Scientific African 33 (2026) e03495

Contents lists available at ScienceDirect

Scientific African

journal homepage: www.elsevier.com/locate/sciaf

Unveiling the potential of medicinal plants in managing respiratory disorders in Kenya: An ethnobotanical and pharmacological relevance

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ARTICLE INFO

Editor: DR B Gyampoh

Keywords:
Kenya
Medicinal plants
Pharmacology
Respiratory disorders
Toxicology

ABSTRACT

Plants have been used as indispensable sources of traditional medicines for humans since ancient times. In Kenya, medicinal plants continue to play an essential role in primary health care. However, the incidence and severity of respiratory illnesses continue to increase disease burden in the country. Numerous medicinal plants have been traditionally employed to remedy diverse respiratory ailments such as influenza and pneumonia. In this study, we synthesized information related to the herbal uses of medicinal plants employed to manage respiratory disorders in Kenya and their ethnopharmacological relevance. A total of 238 plant species belonging to 72 families and 167 genera have been reported to potentially remedy 13 distinct respiratory ailments. Plants in Fabaceae family were predominantly used to manage these ailments. Besides, leaves (33%) and roots (29%) were the major plant parts widely utilized by local healers to prepare ethnomedicinal recipes in form of decoction, and were primarily administered orally. Pharmacological investigations showed that the studied medicinal plants displayed diverse biological activities, which likely contributed to their therapeutic benefits. Toxicological analysis revealed that 92 (39%) plant species were safe. Moreover, the conservation status showed that 88 species were of least concern, 3 were data deficient, 3 were endangered, 2 were vulnerable, and 2 were nearly threatened. This study shows the abundance and widespread utilization of ethnomedicinal plants in treating respiratory illnesses in Kenya. The generated inventory is a valuable addition to the

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https://doi.org/10.1016/j.sciaf.2026.e03495

Available online 2 July 2026

growing database of therapeutic plant resources and can serve as a vehicle for ethnopharmacological research in clinical application and drug discovery.

Abbreviations

ABTS 2,2′-azino-bis (3-ethyl-benzo-thiazoline-6-sulfonic acid)
AP-1 activator protein-1
BALF bronchoalveolar lavage fluid
CAT catalase
COX-1 cyclooxygenase 1
COX-2 cyclooxygenase 2
DD data deficient
DPPH-1 1-diphenyl-2-picrylhydrazyl
ELISA enzyme-linked immunosorbent assay
EN endangered
ERK extracellular signal–regulated kinase
ERK1/2 extracellular signal-regulated kinase ½
FRAP Ferric reducing antioxidant power
GBIF global biodiversity information facility
GPX glutathione peroxidase
GR glutathione reductase
HETE Hydroxyleicosatetraenoic acid
IC_{50} half-maximal inhibitory concentration
ICAM-1 intercellular adhesion molecule-1
IL-1β, and -6 interleukin-1β and 6
IL-6 interleukin-6
IL-8 interleukin 8
iNOS inducible nitric oxide synthase
IUCN international union for conservation of nature
JAK janus kinase
JNK c-Jun-N-terminal kinase
LC least concern
LOX lipoxygenase
LPS lipopolysaccharide
MAPKs mitogen-activated protein kinases
MCP-1 monocyte chemoattractant protein-1
MDA malondialdehyde
MIC minimum inhibitory concentration
MMP-9 matrix metalloproteinase-9
MRSA methicillin-resistant *Staphylococcus aureus*
NDA African natural database
NF-κB nuclear factor-κB
NLRP3 nucleotide-binding domain, leucine-rich–containing family, pyrin domain–containing-3
NO nitric oxide
NR not reported
NT nearly threatened
OVA ovalbumin
PAF platelet-activating factor
PGE2 prostaglandin E2
PKC protein kinase C
PLA2 phospholipase A2
POWO plants of the world online
RSV respiratory syncytial virus
SO_2 Sulfur dioxide
SOD superoxide dismutase
STAT-1 signal transducer and activator of transcription-1
TGF β1-transforming growth factor-beta
Th1 T-helper type 1
Th2 T-helper 2

TLRs toll-like receptors
TMPs traditional medicine practitioners
TNF-α tumour necrosis factor alpha
VCAM-1 vascular cell adhesion molecule-1
VU vulnerable
WFO world flora online.

