76	*Chrysanthemum boreale* (Hochst. ex A.Rich.) Chiov.	Mums	Compositae	Herb	Flower, leaves, and stem	Tea and extract	Nugroho et al., 2013
77	*Croton macrostachyus* Hochst. ex Delile	Woodland croton	Euphorbiaceae	Tree	Whole plant	Decoction	Bum et al., 2012
78	*Coleus amboinicus* Lour.	Cuban oregano	Lamiacea	Herb	Leaves	Leaf juice	Kumari et al., 2012
79	*Datura stramonium* L.	Thorn apple	Solanaceae	Herb	Seed	Powder	Aghdash et al., 2015; Sharma et al., 2013
80	*Daniellia oliveri* (Rolfe) Hutch. & Dalziel	African copaiba balsam tree	Caesalpiniaceae	Tree	Roots	Extraction and decoction	Bum et al., 2011
81	*Detarium microcarpum* Guill. & Perr.	Sweet dattock	Caesalpiniaceae	Tree	Root, bark, and leaves	Decoction	Bum et al., 2011
82	*Delphinium denudatum* Wall. ex Hook.f. & Thomson	Jadwar	Ranunculaceae	Herb	Dried roots	Ethanolic extract and aqueous fraction	Raza et al., 2001
83	*Dalbergia sissoo* DC.	North Indian rosewood	Fabaceae	Tree	Leaves and bark	Ethanol extract	Majeed et al., 2019
84	*Drosera burmannii* Vahl.	Burmann's Sundew	Droseraceae	Herb	Whole plant	Alcoholic and aqueous extract	Hema et al., 2009
85	*Egletes viscosa* L.	Macela	Asteraceae	Herb	Flower head	Essential oil	Souza et al., 1998
86	*Erythrina indica* Lam.	Indian coral tree	Fabaceae	Tree	Leaves	Coarse powder	Rajamanickam and Sathyanarayanan, 2008
87	*Elaeocarpus ganitrus* Roxb. ex G.Don.	Rudraksha	Elaeocarpaceae	Tree	Leaves	Tincture	Dasgupta et al., 1984
88	*Echinodorus berteroi* (Spreng.) Fassett	Cellophane Sword	Alismataceae	Herb	Root	Decoction	Buznego and Pérez-Saad, 2006
89	*Equisetum arvense* L.	Common horsetail	Equisetaceae	Herb	Whole Plant	Aqueous extract	Dos Santos Jr et al., 2005
90	*Eugenia caryophyllata* Thunb.	Clove	Myrtaceae	Shrub	Dried buds	Essential oil	Pourgholami et al., 1999
91	*Eucalyptus urophylla* S.T. Blake	Timor white gum	Myrtaceae	Tree	Leaves	Essential oil	Teixeira et al., 2008
92	*Eucalyptus brassiana* S.T. Blake	Cape York gum	Myrtaceae	Tree	Leaves	Essential oil	Teixeira et al., 2008
93	*Emilia sonchifolia* (L.) DC. ex DC.	Lilac tasselflower	Asteraceae	Herb	Leaves	Ethanolic and aqueous extract	Asije et al., 2006
94	*Ferula gummosa* Boiss.	Galbanum	Apiaceae	Herb	Seed	Acetone extract	Sayyah et al., 2002b
95	*Ferula persica* Willd.	Sakbinaj	Apiaceae	Herb	Gum	Powder paste	Bagheri et al., 2010
96	*Flueggea virosa* (Roxb. ex Willd.) Royle	White-berry bush	Phyllanthaceae	Tree	Whole plant	Alcoholic extract	Pedersen et al., 2009
97	*Flacourtia indica* (Burm.f.) Merr.	Governor's plum	Flacourtiaceae	Shrub	Bark, fruit, and leaves	Ethanolic extract	Ayyanna et al., 2020; Bum et al., 2011

Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
98	*Ficus sycomorus* L.	Sycamore fig	Moraceae	Tree	Stem and bark	Aqueous extract	Sandabe et al., 2003
99	*Ficus religiosa* L.	Bodhi tree	Moraceae	Tree	Leaves	Methanolic extract	Singh and Goel, 2009
100	*Ficus platyphylla* Delile	Broad leaf fig	Moraceae	Tree	Stem and bark	Methanol extract	Chindo et al., 2009
101	*Glycyrrhiza glabra* L.	Liquorice	Fabaceae	Herb	Rhizome and root	Ethanolic extract	Ambawade et al., 2002; Balamurugan et al., 2009
102	*Gentiana olivieri* Griseb.	Gentian	Gentianaceae	Herb	Flower	Ethanolic extract	Aslan et al., 2011
103	*Gladiolus dalenii* Van Geel.	Parrot gladiola	Iridaceae	Herb	Whole plant	Aqueous extract	Ngoupaye et al., 2013
104	*Goodyera schlechtendaliana* Rchb.f.	Schlechtendal's goodyera, miyamauzura	Orchidaceae	Herb	Whole plant	Alcoholic extract	Du et al., 2002
105	*Hypericum perforatum* L.	Goatweed	Hypericaceae	Herb	Leaves	Aqueous and ethanolic extracts	Hosseinzadeh et al., 2005a
106	*Hippeastrum vittatum* (L'Hér.) Herb.	Barbados lily	Amaryllidaceae	Herb	Bulbs	Fresh bulbs triturated and macerated	da Silva et al., 2006
107	*Hedranthera barteri* (Hook.f.) Pichon	Goat's testicles	Apocynaceae	Shrub	Leaves	Methanol extract	Sowemimo et al., 2012
108	*Hoslundia opposita* Vahl.	Orange bird berry	Lamiaceae	Herb	Leaves	Boiled with water to make tincture	Moshi et al., 2005; Risa et al., 2004
109	*Hypoxis colchicifolia* Baker	Broad-leaved hypoxis	Hypoxidaceae	Herb	Whole plant	Extract	Risa et al., 2004
110	*Hymenocardia acida* Tul.	Heart-fruit	Hymenocardiaceae	Shrub	Leaves, bark, and root	Infusion powder	Bum et al., 2011
111	*Hypoxis hemerocallidea* Fisch.	Star flower , African potato	Hypoxidaceae	Herb	Whole plant	Aqueous extract	Ojewole, 2008a
112	*Harpagophytum procumbens* (Burch.) DC. ex Meisn.	Wood spider, devil's claw	Pedaliaceae	Herb	Root	Aqueous extract	Mahomed and Ojewole, 2006
113	*Haplophyllum vermiculare* Hand-Mazz.	Plant of mosquito	Rutaceae	Shrub	Leaves and flower	Powder	Abouri et al., 2012
114	*Hibiscus rosa sinensis*	China rose	Malvaceae	Shrub	Flower	Ethanolic extract	Kasture et al., 2000
115	*Heracleum persicum* Desf.	Persian hogweed	Umbelliferae	Herb	Seed	Acetone extract	Sayyah et al., 2005
116	*Heracleum crenatifolium* Boiss.	Hogweed	Apiaceae	Herb	Fruit	Essential oil	Tosun et al., 2008
117	*Helleborus* sp. L.	Black helleborus	Ranunculaceae	Herb	Root	Ethanol extract	Jäger et al., 2006
118	*Inula conyza* DC.	Ploughman's-spikenard	Asteraceae	Herb	Whole plant	Decoction	Sahranavard et al., 2014
119	*Inula cappa* DC.	Sheep's ear	Asteraceae	Shrub	Root	Decoction	Sharma et al., 2013
120	*Ipomoea stans* var. *hirsuta* B.L. Rob.	Bindweed	Convolvulaceae	Herb	Whole plant	Lyophilized powder	Contreras et al., 1996
121	*Jasminum grandiflorum* L.	Jasmine	Oleaceae	Climber	Leaves and flower	Hydroalcoholic extract and essential oil	Gupta and Reddy, 2013; Wei et al., 2015
122	*Kalanchoe crenata* (Andrews) Haw.	Kalanchoe, neverdie	Crassulaceae	Shrub	Leaves	Extract	Nguelefack et al., 2006
123	*Lagoecia cuminoides* L.	Wild cumin	Apiaceae	Herb	Fruit	Taken as such	Sahranavard et al., 2014