Introduction

The respiratory system comprises a group of organs and tissues that facilitate respiration by enabling the body to absorb oxygen from the atmosphere, thereby supporting optimal functioning of organs. It comprises the lungs, airways, and blood vessels and is responsible for purifying the blood by removing hazardous gases like carbon dioxide. The respiratory system can be categorized into two parts encompassing the upper and lower respiratory tracts [1]. Common symptoms of lower respiratory tract infections include bronchitis, pneumonia, breathing difficulties, and chest problems, among others [2], whereas sinuses, coughs, flu, sore throats, tonsils/tonsillitis, and common colds characterize the upper respiratory tract infections [3].

Respiratory diseases are mostly caused by viral and bacterial pathogens and are among the leading causes of morbidity and mortality in developing countries [4]. Approximately, 90% of the deaths related to these ailments occur in low and middle-income countries [5]. These illnesses account for more than four million annual deaths globally [6,7] and are amongst the most common acute and chronic diseases that contribute significantly to the global burden of diseases [8]. For instance, the infant mortality rate is significantly impacted by acute pneumonia, which is responsible for about 16% of the global deaths within this population [1]. Africa accounts for about 50% of all pneumonia deaths in children under the age of five, with Kenya being among top countries with the highest estimated number of childhood deaths (mortality rate of 50.3 per 10,000 children) [9].

Phyto-therapeutic agents derived from plants have been utilized to remedy diverse ailments in different parts of the world since time immemorial [10], with an estimated use prevalence of 40 – 90% [11]. These agents are important sources of herbal products, and their consumption has been increasing primarily in developing countries since they are readily available, widely accepted by many cultures, relatively inexpensive, and are usually perceived to be safe [12], compared to modern conventional medicines [13]. In these countries, about 80% of the population living in rural areas relies on traditional therapies for their health care needs [14,15]. Numerous studies have been conducted to assess the efficacy of medicinal plants [16,17], and some of the outcomes have prompted the production of plant-based medicines [18]. Consequently, tremendous success has been achieved in the development of herbal medicine enterprises in several countries such as China, Sri Lanka, and India [19]. Besides serving as significant sources of alternative medicines, medicinal plants provide a reliable source of income to traders, harvesters, and traditional healers [14].

In Africa, the use of traditional medicines has been the primary remedy for nearly all illnesses before the advent of conventional medicines [20]. Kenya is among the African countries where traditional medicines are widely utilized and are indigenous to many cultures. Over the past few years, respiratory disorders have been reported among the leading causes of mortality in Kenya [21]. As of December 2021, these ailments affected a total of about 20.6 million individuals, making them the most prevalent health problems affecting local communities [22]. Diverse medicinal plants have been documented by numerous reports to provide health care needs in different communities in Kenya [23–25]. For instance, *Acanthus polystachyus* Delile, *Allium sativum* L., *Steganotaenia araliacea* Hochst., and *Artemisia annua* L. have been traditionally used by the Luo community to manage coughs, respiratory allergies, pneumonia, and asthma, respectively [26]. Averagely, 70% of the Kenyan population relies on these herbal remedies for basic health care [19]. However, their utilization has not been effectively integrated into the primary healthcare system due to unclear legal and policy frameworks [27]. Additionally, the majority of herbal products still lack scientific evidence for their efficacy and safety [28]. The alleged therapeutic benefits of medicinal plants have not been scientifically investigated and validated. Accordingly, we sought to assess the medicinal plants that are traditionally employed in treating symptoms related to respiratory illnesses in Kenya, and examine their pharmacologic efficacy. Specifically, we aimed to answer the following questions; (a). How is the distribution pattern of medicinal plants used to remedy respiratory complaints across Kenya? (b). What respiratory disorders are commonly treated with medicinal plants found in Kenya? (c). Which plant parts are frequently used in preparing herbal remedies for respiratory ailments? (d). What are the modes of preparation and administration of ethnomedicinal recipes? (e). What are the pharmacological properties of medicinal plants used to remedy symptoms related to respiratory illnesses? (f). What is the conservation status of the plants used to treat respiratory disorders?

Materials and methods

Data collection

Information related to the ethno-medicinal uses of plants against respiratory ailments was obtained from different online bibliographical databases, including Springer Link, PubMed, Google Scholar, Science Direct, as well as Local electronic theses and dissertations (ETDs) repositories. The scientific names of documented plant species were confirmed and the misspelled ones corrected using the Plants of the World Online (POWO) (https://powo.science.kew.org/accessed on 5 April 2025), African Natural Database (NDA) version 2.0, and World Flora Online (WFO) (http://www.worldfloraonline.org/accessed on 5 April 2025). In cases where the primary references used names that were considered synonyms, we documented the data using accepted names.