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Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
124	*Lavandula stoechas* L.	French lavender	Lamiaceae	Shrub	Flower	Aqueous and methanolic extract	Gilani et al., 2000
125	*Laurus nobilis* L.	Bay tree	Lauraceae	Tree	Leaves	Essential oil	Sayyah et al., 2002c
126	*Lychnophora staavioides* Mart.	Arnica da serra	Asteraceae	Shrub	Stem, bark, roots, and leaves	Alcoholic extract	Taleb-Contini et al., 2008
127	*Lupinus albus* L.	White lupin	Fabaceae	Herb	Leaves and stem	Aqueous extract	Abdul-Ghani et al., 1987
128	*Leonotis leonurus* (L.) R.Br.	Wild dagga	Lamiaceae	Shrub	Leaves	Aqueous and methanol extract	Bienvenu et al., 2002; Nsuala et al., 2015
129	*Lychnophora rupestris* Semir & Leitão	Falsa arnica	Asteraceae	Shrub	Stem	Methanolic extract and fraction	Taleb-Contini et al., 2008
130	*Lychnophora diamantinana* Coile & S.B.Jones	Arnicas	Asteraceae	Herbs	Stem	Methanolic extract and fraction	Taleb-Contini et al., 2008
131	*Lobelia nicotianaefolia* Roth	Wild tobacco	Campanulaceae	Herb	Leaves	Powder	Tamboli et al., 2012
132	*Lantana camara* L.	Lantana	verbanaceae	Shrub	Leaves	Powder	Kazmi et al., 2012
133	*Myroxylon balsamum* L.	Tolu balsam	Fabaceae	Tree	Seeds and gum	Dry powder	Sahranavard et al., 2014
134	*Myroxylon pereirae* Klotzsch.	Peru balsam	Fabaceae	Tree	Gum	Powder paste	Sahranavard et al., 2014
135	*Melilotus* sp. L.	Sweet clover	Fabaceae	Herb	Leaves and seed	Extraction of fresh leaves and powder of seeds are used orally	Sahranavard et al., 2014
136	*Mitragyna inermis* (Willd.) Kuntze	Kauchii (hausa)	Rubiaceae	Shrub	Leaves, bark, and roots	Aqueous and ethanol extract	Muazu and Kaita, 2008; Timothy et al., 2014
137	*Martynia annua* L.	Cat's claw	Martyniaceae	Herb	Leaves	Decoction	Sharma et al., 2013
138	*Mimosa pudica* L.	Sensitive plant	Mimosaceae	Shrub	Root	Decoction	Focho et al., 2009
139	*Mussaenda angolensis* Wernh.	Ntuabala	Rubiaceae	Shrub	Leaves	Infusion	Focho et al., 2009
140	*Magnolia officinalis* Rehder & E.H.Wilson	Houpu magnolia	Magnoliaceae	Tree	Bark	Ether extract	Watanabe et al., 1975
141	*Matricaria chamomilla* L.	Chamomile	Asteraceae	Herb	Flower	Aqueous extract	Abdul-Ghani et al., 1987
142	*Morinda citrifolia* L.	Indian mulberry	Rubiaceae	Tree	Fruit	Methanol extract	Muralidharan and Srikanth, 2010
143	*Melissa officinalis* L.	Lemon balm	Lamiaceae	Herb	Whole plant	Methanol and aqueous extract	Bhat et al., 2012
144	*Madhuca longifolia* L.	Mahwa	Sapotaceae	Tree	Heart wood	Methanol extract	Patel et al., 2011
145	*Malva sylvestris* L.	Mallow	Malvaceae	Tree	Leaves	Ethanol extract used as a juice	Jäger et al., 2006
146	*Magnolia dealbata* Zucc.	Eleoxochitl	Magnoliaceae	Tree	Leaves and bark	Ethanol extract	Martinez et al., 2006
147	*Mucuna pruriens* (L.) DC.	Velvet bean	Fabaceae	Climber	Leaves	Ethanolic extract	Champatisingh et al., 2011
148	*Moringa oleifa* L.	Horseradish tree	Moringaceae	Tree	Root	Extract	Rajasree et al., 2012
149	*Nigella sativa* L.	Black cumin seed	Ranunculaceae	Herb	Seed	Aqueous extract	Akhondian et al., 2007; Khazdair, 2015

Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
150	*Nicotiana tabacum* L.	Tobacco	Solanaceae	Herb	Leaves	Concoction with bulbs of *A. cepa* and gloves of *A. sativum* is taken orally for 8 months	Focho et al., 2009
151	*Nardostachys jatamansi* (D. Don) DC.	Spikenard, Musk root	Valerianaceae	Herb	Root	Ethanolic extract	Rao et al., 2005
152	*Newbouldia leavis* (P.Beauv.) Seem.	Boundary tree	Bignoniaceae	Shrub	Flower, root, and leaves	Ethanolic extract	Usman et al., 2008
153	*Nelumbo nucifera* Gaertn.	Indian lotus	Nelumbonaceae	Herb	Fruit	Ethanol extract	Rajput et al., 2017
154	*Nauclea latifolia* Sm.	African peach	Rubiaceae	Tree	Root	Decoction	Bum et al., 2009b
155	*Nepeta sibthorpii* Benth.	Catmint	Lamiaceae	Herb	Leaves	Methanol extract	Galati et al., 2004; Taviano et al., 2007
156	*Opopanax chironium* Koch	Hercules-all-heal	Apiaceae	Herb	Gum	Aqueous extract	Sahranavard et al., 2014
157	*Origanum majorana* L.	Sweet marjoram	Lamiaceae	Herb	Leaves	Powder	Deshmane et al., 2007
158	*Oroxylum indicum* (L.) Kurz	Tree of Damocles	Bignoniaceae	Tree	Leaves, seed, and bark	The powder of seeds 2–3 g is taken internally	Sharma et al., 2013
159	*Ocimum sanctum* L.	Holy basil	Lamiaceae	Herb	Leaves and stem	Extract	Jaggi et al., 2003
160	*Origanum vulgare* L.	Oregano	Lamiaceae	Herb	Leaves, stem, and tuber	Aqueous extract	Abdul-Ghani et al., 1987; Shah and Khan, 2006
161	*Olea europaea* L.	European olive	Oleaceae	Tree	Leaves and stem	Aqueous extract	Abdul-Ghani et al., 1987
162	*Ocimum basilicum* L.	Sweet basil	Lamiaceae	Herb	Leaves	Essential oil	Oliveira et al., 2009
163	*Ocimum gratissimum* L.	Clove basil	Lamiaceae	Shrub	Leaves	Essential oil	Freire et al., 2006
164	*Parietaria cretica* L.	Cretan Pellitory-of-the-wall	Urticaceae	Herb	Whole plant	Decoction	Sahranavard et al., 2014
165	*Paeonia officinalis* L.	Garden peony	Paeoniaceae	Herb	Root	Aqueous extract	Tsuda et al., 1997
166	*Populus nigra* L.	Black poplar	Salicaceae	Tree	Fruit	Fresh fruits	Sahranavard et al., 2014
167	*Populus alba* L.	Silver poplar	Salicaceae	Tree	Fruit	Fruits as such	Sahranavard et al., 2014
168	*Pavetta indica* L.	Kankra	Rubiaceae	Shrub	Root and bark	1 g root's fine powder with black pepper powder is administered orally	Sharma et al., 2013
169	*Primula elatior* (L.) Hill	Oxlip	Primulaceae	Herb	Leaves	Tea from the green or dried plant against convulsions	Jäger et al., 2006
170	*Primula veris* L.	Cowslip	Primulaceae	Herb	Leaves	Extract ethanol	Jäger et al., 2006
171	*Pimpinella anisum* L.	Aniseed	Apiaceae	Herb	Seed	Methyl-alcoholic extract	Heidari and Ayeli, 2005
172	*Piper longum* L.	Long pepper	Piperaceae	Climber	Fruit	Aqueous extract	Juvekar et al., 2008
173	*Psorospermum senegalense* Spach	Balanta sukus	Guttiferae	Shrub	Root	Powder	Pedersen et al., 2009
174	*Paeonia emodi* Wall	Peony Rose	Paeoniaceae	Herb	Rhizome, root, and seed	Extract	Hamayun et al., 2006; Khar, 2012
175	*Prosopis africana* (Guill. & Perr.) Taub.	Iron tree	Mimosaceae	Tree	Leaves and bark	Decoction	Bum et al., 2011
176	*Pyrus pashia* Buch. -Ham. ex D.Don	Wild pear	Rosaceae	Tree	Fruit	Ethanolic extract	Murad et al., 2011; Sharma et al., 2019

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Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
177	*Persea americana* Mill	Avocado	Lauraceae	Tree	Leaves	Aqueous extract	Ojewole and Amabeoku, 2006
178	*Piliostigma reticulatum* (DC.) Hochst.	Camel's foot	Caesalpiniaceae	Tree	Leaves	Decoction	Bum et al., 2009a
179	*Plectranthus amboinicus* (Lour.) Spreng.	Indian borage	Lamiaceae	Herb	Whole plant	Aqueous extract	Llanio Villate et al., 1999
180	*Psidium guyanensis* Pers	Araca azedo	Myrtaceae	Shrub	Leaves	Essential oil	Santos et al., 1997
181	*Passiflora edulis* Sims	Purple passionfruit	Passifloraceae	Climber	Leaves	Decoction	Bum et al., 2004
182	*Piper tuberculatum* Jacq.	Pipilongo	Piperaceae	Shrub	Roots	Powder	Felipe et al., 2007
183	*Passiflora incarnata* L.	Maypop	Passifloraceae	Climber	Leaves	Hydroalcoholic extract	Nassiri-Asl et al., 2007
184	*Qualea grandiflora* Mart.	Pau-terra	Vochysiaceae	Tree	Leaves	Crude hydroalcoholic extract and fractions	Gaspi et al., 2006
185	*Ruscus aculeatus* L.	Butcher's-broom	Ruscaceae	Shrub	Leaves and fruit	Aqueous extract	Sahranavard et al., 2014
186	*Ricinus communis* L.	Castor bean	Euphorbiaceae	Shrub	Leaves, flower, and seeds	Ethanol extract	Sharma et al., 2013; Tripathi et al., 2011
187	*Rhus tridentata* L. f.	Bitter grape	Anacardiaceae	Climber	Leaves	Ethanolic and water extract	Risa et al., 2004
188	*Rhus rehmanniana* Engl.	Blunt-leaved Currant	Anacardiaceae	Tree	Leaves	Extract	Risa et al., 2004
189	*Ruta graveolens* L.	Rue	Rutaceae	Herb	Whole plant	Hydro -alcoholic extract	Keihanian et al., 2012
190	*Ruta chalepensis* L.	Fringed rue	Rutaceae	Shrub	Flower and leaves	Ethanol extract	Gonzalez-Trujano et al., 2006
191	*Rosmarinus officinalis* L.	Rosemary	Lamiaceae	Shrub	Whole plant	Aqueous extract	Abdul-Ghani et al., 1987
192	*Rauwolfia serpentina* (L.) Benth. ex Kurz	Indian snakeroot	Apocynaceae	Climber	Whole Plant	Tincture	Charveron et al., 1984
193	*Rhus pyroides*	Firethorn Rhus	Anacardiaceae	Shrub	Leaves	Ethanol extract	Svenningsen et al., 2006
194	*Seseli tortuosum* L.	Lankstytasis auksveitis	Apiaceae	Tree	Leaves	Extraction and tea	Sahranavard et al., 2014
195	*Securidaca longipedunculata* Fresen.	Violet tree	Polygalaceace	Tree	Bark, leaves, and root	Aqueous extract	Adeyemi et al., 2010; Muazu and Kaita, 2008
196	*Strychnos henningsii* Gilg	Red bitterberry	Loganiaceae	Shrub	Bark and leaves	Leaves or bark boiled	Musila et al., 2004
197	*Scutellariae radix* L.	Chinese skullcap	Lamiaceae	Herb	Root	Aqueous extract	Wang et al., 2000
198	*Sesbania grandiflora* (L.) Pers.	Sesbania	Fabaceae	Tree	Leaves	Benzene: ethyl acetate fraction	Kasture et al., 2000
199	*Senna singueana* (Delile) Lock	Scrambled egg	Caesalpiniaceae	Tree	Roots, bark, leaves, and flowers	Powder taken with water	Bum et al., 2011
200	*Solanum nigrum* L.	Black nightshade	Solanaceae	Herb	Whole plant or leave	Aqueous extract	Murad et al., 2011; Wannang et al., 2008
201	*Sutherlandia frutescens* (L.) R. Br.	Cancer bush	Fabaceae	Shrub	Leaves	Aqueous extract	Ojewole, 2008b

Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
202	*Sanseviera liberica* (Gérôme & Labroy)	African bow-string hemp	Agavaceae	Herb	Root	Aqueous extract	Adeyemi et al., 2007
203	*Spondias mombin* L.	Yellow mombin	Anacardiaceae	Tree	Leaves	Aqueous, methanol, and ethanol extract	Ayoka et al., 2006
204	*Smilax zeylanica* L.	Kumarika	Lilliaceae	Shrub	Root and rhizome	Alcohol and aqueous extract	Madhavan et al., 2008
205	*Syzygium cumini* (L.) Skeels	Malabar plum	Myrtaceae	Tree	Seed	Infusion, hydroalcoholic extract	De Lima et al., 1998
206	*Schizandra chinensis* B.	Magnolia vine	Schisandraceae	Climber	Fruit	Methanol extract	Han et al., 2000
207	*Silybum marianum* (L.) Gaertn.	Milk thistle	Asteraceae	Herb	Seed	Ethanol extract	Waqar et al., 2016
208	*Sclerocarya birrea* (A.Rich.) Hochst.	Marula	Anacardiaceae	Tree	Stem-bark	Aqueous extract	Ojewole, 2007
209	*Spathodea campanulata* P. Beauv.	African Tulip	Bignoniaceae	Tree	Leaves	Ethanol extract	Ilodigwe et al., 2010
210	*Salvadora persica* L	Tooth-brush tree	Salvadoraceae	Shrub	Stem	Lyophilized decoction	Monforte et al., 2002
211	*Swertia corymbose* (Griseb)	Avalpoovu	Gentianaceae	Herb	Leaves	Methanol extract	Mahendran et al., 2014
212	*Trigonella caerulea* (L.) Ser	Blue fenugreek	Fabaceae	Herb	Leaves and seed	Decoction and tea	Sahranavard et al., 2014
213	*Trigonella hamosa* L.	Egyptian fenugreek	Fabaceae	Herb	Leaves and seed	Powder	Sahranavard et al., 2014
214	*Terminalia arjuna* (Roxb. ex DC.)	Arjuna	Combretaceae	Tree	Bark	Powder	Balamurugan et al., 2009
215	*Terminalia chebula* Retz.	Chebulic myrobalan	Combretaceae	Tree	Fruit	Ethanolic extract	Debnath et al., 2010
216	*Ternstroemia* sp.	El Yunque Colorado	Ternstroemiaceae	Tree	Bark	Decoction	Focho et al., 2009
217	*Tabernaemontana vertricosa* Hochst. Ex A. DC	Forest toad tree	Apocynaceae	Shrub	Bark	Pulverized bark or decoction	Focho et al., 2009
218	*Tagetes erecta* L.	African marigold	Asteraceae	Herb	Flower	Ethanolic extract	Shetty et al., 2009
219	*Terminalia glaucescens* Planch. ex Benth	Fula-pulaar	Combretaceae	Tree	Leaves, root, and bark	Decoction	Bum et al., 2011
220	*Terminalia mollis* M.A.Lawson	Large-leaved terminalia	Combretaceae	Tree	Roots	Dry powder	Bum et al., 2011
221	*Tetrapleura tetraptera* (Schum. & Thonn.) Taub.	Aridan	Mimosaceae	Tree	Roots, bark, and fruit	Decoction	Aderibigbe et al., 2007; Bum et al., 2011
222	*Trichilia emetica* Vahl	Natal mahogany	Meliaceae	Tree	Roots, bark, and leaves	Methanolic extract	Bum et al., 2011; Komane et al., 2011
223	*Taxus wallichiana* Zucc.	Himalayan yew	Taxaceae	Tree	Leaves	Methanolic extract	Nisar et al., 2008
224	*Ternstroemia pringlei* (Rose) Standl.	Flor de tila	Theaceae	Tree	Flower	Methanolic extract	Balderas et al., 2008
225	*Trachyspermum ammi* (L.) Sprague	Ajowan	Apiaceaea	Herb	Seed	Methanolic extract	Rajput et al., 2013
226	*Tilia europaea* L.	Common linden	Tiliaceae	Tree	Leaves	Ethanolic extract	Jäger et al., 2006
227	*Tricosanthes dioica* Roxb.	Parwal	Curcurbitaceae	Herb	Fruit	Aqueous extract	Singh et al., 2012
228	*Tanacetum parthenium* (L.) Sch.Bip.	Feverfew	Asteraceae	Herb	Leaves	Ethanolic extract	Jäger et al., 2006

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Table 2 (*continued*)

S. No.	Medicinal plants	Common name	Family	Habitat	Part used	Nature	References
229	*Urginea maritima* Baker	Squill	Hyacinthaceae	Bulb	Bulb	Dry powder	Sahranavard et al., 2014
230	*Voacanga bracteata* Stapf	Soekoen bread tree	Apocynaceae	Shrub	Bark	Pulverized bark	Focho et al., 2009
231	*Valeriana officinalis* L.	Garden heliotrope	Caprifoliaceae	Herb	Root	Aqueous extract	Rezvani et al., 2010
232	*Viola biflora* L.	Twoflower violet	Violaceae	Herb	Flower	Tincture	Hamayun et al., 2006
233	*Viola canescens* Wall	Himalayan White Violet	Violaceae	Herb	Flower	Powder	Hamayun et al., 2006
234	*Vitellaria paradoxa* C.F. Gaertn.	Shea tree	Sapotaceae	Tree	Leaves and bark	Decoction	Bum et al., 2011
235	*Vitex negundo*	Chinese chaste tree	Lamiaceae	Tree	Leaves	Leaves' powder extract	Tandon and Gupta, 2005
236	*Viscum sapense* L. f.	Mistletoe	Loranthaceae	Tree	Stem	Methanol extract	Amabeoku et al., 1998
237	*Vitex agnus castus* L.	Vitex	Lamiaceae	Tree	Fruit	Hydrophilic extract	Saberi et al., 2008
238	*Viscum album* L.	European mistletoe	Loranthaceae	Shrub	Leaves	Aqueous extract	Gupta et al., 2012
239	*Verbena officinalis* L	Holy herb	Verbenaceae	Herb	Whole plant	Decoction, ethanol extract	Jäger et al., 2006
240	*Withania somnifera* (L.) Dunal	Winter cherry	Solanaceae	Shrub	Root	Alcoholic extract	Balamurugan et al., 2009; Raju et al., 2017; Uddin et al., 2012
241	*Zizyphus jujba* Mill.	Red date	Rhamnaceae	Tree	Bark	Alcoholic extract	Acharya et al., 1994

P/Q types voltage gated calcium channels (Jouvenceau et al., 2001). Ligand-gated ion channels that are nicotinic, acetylcholine, and GABA receptors subunits, are associated with frontal and generalize epilepsies, respectively. The striking features are variable in epilepsy phenotypes and are associated with the known gene mutations that underlie all known monogenic syndromes. Mutations in two genes that do not encode ion channels have been identified in the idiopathic epilepsies (Scheffer and Berkovic, 2003).