Detailed literature searches comprised the use of a single or combination of keywords such as ‘medicinal plants/Kenya’,

'ethnobotanical study', 'traditional medicines', 'respiratory disorders', 'tonsillitis/traditional medicinal plants', 'pneumonia/traditional medicinal plants', 'asthma/traditional medicinal plants', and 'colds/traditional medicinal plants', 'pharmacological properties', 'toxicity/medicinal plants', 'conservation', among others. Studies identified through keyword searches in the literature databases are illustrated in Fig. 1. Preparation of this review was not restricted to the selection of English-language publications. Global Biodiversity Information Facility (GBIF) (https://www.gbif.org/accessed on 20 April 2025) was used to verify and retrieve the missing data related to growth forms as well as the names of families, genera, and authors of scientific names. Furthermore, in cases where the primary sources did not include the information related to methods used to prepare and administer medicinal plants, we documented them as 'unspecified'.

Study selection

This study incorporated both indigenous and exotic medicinal plant species occurring across diverse ecological regions of Kenya. The selection of medicinal plants used to remedy respiratory disorders was based on the following eligibility criteria.

Inclusion criteria

Information obtained from various literature sources, comprising the details related to family, generic, and scientific names of medicinal plants, their growth forms, parts used for medicinal purposes, modes of preparation, routes of administration, plant growth habits, treated conditions, biological activities, toxicity, and conservation status were selected. Furthermore, data on the names of counties and study sites where the original research was conducted were included. Subsequently, the database was consolidated and organized in Excel. A total of 407 published articles up to May 2025 were identified Fig. 1.

Exclusion criteria

Titles that were out of scope of the study aims, insufficient data, duplicates, and those of limited rigor were discarded. Additionally, studies that exclusively used the local plant names or identified plants only at the genus level were excluded.

Data analysis

The ethnomedicinal plant survey classified respiratory infections into 13 categories based on the ailments listed in published articles. This process involved classifying illnesses or categories of disorders that share similarities into a single group. A catalogue of species was compiled by including each plant that was mentioned across multiple locations as a remedy for a particular respiratory illness only once. Besides, the conservation status of the listed medicinal plants was assessed following the IUCN Red List categories and criteria (https://www.iucnredlist.org/accessed on 28 April 2025).

Study area

A systematic review was conducted to document plant species sourced and traded as herbal medicines utilized to cure respiratory ailments in Kenya. This country is located in East Africa and is horizontally intersected by the equator, between 5^0 N and 5^0 S latitude and 34^0 E and 42^0 E longitudes [29]. It is bordered by the Indian Ocean to the Southeast, Somalia to the East, Ethiopia and Sudan to the North, Uganda to the West, and Tanzania to the South. The country covers an area of about 582,650 km^2, with variations in altitudes

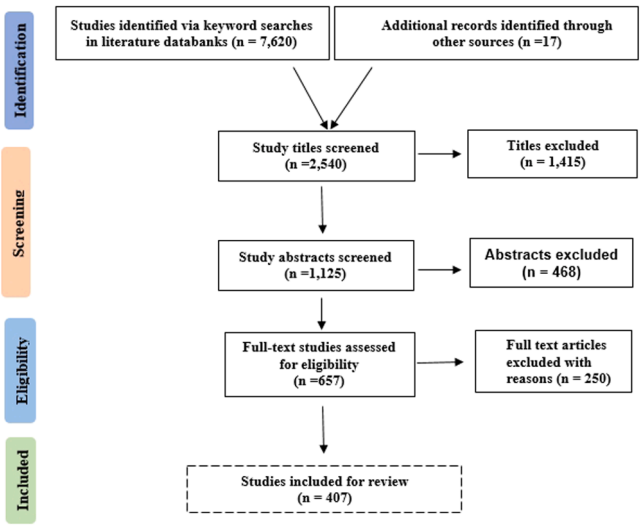

Fig. 1. Selection of studies for inclusion in the review.

from the coastal plains to plateaus and mountains towards its centre [30]. The climate is affected by varying topography, from tropical to temperate, with a significant portion of the land being arid and semi-arid, primarily towards the Eastern and Northern parts [31].

Results and discussion

Distribution patterns of medicinal plants used to remedy respiratory complaints

Medicinal plants used by local communities to treat respiratory disorders were reported in the different regions that are distributed in thirty (30) counties (Fig. 2, **Supplementary Table 1**). We obtained 7,620 articles from various web sources based on the search strategy and inclusion criteria. However, 381 articles that provided comprehensive information regarding the medicinal utilization of plants to cure respiratory infections were chosen and included in the present study. The findings from previous reports show that studies related to the utilization of medicinal plants to cure respiratory ailments were conducted in diverse locations in Kenya (**Supplementary Table 1**), including marketplaces, towns, conservancies, forests, and hills. Nonetheless, they remain underexplored primarily in the Northern and Coastal regions (Fig. 2).

Diversity of medicinal plants used to treat respiratory tract disorders

Kenya is endowed with rich diverse repository of medicinal plants with the aptitude to manage respiratory complications. The literature survey from multidisciplinary electronic databases showed that a total of 238 species belonging to 72 families and 167 genera are used to manage thirteen (13) symptoms of respiratory illnesses. According to this study, out of the 238 medicinal plants, 27% belonged to the Asteraceae and Fabaceae families. The most dominant family was Fabaceae (15%), which encompassed 37 species (Fig. 3), followed by Asteraceae (10%), Euphorbiaceae (6%), Lamiaceae (5%), and Rutaceae (5%). The families Acanthaceae (6 species), Solanaceae (7 species), Rubiaceae (7 species), and Anacardiaceae (6 species) each with a proportion of 3%, while Asphodelaceae (5 species), Cucurbitaceae (5 species), Combretaceae (4 species), Boraginaceae (4 species), Verbenaceae (4 species), Burseraceae (4 species), and Myrtaceae (4 species) families respectively reported (2%) (Fig. 3, Table 1). In addition, each of the six families documented three species, whereas two plant species were documented in each of the reported fourteen families. Thirty-seven (37) families were the least dominant, and each reported a single species (Fig. 3, Table 1).

Several ethnobotanical studies showed that medicinal plant species from Asteraceae and Fabaceae families were highly utilized to treat different ailments [2,1,16], agreeing with the findings of this study. The evidence supporting the assertion that Fabaceae is the most dominant plant family with medicinal benefits was hypothesized by Van (2020). Members of the Fabaceae family are popular and highly preferred in African traditional medicines due to their high abundance, easy accessibility, and ability to thrive in different environments [32].

According to the data presented in Table 1, it is evident that multiple plant species may be used to treat a specific ailment. For

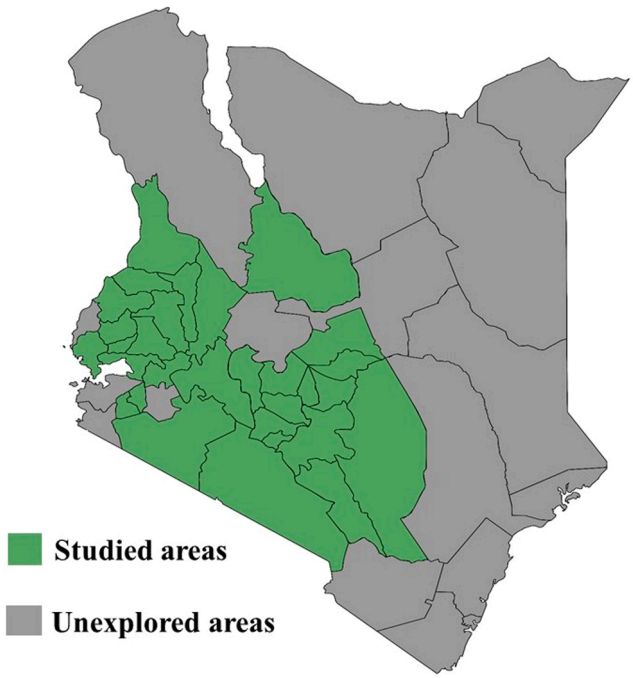

Fig. 2. Distribution of medicinal plants used to treat respiratory ailments in Kenya.