Available antiepileptic drugs suppress seizures without correcting the underlying cause generating seizures, and are effective in 60–70% of individuals (Beghi, 2020). Synthetic drugs used for brain disorders are expensive and sometimes show serious and unavoidable side effects with poor patient compliance. Hence, herbal and Ayurveda treatments are preferred over synthetic drugs for neurological disorders like Alzheimer disease, Parkinson disease, depression, epilepsy, schizophrenia, anxiety, and neuropathy due to low cost, lesser side effects, and better therapeutic effects. The accessibility, negligible incidence of side effects, and cost effectiveness of plant products offer considerable benefits over synthetic drugs (Balkrishna and Misra, 2017). Approximately 70% people of developing countries still rely on complementary and alternative medicines regardless of the improvement in conventional medicines (Shaheen and Kamran, 2017). The aim of this review article is to highlight the efficacious plants used in epilepsy according to the documented researches worldwide.

2. Methodology

First of all, articles showing the role of medicinal plants as antiepileptic agents were searched and downloaded from online research databases (PubMed, Medline, Web of Science, Google Scholar, and ScienceDirect) using specific keywords viz. herbal plants, medicinal plants, antiepileptic, antiseizures, prevalence, and epidemiology. All these articles were then viewed one by one and the medicinal plants, which were found to be effective in epilepsy were collected and tabulated (Table 2). The information about the local use and mode of applications of these plants in epilepsy were collected from folk medicine users, local traditional healers, and local elderly people having knowledge of herbal plants. The principle phytoconstituents of important medicinal plants are listed in Table 3.

3. Result and discussion

Total 97 families were found to be useful in epilepsy, of which, the highest occurrence belonged to Lamiacea 19 (18.56%), Asteraceae and Fabaceae 16 (16.50%) each, Fabaceae 11 (11.34%), Rubiaceae, Rutaceae, and Apocynaceae 6 (2.4%) each, Caesalpiniaceae, Solanaceae, Byrtaceae and Anacardiaceae 5 (2%) each, and Liliaceae, Mimosaceae, Ranunculaceae and Combretaceae 4 (1.6%) each. Other families were found to have 1 or 2 plants to be effective in epilepsy in the list.

From the literature review, it was found that herbs were the most common plants to have antiepileptic activities. This can make the plant selection easy for researchers, who are interested in plants-based treatment for epilepsy, by concentrating

Table 3 Principal phytoconstituents of medicinal plants effective in epilepsy treatment.

S. No.	Medicinal plants	Principal constituents	References
1	*Acalypha fruticosa* Forssk.	Acalyphin, apigenin, kaempferol, and 3-O-rutinoside	Govindu and Adikay, 2014
2	*Achyranthes aspera* L.	Betaine, oleonic acid, bisdesmosidic, ecdysterone, triacontanol, achyranthine, spinasterol, and spathulenol	Gawande et al., 2017; Sharma et al., 2013
3	*Acorus calamus* L.	Asarone and β-asarone	Mukherjee et al., 2007
4	*Acorus gramineus* Aiton	α-asarone, asaraldehyde, isoacoramone, propioveratrone, β-asarone, isoacoramone, propioveratrone, and tyrosol	Yang et al., 2006
5	*Aeollanthus suaveolens* Mart. ex Spreng.	Linalool and y-decanolactone	Elisabetsky and Coelho de Souza, 1997
6	*Afrormosia laxiflora* (Benth. ex Baker) Meeuwen	Methydeoxybnzoins angolensin, 2-omethyl angolensin, and demethylpterocarpin	Haruna, 2000
7	*Albizzia lebbeck* (L.) Benth.	Echinocystic acid, melacacidin, D-catechin, β-sitosterol, albiziahexoside, and betulnic acid	Kasture et al., 2000
8	*Anacyclus pyrethrum* (L.) Lag.	Eugenol, pyrethrine, pellitorine, palmitic acid, and naphthalene	Zaidi et al., 2013
9	*Anisomeles malabarica* (L.) R.Br.	Anisomeles, anisomelic acid, abietadiene, β-caryophyllene α-farnesene, linoleic acid, trans-ferruginol, and abietol	Choudhary et al., 2011
10	*Annona diversifolia* Saff.	Palmitone, annoreticuin, bullatacin, squamosine, rolliniastatin, and reticullacinone	González-Trujano et al., 2001
11	*Annona senegalensis* Pers.	Kaurenoic acid, citronellal, citronellol, geranial, thymol, β – caryophyllene, and carvacrol	Okoye et al., 2013
12	*Annona squamosa* L.	Anonaine, acetogenin. sabinene, α –pinene, limonene annotemoyin-2, and reticulatain-2	Porwal and Kumar, 2015; Saluja and Santani, 1994
13	*Anthocephalus cadamba* (Roxb.) Miq.	Cadambine, cadamine, isocadambine, isocadambine, hentriacontanol, and β-sitosterol	Nagakannan et al., 2011
14	*Areca catechu* L.	Arecaidine, guvacine, catechin isorhamnetin, quercetin, liquiritigenin, resveratrol, ferulic acid, vanillic acid, beta-sitosterol, and cycloartenol	Lodge et al., 1977
15	*Artemisia dracunculus* L.	Transanethole, pinene, sabinene, isoelemicin, methyl eugenol, elemicin, and beta-ocimene	Sayyah et al., 2004
16	*Artemisia verlotorum* Lamotte	Alpha-thujone, eupatilin, farnesol, cedrol, coumarins, and eupatilin	de Lima et al., 1993
17	*Artemisia vulgaris* L.	Linalool, Pinene, 1,8-cineole, sabinene, camphor, camphene, caryophyllene oxide, α-thujone, and β-thujone	de Almeida et al., 2013
18	*Bacopa monnieri* (L.) Wettst.	Brahmine, nicotinine, serine, herpestine, and bacosides A and B	Mathew et al., 2010
19	*Berberis integerrima* Bunge	Berberine, palmatine, oxyacanthine, berbamine, and anthocyanin	Hosseinzadeh et al., 2013; Moein et al., 2020
20	*Berberis vulgaris* L.	Berberin, acanthine, bargustanine, berbamine, berberrubine, beriambine, bervuleine, columbamine, jatrorrhizine, lambertine, magnoflorine, palmatine, and thaliemidine	Bhutada et al., 2010; Imanshahidi and Hosseinzadeh, 2008
21	*Boerhaavia diffusa* L.	Liriodendrin, palmitic acid, β-sitosterol, tetracosanoic, hexacosonoic, stearic, arachidic acid, urosilic acid, and hentriacontane,	Adesina, 1979; Mahesh et al., 2012; Sharma et al., 2013
22	*Bupleurum chinensis* DC.	Saikosaponin	Yu et al., 2012
23	*Butea monosperma* (Lam.) Kuntze	Palasonin, aleurilic, Triterpene, butrin, isobutrin, and butein	Kasture et al., 2000
24	*Caesalpinia bonducella* L.	Bonducillin, phytosterinin, β-sitosterol, flavonoids, aspartic acid, arginine, citrulline, and β-carotene	Balamurugan et al., 2009
25	*Caesalpinia sappan* (L.) Tod.	Sappanchalcone, xanthone, coumarin, chalcones, flavones, homoisoflavonoids, and brazilin	Baek et al., 2000
26	*Cannabis sativa* L.	Marijuana, cannabinoids delta-9-tetrahydrocannabinol, cannabinol, and δ 8-tetrahydrocannabinol	Consroe et al., 1976; Gloss and Vickrey, 2014; Izquierdo et al., 1973
27	*Canscora decussata* (Roxb.) Schult. & Schult.f.	Hypericin, hyperforin, and xanthones	Dikshit et al., 1972
28	*Carum copticum* (L.) Benth. & Hook.f. ex Hiern	Steroptin, thymine, cumin, lysine, and threonine	Rezvani et al., 2011
29	*Cassia fistula* L.	Fistulic Acids, Sennosides A B, Anthraquinones, Oxalic, Linoleic, Oleic, and Stearic acids.	Kalaiyarasia et al., 2015
30	*Cedrus deodara* (Roxb. ex D. Don) G.Don	α-pinene, β-pinene, myrcene, limonene-α, β-caryophyllene, β-copaene, α-himachalene, β-humulene, γ-muurolene, β-himachalene, Germacrene D, α-muurolene, and δ-cadinene	Viswanatha and Nandakumar, 2009
31	*Celtis integrefolia* L.	Gabapentin, choline, vitexin, oxalic, mallic, and gallic acid	Muazu and Kaita, 2008
32	*Chrysanthemum boreale* Makino	Aglycone and acacetin	Nugroho et al., 2013

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Table 3 (*continued*)

S. No.	Medicinal plants	Principal constituents	References
33	*Coriandrum sativum* L.	Coumarins, imonene, α-pinene, β-phellandrene, linalool, linalyl acetate, geraniol, borneol, citronellol, β-caryophyllene, and thymol	Hosseinzadeh and Madanifard, 2000
34	*Cotyledon orbiculata* L.	Orbicusides A-C and tyledoside D	Amabeoku et al., 2007
35	*Craterocapsa tarsodes* Hilliard & B.L.Burtt	Acteoside, verbascoside, and pinocembrin 7-β-neohesperidoside	Van Heerden et al., 2002
36	*Crocus sativus* L.	Crocin, crocetin, safranal, and picrocrocin.	Hosseinzadeh and Khosravan, 2002
37	*Curcuma longa* L.	Curcumin, curcuminoid, bisabolene, sesquiterpenoid, and turmerone	Orellana-Paucar et al., 2012
38	*Cymbopogon proximus* (Hochst. ex A.Rich.) Chiov.	Piperitone, citral α, citral β, nerol geraniol, citronellal, terpinolene, geranyl acetate, myrecene, and terpinol methylheptenone	El Tahir and Abdel-Kader, 2008
39	*Cymbopogon winterianus* Jowitt ex Bor	Geraniol, citronella, and citronellol	Quintans-Júnior et al., 2008
40	*Cynanchum otophyllum* Schneid	Otophylloside A(IV) and otophylloside B(V)	Mu et al., 1986
41	*Cynanchum wilfordii* (Maxim.) Hemsl.	Cynawilfoside A, cynauricoside A, wilfoside, and cyanoauriculoside	Li et al., 2016
42	*Cyperus articulates* L.	Cathechins, triterpenes, sesquiterpenes, mustakone cyperotundone, α-cyperone, and sesquichamaenol	Brillatz et al., 2020; Bum et al., 2001
43	*Cyperus rotundus* L.	Sugeonol, humulen, β-selinene, zierone, and cyperone	Khalili et al., 2011
44	*Delphinium denudatum* Wall. ex Hook.f. & Thomson	Diterpenoid, delvestine alkaloidbrumonine, and lycaconitine	Raza et al., 2001
45	*Egletes viscosa* (L.) Less.	Transpinocarvyl acetate, b-pinene, linalool, and terpinen-4-ol	Souza et al., 1998
46	*Equisetum arvense* L.	Isoquercitrin, ascorbic acid, silicic acid, and palustrinine	Dos Santos Jr et al., 2005
47	*Erythrina indica* Lam.	Genistein, wighteone, alpinumisoflavone, dimethyl-alpinumisoflavone, erythrodio, 8-prenylerythrinin C, erysenegalensein E,erythrinassinate B, stigmasterol, and oleanolic acid	Rajamanickam and Sathyanarayanan, 2008
48	*Eucalyptus brassiana* S.T. Blake	Phellandrene, p-cymene, and cineole	Teixeira et al., 2008
49	*Eugenia caryophyllata* Thunb	Eugenol, carvacrol, isoeugenol, acetyl-eugenol and safrole	Dallmeier and Carlini, 1981; Pourgholami et al., 1999
50	*Ferula gummosa* Boiss	Linalool and eugenol, pinene, and methyleugenol	Sayyah et al., 2002b
51	*Ficus platyphylla* Delile	Herniarin, coumarins, β-sitosterol, and d-glucoside	Chindo et al., 2009
52	*Flacourtia indica* (Burm.f.) Merr.	Beta-sistosterol, coumarine, butyrolactone, flacourtine, and terpenoids	Bum et al., 2011
53	*Gastrodia elata* Blume	Vanillin, gastrodin, parishin, and vanillic acid	Ojemann et al., 2006
54	*Gentiana olivieri* Griseb.	Ursolic acid, secoiridoid, and swertiamarin	Aslan et al., 2011
55	*Gladiolus dalenii* Van Geel	Beta-sitosterol, terpenoids, and glycosides	Ngoupaye et al., 2013
56	*Glycyrrhiza glabra* L.	Glycyrrhizine and liquiritigenin	Xiao et al., 2015
57	*Goodyera schlechtendaliana* Rchb.f.	Goodyerin, syringaldehyde, 5-hydroxymethylfurfural, alloimperatorin, vanillic acid, ferulic acid, glyceroyl monopalmitate, and β-sitosterol	Du et al., 2002
58	*Harpagophytum procumbens* (Burch.) DC. ex Meisn.	Iridoids harpagoside, cinnamic acid, harpagide, and procumbide	Mahomed and Ojewole, 2006
59	*Hedranthera barteri* (Hook. f.) Pichon	Quercetin conophargngine and calcium	Sowemimo et al., 2012
60	*Heracleum crenatifolium* Boiss.	Octanol, caffeic acid, ferulic acid, rutin, quercetin, and octyl acetate	Tosun et al., 2008
61	*Heracleum persicum* Desf. ex Fisch., C.A.Mey. & Avé-Lall.	Eugenol, cineol, and linalool	Atefeh et al., 2010; Sayyah et al., 2005
62	*Hibiscus rosa sinensis* L.	Anthraquinone and glucoside	Kasture et al., 2000
63	*Hippeastrum vittatum* (L'Hér.) Herb.	Montanine	da Silva et al., 2006
64	*Huperzia serrata* (Thunb.) Trevis.	Huperzine A, Y, and Z and huperserines A–D,	Coleman et al., 2008
65	*Hypoxis hemerocallidea* Fisch	β-sitosterol and rooperol	Ojewole, 2008a
66	*Jasminum grandiflorum* L.	Jasmonic acid, Secoiridoid, protocatechuic acid, triterpene, and oleanolic acid	Wei et al., 2015
67	*Lantana camara* L.	Ursolic acid, and stearoyl glucoside	Kazmi et al., 2012
68	*Laurus nobilis* L.	Methyleugenol, eugenol, and pinene	Sayyah et al., 2002c
69	*Leonotis leonurus* (L.) R.Br.	Quinone and Leonurenone A and B	Bienvenu et al., 2002

Table 3 (*continued*)

S. No.	Medicinal plants	Principal constituents	References
70	*Lobelia nicotianaefolia* Roth	Lobeline, lobelanine, lobelanidine, norlobelanine, lelobanidine, norlelobanidine, and norlobelanidin	Tamboli et al., 2012
71	*Lychnophora diamantinana* Coile & S.B.Jones	Caffeoylquinic acid, lychnopholide, centratherin, and goyazensolide	Taleb-Contini et al., 2008
72	*Lychnophora rupestris* Semir & Leitão	Caffeoylquinic acid, caffic acid, and lychnopholide	Taleb-Contini et al. (2008)
73	*Magnolia dealbata* Zucc.	Honokiol and magnolol	Martinez et al., 2006
74	*Magnolia officinalis* Rehder & E.H.Wilson	Magnolol, honokiol, magnaldehyde, magnatriol B, randaiol, and obovatol	Watanabe et al., 1975
75	*Matricaria chamomilla* L.	Apigenin, camphene, α-pinene, isopropyl hexadecanoate, camphor, 1,8-cineole, sabinene, and α-terpinene	Avallone et al., 2000
76	*Melissa officinalis* L.	β-caryophyllene, geranial, 1,8-cineole, neral, dehydroaromedendrene, and thymol	Bhat et al., 2012
77	*Mimosa pudica* L.	Mimosin, succinic acid, β-sitosterol, and stigmasterol	Patro et al., 2015
78	*Mitragyna inermis* (Willd.) Kuntze	Rotundifoline and uncarine	Muazu and Kaita, 2008
79	*Mondia whitei* (Hook.f.) Skeels	Propacin, Isovanalin, loliolide, and coumarinolignam	Fred-Jaiyesimi and Ogunjobi, 2013
80	*Nardostachys jatamansi* (D. Don) DC.	Jatamansone and essential oil	Rao et al., 2005
81	*Nelumbo nucifera* Gaertn.	Lotusine, liensinine, dauricine, isoliensinine, nuciferine, pronuciferine, roemerine, procyanidin, neferine, and armepavine	Rajput et al., 2017
82	*Nepeta sibthorpii* Benth.	Nepetalactones, 1,8-cineole, linalool, teucrioside, lamiuside, and verbascoside	Galati et al., 2004
83	*Newbouldia leavis* (P.Beauv.) Seem.	Harmane, harmol, harmine, and harmaline	Tsabang et al., 2016; Usman et al., 2008
84	*Nigella sativa* L.	Thymoquinone, p-cymene, carvacrol, thymohydroquinone, dihydrothymoquinone, α-thujene, thymol, t-anethole, β-pinene, α-pinene, and γ-terpinene	Hosseinzadeh et al., 2005b
85	*Ocimum basilicum* L.	1.8-cineole, linalool, and geraniol	Oliveira et al., 2009
86	*Ocimum gratissimum* L.	Eugenol, linalool, 1,8-cineole and β-selinene	Freire et al., 2006
87	*Origanum majorana* L.	Geranyl acetate, α-Terpinyl acetate, carvacrol, and ursolic acid	Deshmane et al., 2007
88	*Origanum vulgare* L.	Carvacrol, thymol, linalool, γ-terpinene, p-cymene, β-caryophyllene, and germacrene D	Abdul-Ghani et al., 1987
89	*Paeonia emodi* Royle	Paeoniflorin, oleanolic acid, betulinic acid, ethyl gallate, methyl grevillate, wurdin, benzoylwurdin, and emodinol	Zaidi et al., 2012
90	*Paeonia officinalis* L.	Paeoniflorin and gallotannin	Tsuda et al., 1997
91	*Panax ginseng* C.A.Mey.	Panaxadiols	Lian et al., 2005
92	*Passiflora edulis* Sims.	Ascorbic acid, carotene, and vanillic acid,	Bum et al., 2004
93	*Piper nigrum* L.	Piperine, alkamides, piptigrine, wisanine, dipiperamide D, and dipiperamide E	da Cruz et al., 2013
94	*Piper tuberculatum* Jacq.	Piplartine, β-caryophyllene, and α-cadinol	Felipe et al., 2007
95	*Poria cocos* F.A.Wolf.	Tumulosic acid, mannitol, dehydrotumulosic acid, beta-sitosterol, ribitol, and oleanic acid	Gao et al., 2016
96	*Psidium guyanensis* Pers.	Beta-eudesmo, ugenol, thymol, and carvacrol	Santos et al., 1997
97	*Pyrus pashia* Buch. Ham. ex D.Don	Chrysin, lupeol, β-sitosterol, and D-glucoside	Sharma et al., 2019
98	*Rauwolfia serpentina* (L.) Benth. ex Kurz	Raubasine, ajmaline, reserpine, ajmalicine, and serpentine	Charveron et al., 1984
99	*Rhus dentata* Thunb.	Apigenin, agathisflavone, β-bisabolene, β-farnesene, β-curcumene, and caryophyllene oxide	Svenningsen et al., 2006
100	*Rhus pyroides* Burch.	Apigenin, agathisflavone, and amentoflavone	Svenningsen et al., 2006
101	*Ricinus communis* L.	Ricinine, ricin, ricinoleic acid, stearic, linoleic, palmitic acid, sitosterol, and squalene	Ladda, 2014; Tripathi et al., 2011
102	*Rosa damascene* Herrm.	Eugenol, β-citronellol, geraniol, citronellol, and nerol	Ramezani et al., 2008
103	*Ruta graveolens* L.	Rutin, quercetin, cineol and l-limonene, palmitic acid, stearic acid, and oleic acid	Ahmad and Amabeoku, 2013
104	*Salvadora persica* L.	Trimethylamine and salvadorine, benzyl nitrile, isotymol, thymol, eugenol, β-caryophyllene, and eucalyptol	Khan et al., 2010; Monforte et al., 2002
105	*Sanseviera liberica* (Gérôme & Labroy)	Catechins, flavones, carotenoids, and phytates	Adeyemi et al., 2007