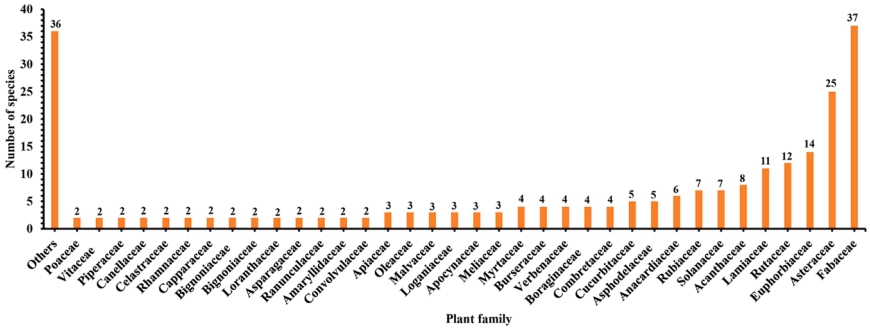

Fig. 3. Taxonomic diversity of plant species used to manage respiratory conditions.

instance, *Lepidagathis scariosa* Nees., *Justicia flava* (Forssk.) Vahl, *Lannea schweinfurthii* (Engl.) Engl., and *Steganotaenia araliacea* Hochst. are used to treat pneumonia. It is also apparent that a single plant species can be used to remedy multiple respiratory problems. For example, roots obtained from *Uvaria scheffleri* Diels in the form of decoction or infusion can be used to remedy pneumonia, cough, tuberculosis, asthma, and sore throat. Besides, a decoction prepared from the whole plant obtained from *Galinsoga parviflora* Cav. can be used to treat tonsils, common cold, and asthma (Table 1). The majority of documented plant species reported in this study have also been stated in different parts of the world to treat diverse respiratory ailments. For instance, *Warburgia ugandensis* Sprague, *Catha edulis* (Vahl) Endl., *Albizia amara* (Roxb.) Boivin, *Piper capense* L., *Cymbopogon citratus* (DC.) Stapf, *Citrus limon* (L.) Osbeck, *Citrus aurantiifolia* (Christm.) Swingle, and *Withania somnifera* (L.) Dunal are used to treat coughs, whereas *Momordica foetida* Schumach, *Croton macrostachyus* Delile, *Acacia nilotica* (L.) Delile, *Morella serrata* (Lam.) Killick, *Olea europaea* L., *Rubia cordifolia* L., *Solanum incanum* L., and *Rhamnus prinoides* L'Herit are used to cure tonsillitis in Ethiopia [1]. Additionally, *Mangifera indica* L., *Lippia javanica* (Burm.f.) Spreng, *Zanha africana* (Radlk.) Exell, *Citrus limon* (L.) Burm.fil., *Psidium guajava* L., *Erythrina abyssinica* Lam., *Cassia abbreviata* Oliv., *Warburgia salutaris* (G. Bertol.) Chiov., and *Searsia pyroides* (Burch.) Moffett are commonly employed to manage respiratory disorders in Zimbabwe [16].

Plant-derived remedies have been relatively significant in managing ailments associated with humans (**Supplementary Table 2**). While the plants reported in this study cure respiratory disorders, some have multiple medicinal applications. Pharmacological evaluations showed that the majority of medicinal plants can be utilized as therapy for a variety of ailments due to their diverse biological properties [2]. The most common bioactivities among documented medicinal plants were antimicrobial, antioxidant, and anti-inflammatory properties. Antimicrobial effect was exhibited by 144 plants, followed by antioxidant (91 plants), anti-inflammatory (93 plants), antidiabetic/anti-obesity (50 plants), analgesic (39 plants), antipyretic (26 plants), immunomodulatory (11 plants), anti-allergic (7 plants), anti-asthmatic (5 plants), and antitussive (3 plants) activities, suggesting their folkloric use in alleviating respiratory disorders (Table 1 & **Supplementary Table 2**).

Frequently treated respiratory tract ailments

The present study shows that cough is treated by 95 plant species, common cold by 75 plants, pneumonia by 67 plants, asthma by 46 plants, chest problems by 38 plants, tonsils/tonsillitis by 31 plants, tuberculosis by 23, flu by 21 plants, throat problems by 11 plants, bronchial complications by 7 plants, breathing problems by 4 plants, respiratory allergies by 4 plants, and blocked nose by 3 plants (Table 1).

The majority of documented plant species are used to treat coughs (22%), common colds (18%), and pneumonia (16%) (Fig. 4). Similarly, studies from Ethiopia and Zimbabwe demonstrated that the vast majority of therapeutic plants were used to treat coughs and common colds [16,54], indicating their widespread prevalence as respiratory complications across numerous countries.