(*continued on next page*)

Table 3 (*continued*)

S. No.	Medicinal plants	Principal constituents	References
106	*Schizandra chinensis* (Turcz.) Baill.	Schizandrin and daucosterol	Han et al., 2000
107	*Scutellaria baicalensis* Georgi	Baicalin, wogonin, wogonoside, and baicalein	Liu et al., 2012; Park et al., 2007
108	*Scutellariae radix* L.	Baicalein, oroxylin A, and skullcapflavone II	Wang et al., 2000
109	*Senna singueana* (Delile) Lock	7-methyl physcion and cassiamin A	Bum et al., 2011
110	*Sesbania grandiflora* (L.) Poir.	Isovestitol, medicarpin, sativan, and betulinic acid	Kasture et al., 2000
111	*Silybum marianum* (L.) Gaertn.	Silymarin, silydianin, silychristin, and silibinin	Waqar et al., 2016
112	*Smilax zeylanica* L.	Dioscin, smilagenin, and sarsapogenin	Madhavan et al., 2008
113	*Spathodea campanulate* P. Beauv.	Geranyl acetae, α-humulene, β-caryophyllene, farnesyl acetone, aromadendrene, α-gurjunene, and tricosane	Ilodigwe et al., 2010
114	*Spondias mombin* L.	δ-cadinene, α-humulene, α-gurjunene, and α-muurolene	Ayoka et al., 2006
115	*Sutherlandia frutescens* (L.) Goldblatt & J.C.Manning	Canavanine, pinitol, L-arginine, asparagine, and canavanine	Ojewole, 2008b
116	*Swertia corymbose* (Griseb.) Fielding & Gardner	Loganic acid, swertiamarin, sweroside, gentiopicroside, isovitexin, amoroswertin, amarogentin, gentiacaulein, decussating, and swertianin	Mahendran et al., 2014
117	*Syzygium cuminii* L.	Eugenol, linalool oxide, and linalool	De Lima et al., 1998; Ramya et al., 2012
118	*Tanacetum parthenium* (L.) Sch.Bip.	Apigenin bornyl acetate, camphene, bornyl isovalerate, borneol, juniper camphor, and β-eudesmol	Jäger et al., 2009
119	*Tetrapleura tetraptera* (Schumach. & Thonn.) Taub.	Aridanin, D-fructose, glycidol piperazine, glyceraldehydes, octadecenoic acid, and octodrine	Aderibigbe et al., 2007; Bum et al., 2011
120	*Trachyspermum ammi* (L.) Sprague	Thymol, γ-terpinene, *para*-cymene, and α- and β-pinene	Rajput et al., 2013
121	*Trichilia emetica* Vahl	Trichirokin, scopoletin, benzoic acid, protocatechuic acid, lignoceric acid, β-sitosterol, and stigmasterol	Bum et al., 2011
122	*Uncaria rhynchophylla* (Miq.) Miq.	Rhynchophylline	Hsu et al., 2013
123	*Viola tricolor* L.	Valepotriates and valerenic acid, kaempferol, luteolin, violanthin, quercetin, and rutin	Rahimi et al., 2019
124	*Viscum album* L.	Lectins, viscotoxins, and flavones	Gupta et al., 2012
125	*Vitellaria paradoxa* C.F. Gaertn.	Linalool, stearic and oleic acid	Bum et al., 2011
126	*Withania somnifera* (L.) Dunal	Withniol, withanine, and somniferine	Uddin et al., 2012

on herbs for their research. According to plants habit, of 241 plants, herbs were 102 (42.15%), trees were 72 (29.75%), shrubs were 54 (22.31%), climbers were 12 (4.96%), and bulbs were 2 (0.83%) (Fig. 1).

According to the plants' parts used, 105 (43.39%) were found to have antiepileptic potentials in leaves, 51 (31.07%) in roots, 20 (8.36%) in stem, 8 (3.31%) in rhizome, 4 (1.65 %) in bulb, 32 (13.22%) in bark, 6 (2.48%) in gum, 19 (7.85%) in flowers, 18 (7.44%) in fruits, 24 (9.92%) in seeds, and 29 (11.98%) in whole plant (Fig. 2).

A study was conducted to find out the antiepileptic effect *Acalypha fruticose* aerial parts extract in mice. *A. fruticosa* extract at 30–300 mg/kg, p.o. dose was evaluated in pentylenetetrazol (PTZ), maximum electroshock (MES) and isoniazid (INH)-induced convulsions in mice. As compared to diazepam-treated mice in the MES technique, the plant extract considerably protected the mice from convulsions generated by electroshock in a dosage-dependent manner and displayed higher activity at 300 mg/kg dose. The extract prevented convulsions in mice more effectively than phenobarbitone sodium in the PTZ technique, while it delayed dose-dependently the latency of convulsions in mice in INH protocol but could not prevent the mortality. It was concluded that the presence of antioxidant principles like flavonoids in the extract may be responsible for considerable and dose-dependent antiepileptic effect (Govindu and Adikay, 2014). In a different study, the traditional antiepileptic use of *Achyranthes aspera* Linn. was evaluated in PTZ, picrotoxin, bicuculline, and MES-induced seizure models. In PTZ, picrotoxin, and bicuculline treatment, *A. aspera* extract at 5–10 mg/kg dose showed a substantial increase in seizure threshold compared to saline treated mice; however, the extract did not show any protection in

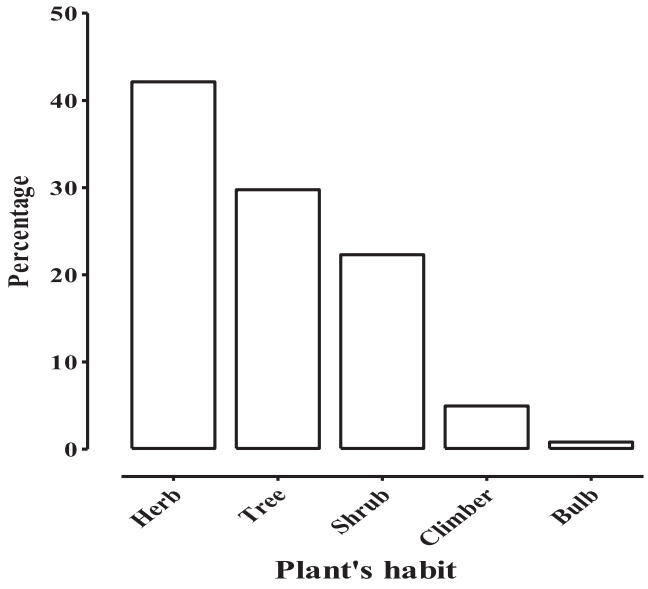

Fig. 1 Antiepileptic traits of plants based on their habits.