Life forms and plant parts used against respiratory diseases

The most commonly used plant habits for remedial against respiratory disorders in Kenya are trees (98 species, 38%), followed by shrubs (86 species, 33%), herbs (51 species, 20%), climbers (14 species, 5%), and lianas (9 species, 4%) (Fig. 5). The high abundance of woody plants (trees and shrubs) makes them easily accessible to users. The prevalence of woody plants in Kenya is due to the diverse climatic and ecological conditions that favour their growth and survival [55]. These findings correspond to the results obtained by Nyagumbo et al. [16] in the study of medicinal plant species used to manage respiratory ailments in Zimbabwe.

Herbaceous plants have been found as the third most dominant life form (20%). Semenya & Maroyi [56] reported the popularity of herbs as a common therapy for the asthmatic condition in South Africa. Previous analysis by Alamgeer et al. [2] indicated the dominance of herbaceous plants in the management of respiratory illnesses in Pakistan, consistent with an ethnomedicinal study of plant species utilized to remedy symptoms related to respiratory infections in Ethiopia [1,54].

Different plant parts used to manage respiratory ailments in Kenya are summarized in Fig. 6. The ethnomedicinal recipes were frequently prepared from the leaves (33%), followed by roots (29%), and barks (21 %) (Fig. 6). The stems, whole plants, fruits, seeds, and tubers accounted for 17%. These findings are in agreement with Haile et al. [1], who reported leaves as the most commonly

Table 1
Medicinal plants used in managing respiratory disorders in Kenya.

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
	Acanthaceae								
1.	*Acanthus polystachyus* Delile	Roots	Decoction	Cough	Orally	Shrub	NR	NR	[26]
2.	*Asystasia schimperi* T.Anderson	Leaves	Infusion	Cough	Orally	Herb	NR	NR	[33]
3.	*Lepidagathis scariosa* Nees.	Leaves	Infusion	Pneumonia	Orally	Herb	NR	NR	[33]
4.	*Acanthus pubescens* (Oliv.) Engl.	Leaves	Burning to ashes	Cough, asthma, common cold, pneumonia, flu, and tonsils	Orally	Shrub	NR	NR	[33]
5.	*Hypoestes aristata* (Vahl) Sol. ex Roem. & Schult.	Roots	Concoction	Tuberculosis, chest complaints, cough, and pneumonia	Orally	Shrub	LC	Stable	[34]
6.	*Justicia flava* (Forssk.) Vahl	Leaves	Infusion	Pneumonia	Orally	Herb	NR	NR	[33]
7.	*Thunbergia alata* Sims	Leaves	Decoction/infusion	Cough and tonsils	Orally	Herb	NR	NR	[33,35]
		Roots	Unspecified	Sore throat	Chewing		-	-	[36]
8.	*Justicia betonica* L.	Leaves/ flowers	Burning to ashes	Cough	Orally	Herb	NR	NR	[33]
	Amaranthaceae								
9.	*Achyranthes aspera* L.	Roots	Burning to ashes	Cough	Orally	Herb	NR	NR	[33]
	Amaryllidaceae								
10.	*Allium sativum* L.	Bulbs	Concoction	Respiratory allergies	Orally/chewing	Herb			[26]
11.	*Allium ampeloprasum* L.	Leaves	Decoction	Coughs and flu	Inhalation	Herb	LC	Unknown	[37]
	Anacardiaceae								
12.	*Searsia natalensis* (Bernh. ex C.Krauss) F.A.Barkley	Whole plant/ leaves/roots	Concoction/ decoction/pounding	Flu, coughs, Asthma, common cold, and chest pains	Orally	Shrub/ tree	LC	Stable	[26,38]
		Stems/seeds/ barks	Infusion	Chest pain, common cold, and pneumonia	Orally		-	-	[35,26,38]
13.	*Lannea schweinfurthii* (Engl.) Engl.	Barks	Infusion	Pneumonia	Orally	Tree	NR	NR	[39]
14.	*Searsia pyroides* (Burch.) Moffett	Leaves/ stems/roots/ barks	Decoction	Common cold and cough	Orally	Shrub	NR	NR	[40]
15.	*Mangifera indica* L.	Leaves	Unspecified	Cough	Chewing	Tree	DD	Unknown	[35,26,38,25]
		Leaves	Boiling	Asthma	Orally	-			
16.	*Pistacia aethiopica* Kokwaro	Leaves	Decoction	Common cold	Orally	Tree	NT	Unspecified	[25]
17.	*Lannea triphylla* (Hochst.) Engl.	Barks	Unspecified	Common cold and cough	Chewing	Shrub/ tree	NR	NR	[36]
	Annonaceae								
18.	*Uvaria scheffleri* Diels	Roots	Decoction/infusion	Pneumonia, cough, tuberculosis, asthma, and sore throat	Orally	Shrub/ liana	NR	NR	[36]
	Apiaceae								
19.	*Coriandrum sativum* L.	Leaves	Decoction	Common cold	Inhalation	Herb	NR	NR	[37]
20.	*Daucus incognitus* (C.Norman) Spalik, Reduron & Banasiak	Roots	Decoction	Pneumonia	Orally	Herb	NR	NR	[41]
21.	*Steganotaenia araliacea* Hochst.	Roots/barks	Decoction	Pneumonia	Orally	Tree	LC	Stable	[26]
	Araceae								
22.	*Culcasia falcifolia* Engl.	Leaves	Burning	Cough	Orally	Liana/ climber	LC	Stable	[33]
	Araliaceae								
23.	*Cussonia holstii* Engl.	Barks	Pounding	Cough	Chewing		LC	Stable	[25]
	Asteraceae								

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
24.	*Launaea cornuta* (Hochst. ex Oliv. & Hiern) C.Jeffrey	Leaves	Infusion	Chest pain	Orally	Herb	NR	NR	[35]
25.	*Solanecio mannii* (Hook.fil.) C. Jeffrey	Fruits	Unspecified	Common cold and chest infections	Chewing	Tree	LC	Stable	[34]
		Roots	Decoction	Pneumonia and cough	Orally		NR	NR	[33]
26.	*Hoffmannanthus abbotianus* (O. Hoffm.) H.Rob., S.C.Keeley & Skvarla	Leaves	Decoction	Common cold and cough	Orally	Tree	NR	NR	[34]
27.	*Tagetes minuta* L.	Leaves	Decoction	Common cold and asthma.	Orally/chewing	Herb	NR	NR	[25,41]
28.	*Lactuca inermis* Forssk.	Leaves	Decoction	Tonsils	Orally	Herb	NR	NR	[25]
29.	*Artemisia annua* L.	Leaves	Decoction	Asthma	Orally	Herb	NR	NR	[26]
30.	*Microglossa pyrifolia* (Lam.) Kuntze	Leaves/roots	Maceration/ concoction	Cough	Orally	Shrub	NR	NR	[26]
31.	*Tithonia diversifolia* (Hemsl.) A. Gray	Leaves/roots	Decoction	Asthma and tonsils	Orally/topically		NR	NR	[26,25,40]
		Barks	Concoction	Common cold and cough	Orally	Shrub			[40]
32.	*Aspilia mossambicensis* (Oliv.) Wild	Leaves/roots	Unspecified	Cough and pneumonia	Unspecified	Shrub	NR	NR	[42]
33.	*Chrysanthemum americanum* (L.) Vatke ex Weberl. & Lagos	Whole plant	Ash infusion	Cough	Orally	Herb	NR	NR	[33]
34.	*Galinsoga parviflora* Cav.	Whole plant	Decoction	Tonsils, common cold, and asthma	Orally/chewing	Herb	NR	NR	[35]
35.	*Vernonia brachycalyx* C.Hoffm.	Roots	Decoction	Pneumonia	Oral	Herb	NR	NR	[37]
36.	*Emilia discifolia* (Oliv.) C.Jeffrey	Leaves	Infusion	Asthma	Orally	Herb	NR	NR	[33]
37.	*Acmella caulirhiza* Delile	Leaves/ flowers	Decoction/crushing	Cough and common cold	Orally	Herb	NR	NR	[40]
38.	*Baccharoides lasiopus* (O.Hoffm.) H. Rob.	Leaves	Decoction	Pneumonia and common cold	Orally	Shrub	LC	Stable	[37,25]
39.	*Sonchus asper* (L.) Hill	Bulbs	Juice	Tonsils, cough	Orally	Herb	LC	Stable	[33]
40.	*Sonchus oleraceus* L.	Roots	Decoction	Chest pains and tonsils	Orally	Herb	NR	NR	[25]
41.	*Psiadia punctulata* (DC.) Oliv. & Hiern ex Vatke	Stems/barks/ roots	Unspecified	Cough	Unspecified	Shrub	NR	NR	[43]
42.	*Eschenbachia subscaposa* (O.Hoffm.) G.L.Nesom	Roots	Decoction	Tonsils	Orally	Herb	NR	NR	[26,11]
43.	*Erigeron sumatrensis* Retz.	Leaves	Crushing	Throat infections and tonsils	Orally	Herb	NR	NR	[40]
44.	*Ageratum conyzoides* L.	Leaves	Decoction	Cough.	Orally	Herb	NR	NR	[44]
45.	*Tarchonanthus camphoratus* L.	Leaves/whole plant	Decoction	Asthma and bronchitis	Unspecified	Tree	LC	Stable	[38]
46.	*Schkuhria pinnata* (Lam.) Kuntze	Roots/leaves	Decoction	Cough	Orally	Herb	NR	NR	[25]
47.	*Aspilia pluriseta* Schweinf.	Barks	Crushing	Cough	Chewing	Herb/ shrub	NR	NR	[25]
48.	*Kleinia squarrosa* Cufod. **Apocynaceae**	Stems	Decoction	Pneumonia	Orally	Shrub	NR	NR	[36]
49.	*Acokanthera schimperi* (A.DC.) Schweinf.	Leaves	Unspecified	Asthma and tuberculosis	Unspecified	Tree	NR	NR	[45]
50.	*Carissa spinarum* L.	Barks/leaves/ seeds	Unspecified	Chest problems	Unspecified	Shrub	NR	NR	[26,43,25]
		Roots	Decoction	Common cold, pneumonia, asthma, and chest problems	Orally		-	-	
51.	*Tabernaemontana stapfiana* Britten **Asclepiadaceae**	Roots/barks	Decoction	Chest problems and pneumonia	Orally	Tree	LC	Stable	[33]