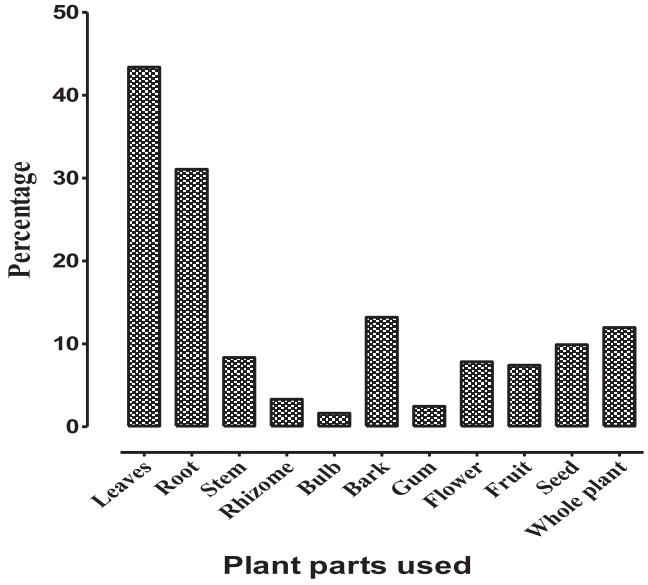

Fig. 2 Antiepileptic propertiess of different parts of plants.

MES-induced seizures. Furthermore, *A. aspera* therapy at 5–10 mg/kg dose increased the GABA levels in the hippocampus and cortex as compared to control group in HPLC quantification. It was assumed that the anticonvulsant effect of *A. aspera* extract may be facilitated by the GABAergic neurotransmission involvement (Gawande et al., 2017)

Traditionally, *Anacyclus pyrethrum* DC root has long been known for its antiepileptic effect in Unani medicine from ancient time. To rationalize this ethnomedical claim, *A. pyrethrum* root extract (APE) was evaluated at 100–800 mg/kg dose in against PTZ, elevated plus maze (EPM), bicuculline, and increasing current electroshock (ICES) models for anticonvulsant and anxiolytic effects. The neurotoxicity of extract was found in rotarod test model including an additional higher dose (1600 mg/kg). The APE dose-dependently showed significant ($P < 0.001$) anticonvulsant effect against PTZ (70 mg/kg, i.p.), while against bicuculline (30 mg/kg, i.p.) at 800 mg/kg dose only ($P < 0.001$). Furthermore, the extract failed to protect mice against ICES-induced seizures ($P > 0.05$). The plant also exhibited anxiolytic activity in EPM ($P < 0.001$) model and impaired motor coordination at only 1600 mg/kg dose in rotarod model. HPTLC confirmed the presence of eugenol in the extract, which was responsible for anticonvulsant and anxiolytic effects of APE facilitated by GABAergic neurotransmission (Zaidi et al., 2013).

Annona squamosa and its active alkaloid (-) anonaine was found to be used for epilepsy treatment. For neuroprotective determination, the variations of GABA, $GABA_A$, and $GABA_B$ receptors in the brain cortex area of epileptic-rats and the prospective applications of *A. squamosa* and its screened phytochemical (anonaine) were examined by using confocal microscopy method. The radial and Y-maze models were used to investigate nootropic activity in epileptic rats. In the brain of epileptic rats, GABA receptor binding studies revealed a substantial decrease in Bmax ($P < 0.001$) as compared to controls, while the microscopic (confocal) investigation showed reduced GABA receptors in epileptic animals. In the radial and Y-maze models, *A. squamosa* leaves extract and its screened constituent, anonaine, displayed memory regaining, and memory boosting effects. It was concluded from the aforementioned data and observations that anonaine improved the alterations in epileptic rat behavior and lowered the GABA receptors (Porwal and Kumar, 2015).

Berberis integerrima (Berberidaceae) contains berberine as main bioactive components. Berberine is known for its neuroprotective effect and its uses in other neurological disorders. The anticonvulsant effect of methanolic, hydromethanolic, and chloroform extract of *B. integerrima* was evaluated using PTZ and MES-induced seizure models. In PTZ test, methanolic extract at 140–200 mg/kg as well as hydromethanolic and chloroform fractions at 200 mg/kg each given orally increased the tonic extensions in hind limb. The methanolic extract protected 2/8 animals at a dose of 200 mg/kg while hydromethanolic and chloroform fractions protected 3/8 animals at a dose of 200 and 140 mg/kg, respectively. In the MES test, this plant did not show any anticonvulsant effect. Authors concluded that *B. integerrima* presented anticonvulsant effect in PTZ-induced seizure model, and future research may produce some valuable constituents from these plants for epilepsy (Hosseinzadeh et al., 2013).

Indian and Tanzanian traditional healers are using *Cassia fistula L.* for treatment of various neurological disorders including epilepsy from ancient time. The anticonvulsant and anxiolytic activities of *Cassia fistula* pods extract were evaluated to provide scientific validation to the traditional antiepileptic use of this plant. Anticonvulsant activity was checked in PTZ model and anxiolytic activity was performed by EPM and open field test (OFT). Phenobarbitone-induced sleep and rotarod behavior test models were used for the evaluation of sedative and motor toxicity effects respectively. *C. fistula* at 50–100 mg/kg p.o. dose delayed the onset of clonic seizure and generalized tonic clonic seizure and protected animals completely from death. *C. fistula* at 100 mg/kg increased the entries into and time spent in open arm in EPM, while increased the number of central squares crossing and time spent in central squares in OFT. The plant extract did not cause sedation or motor toxicity at the above used doses.

The authors claimed that the plant showed clear anticonvulsant and anxiolytic activities, and in future, effective phytochemicals with antiepileptic activity can be obtained (Kalaiyarasia et al., 2015).

In a different study, a total of 21 compounds, including 9 new compounds named cynawilfosides A-I (1–9) and 12 already known constituents from the roots of *Cynanchum wilfordii* plants were isolated. The spectroscopic analysis and chemical methods were used for the elucidation of new compounds structure. Cynawilfoside A-1, cynauricoside A-11, wilfoside C1N-16, wilfoside K1N-17, and cyanoauriculoside G-18 showed remarkable protection activity of 90, 60, 40, 70, and 55.5% in MES-induced mouse seizure model with ED50 values of 48.5, 95.3, 124.1, 72.3, and 88.1 mg/kg respectively. The authors concluded that these new compounds need further evaluation to be prospective candidates and therapeutic agents against epilepsy (Li et al., 2016).

A research study was conducted to isolate and identify the active constituents responsible for the anticonvulsant activity of *Cyperus* articulates. All solvents extracts were assessed for anticonvulsant activity in PTZ-induced seizure in zebrafish seizure model. The highest antiseizure activity was achieved with hexane extract. Also, hexadecane and blood brain barrier (BBB) parallel membrane-permeability assay methods were used to evaluate the absorption of bioactive constituents through GIT and BBB. The hexane extract showed the highest anticonvulsant activity with 93% reduction in PTZ-induced seizures. Four sesquiterpenoids, identified as mustakone (1), cyperotundone (2), sesquichamaenol (3), and 1,2-dehydro-α-cyperone (4) revealed remarkable anticonvulsant activities. Further, the compounds of hexane extract including compounds 1 and 2 were observed to cross gastrointestinal barrier and the main compound 2 crossed the BBB as well. Results showed anticonvulsant activity of various active constituents from hexane extract of *C. articulatus* rhizomes which supported its folkloric uses for epilepsy treatment (Brillatz et al., 2020).

Phytol is already reported for antiseizure activity, and it was considered that this compound might be responsible for the antiseizure activity of *Jasminum grandiflorum* (Wei et al., 2015). *Mimosa pudica* L. (Mimosaceae) is known to be used traditionally for various diseases like convulsion, insomnia, tumor, alopecia, and snake bite etc. Researchers tested this plant for epilepsy, motor activities, and algesia activities. The ethyl-acetate extract of *M. pudica* leaves (EAMP) at 100–400 mg/kg/day doses were given orally to mice for consecutive 7-days. The antiepileptic activity was assessed in MES, PTZ, and INH-induced seizure models, whereas the motor activities of mice were evaluated in actophotometer, rotarod, and traction tests. The analgesic activity was examined in hot-plate, acetic acid-induced writhing, and tail flick test rats' models. The acute toxicity study of the extract was checked at 50–2000 mg/kg/p.o. and behavioral changes were observed for 24 h. The EAMP (100–400 mg/kg/day) reduced the duration of seizures in MES seizure model with significant level ($P < 0.01$) and delayed onset of tonic-clonic seizures in PTZ and INH seizure models with significant level ($P < 0.001$). The EAMP exhibited analgesic activity in a dose-dependent manure by augmenting the reaction-time as compared to control group, while motor activities were improved dose-dependently as compared to standard group. No lethal effects were appeared in the acute toxicity study. Results confirmed the antiepileptic, analgesic, and motor activities of EAMP in animals' models (Patro et al., 2015).

Antiepileptic activity of *Nelumbo nucifera* fruits extract (NNEF) was evaluated in rats in strychnine induced-seizure model divided in 5 groups (each group = 7 rats) i.e., in control (2% gum tragacanth), reference (diazepam 1 mg/kg), and 3 test groups (50, 100 and 200 mg/kg). Daily doses were given orally for consecutive 15 days. It was found that NNFE at 200 mg/kg dose presented most significant delay in the instigation of seizures as compared to the control group, however, the duration of seizure was increased and intensity was decreased, leading to the better rats' survival rate (42.85%), which was comparable to the result of reference drug (diazepam). Findings concluded that NNEF has valuable antiepileptic activity, but further advanced studies, in large number of animals, are needed to validate these outcomes (Rajput et al., 2017).

A bioactive compounds class, Triterpenes found in *Poria cocos* Wolf (Polyporaceae), has been traditionally in use from ancient time to treat numerous diseases in China. Though, their antiepileptic activities and mechanistic pathways are still not fully discovered. The total triterpenes ethanolic extract (TTPE) of *P. cocos* was characterized by HPLC fingerprint-analysis. Male ICR (Institute of Cancer Research) mice were given TTPE (5, 20, 80, and 160 mg/kg). and reference drugs twice a day for 7 days by intragastric-gavage (i.g.) method. Antiepileptic activities of TTPE were examined in MES and PTZ-induced mouse seizure models for 30- and 60-min duration, respectively. Rotarod test and locomotor activity were performed for 5- and 60-min duration, respectively. The levels of aspartic acid (Asp), glutamic acid (Glu), glycine (Gly), and GABA were estimated in convulsive mice. The expressions of $GABA_A$ and glutamate decarboxylase-65 (GAD65) were examined after TTPE treatment in the rats' brain in chronic epileptic wistar rats' model. The LC_{50} of TTPE was found to be above 6 g/kg. In MES- and PTZ-induced seizures model, TTPE (5–160 mg/kg) protected mice at 65% and 62.5%, respectively, but did not show any significant effect on rota-rod treadmill. TTPE (20–160 mg/kg) decreased the locomotor movements and onset time of pentobarbital-induced sleep. TTPE declined Asp and Glu levels in convulsive mice but raised the $GABA_A$ and GAD65 expressions in the rats' chronic epileptic model. The authors stated that the TTPE possessed potential antiepileptic activity and further studies are required to isolate the active constituents from TTPE that are responsible for antiepileptic effect (Gao et al., 2016).

Researchers validated the traditional anticonvulsant use of ethanolic extract of fruits of *Pyrus pashia* (EPP) in rats' model. Also, the antiepileptic activity of the isolated chrysin was investigated in experimental animals' model to find out the possible EPP mechanism in epilepsy treatment. Additionally, the safety study of chrysin was evaluated to explore the possible therapeutic options in managing epilepsy. The anticonvulsant activity of standardized EPP was checked in terms of duration of seizures and onset of hind-limb tonic extension in MES and PTZ-induced seizure model. Furthermore, in addition to antioxidant activity, the chrysin's antiseizure and electrophysiological activities were studied against PTZ-induced convulsion in experimental rats' model. Additionally, the chrysin was also assessed for neurotoxic effect in terms of duration of running and duration of

movement in rotarod and photo-actometer apparatus respectively. The EPP (100–400 mg/kg) and chrysin (2.5–10 mg/kg) doses showed remarkable anticonvulsant activities in MES and PTZ-induced acute seizure model using experimental rats. Moreover, chrysin did not induce sedation in experimental animals' model. Results showed that EPP could be deemed as alternative and potential therapeutic agent in epilepsy's management (Sharma et al., 2019).

The anticonvulsant effect of *Ricinus communis* L. (Euphorbiaceae) leaves extract in MES and PTZ-induced seizures in albino rats and albino mice was assessed. *R. communis* extract was also analyzed in Eddy's hot plate for analgesic activity. The ethanolic extract of *R. communis* leaves (250 mg/kg) was given orally to both rats and mice and its anticonvulsant effect was compared with the standard antiepileptic drug, phenytoin in MES and diazepam as standard control in PTZ-induced seizure models, respectively. The latency of seizures and mortality rate was noted. The extract significantly suppressed the duration of the tonic convulsions and exhibited recovery in MES-induced seizure model. It also reduced the number and duration of convulsions, delayed the onset time of clonic seizures, and protected animals against mortality in PTZ-induced seizures model. The extract also showed analgesic activity in Eddy's hot plate method, possibly through inhibition of prostaglandin synthesis and membrane stabilization. The extract could have the probability of exhibiting anticonvulsant activity by interfering with GABA and glutamate mechanisms. Phytochemical screening showed the occurrence of flavonoids and fatty acids that might be responsible for its anticonvulsant effect (Ladda, 2014).

Silybum marianum seed extract (300 mg/kg) showed considerable protection against PTZ-induced convulsions (seizure frequency, duration, and fatality). Furthermore, the extract at 300 mg/kg/day dose was found to be effective to protect the oxidative stress in the mice brain, resulting in a remarkable increased superoxide dismutase (0.4 ± 0.1 mol/mg protein) and catalase activity (4.7 ± 0.8 U/mL), while decrease in lipid peroxidation (1.4 ± 0.4 nmol/mg protein), when compared to the induced untreated group ($P < 0.05$). Authors concluded that the antiseizure activity of S. marianum seeds extract might be due to its antioxidant activity (Waqar et al., 2016).

The anticonvulsant, anxiolytic, and sedative activities of the *Swertia corymbosa* methanolic extract (SCMeOH) were evaluated. After acute-toxicity test, SCMeOH was studied in PTZ, INH, and MES-induced seizure models for its anticonvulsant activity. The anxiolytic activity was checked in open field test (OFT) and elevated-plus-maze (EPM) models, while actophotometer and rotarod test models were used to evaluate the locomotor and sedative activities of SCMeOH. In OFT, SCMeOH at 125–500 mg/kg dose significantly ($P < 0.01$, $P < 0.001$) increased the numbers of rearing, while reduced the numbers of ambulation and central motor activity ($P < 0.01$, $P < 0.001$). The extract increased the time spent and the number of entries in open arms, while decreased the number of locomotion ($P < 0.001$) in EPM and actophotometer test respectively. SCMeOH at 125–500 mg/kg dose protected animals against the PTZ and INH-induced convulsions. At the same above doses, the extract increased the latency of convulsion with significant level ($P < 0.01$, $P < 0.001$). SCMeOH also decreased the duration time of tonic hind-limb extension in MES-indued seizure model (Mahendran et al., 2014).

The strychnine-induced seizure model was used to check the anticonvulsant effect of methanolic extract of *Trachyspermum ammi*. After administration of *T. ammi* extract (50 mg/kg) and diazepam (1 mg/kg) for consecutive 14 days, rats were examined in strychnine-induced seizure model. The onset and duration time of convulsions, and the animal's protection from seizures were recorded. *T. ammi* extract at 50 mg/ kg and diazepam at 1 mg/kg concentrations delayed the onset time of convulsion by 6.25 ± 0.51 and 2.57 ± 0.81 min, respectively as compared to the vehicle control (0.146 ± 0.01 min). The animals' survival rate, treated with *T. ammi* extract and diazepam was estimated as 42.8 and 71.4% respectively, compared to the vehicle control. However, both *T. ammi* extract and diazepam increased the duration of convulsions as compared to control group (Rajput et al., 2013).

The anticonvulsant effects of *Viola tricolor* extract in PTZ and MES-induced seizure model were studied. A total of 26 mice groups ($n = 10$) were selected for the administration of *V. tricolor* hydroalcoholic extract (VHE; 100, 200, and 400 mg/kg), ethyl acetate fractions (EAF; 50, 100, and 200 mg/kg), and n-butanol fractions (NBF; 50, 100, and 200 mg/kg) as well as reference drug diazepam (3 mg/kg) and vehicle control group. Seizures were induced in all group's mice by the administration of PTZ (100 mg/kg) or induced by MES (50 Hz, 1 s and 50 mA) after 30 min of treatment. The VHE at 400 mg/kg dose significantly ($P < 0.001$) enhanced the latency to the generalized tonic-clonic seizures (GTCs) caused by PTZ as compared to the vehicle control group. The EAF at its all 3 doses (50, 100, and 200 mg/kg) remarkably delayed the latency of PTZ-generated seizures compared to the vehicle group. Furthermore, the NBF at its all dose (50, 100, and 200 mg/kg) increased the GTCs latency produced by PTZ in comparison to vehicle group. Moreover, the MES-induced hind limb tonic extension (HLTE) was reduced by all concentrations of the VHE, EAF, and NBF as compared to the vehicle group. Findings revealed that *V. tricolor* and its different fractions had anticonvulsant activities as validated by the extension of latency to the first GTCs caused by PTZ and reduction in the occurrence of HLTE generated by MES (Rahimi et al., 2019).

Abstract - is study aims to investigate the effect of a methanol extract of Trachyspermum ammi (L.) as an antiepileptic

4. Conclusions

Herbs are important sources of medicinal agents used to reverse various types of neurodegenerative and neuroinflammatory pathways and correcting the abnormal pathologies. In this review, we identified 241 plants effective in neurodegenerative disorder with special focus on epilepsy and convulsion. These data can be further validated and investigated for the discovery of new and ideal alternative drugs to the existing allopathic antiepileptic medications with maximum efficacy, good tolerability, lowest interactive level, and minimum adverse drug reaction.

Declaration of Competing Interest

Authors declare that they have no conflict of interest

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