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
52.	*Periploca linearifolia* Dill. & A. Rich.	Roots	Sap	Common cold	Unspecified	Liana	NR	NR	[35]
	Asparagaceae								
53.	*Asparagus racemosus* Willd	Roots	Decoction	Sore throat and pneumonia	Orally	Shrub	NR	NR	[11]
54.	*Asparagus setaceus* (Kunth) Jessop	Leaves	Crushing	Cough	Chewing	Climber	NR	NR	[25]
	Asphodelaceae								
55.	*Aloe volkensii* Engl.	Leaves	Unspecified	Pneumonia	Unspecified		LC	Unknown	[46]
56.	*Aloe kedongensis* Reynold	Leaves	Concoction/ infusion	Asthma, pneumonia, and common cold	Orally	Shrub	NR	NR	[33]
57.	*Aloe ballyi* Reynolds	Leaves	Decoction	Common cold	Inhalation	Tree	EN	Decreasing	[26,43,25]
58.	*Aloe secundiflora* Engl.	Leaves	Decoction	Pneumonia	Orally	Herb	LC	Stable	[35]
59.	*Aloe turkanensis* Christian	Leaves	Burning	Pneumonia	Poultice	Tree	NR	NR	[36]
	Basellaceae								
60.	*Basella alba* L.	Leaves	Pounding	Breathing difficulties.	Orally	Herb	NR	NR	[37,41]
	Bignoniaceae								
61.	*Kigelia africana* (Lam.) Benth.	Barks	Decoction	Common cold, pneumonia, and flu.	inhalation	Tree	LC	Stable	[37,26]
62.	*Spathodea campanulata* Beauverd	Barks	Decoction/infusion	Common cold and chest problems	Orally	Tree	LC	Stable	[33,41]
	Boraginaceae								
63.	*Cordia sinensis* Lam.	Barks	Unspecified	Chest pains	Unspecified	Shrub/ tree	LC	Unknown	[45]
64.	*Cordia africana* Lam.	Barks	Decoction	Pneumonia	Unspecified	Tree	LC	Unknown	[47]
65.	*Trichodesma zeylanicum* (Burm.fil.) R.Br.	Whole plant	Decoction	Common cold and flu	Inhalation	Shrub	NR	NR	[37]
66.	*Ehretia cymosa* Thonn.	Leaves/roots	Infusion	Pneumonia, cough, tonsil and asthma	Orally	Shrub	LC	Decreasing	[33]
	Burseraceae								
67.	*Commiphora africana* (A.Rich.) Engl.	Roots	Decoction	Pneumonia	Orally	Tree	LC	Stable	[26]
68.	*Commiphora rostrata* Engl.	Leaves	Unspecified	Chest pains and cough	Chewing	Shrub/ tree	NR	NR	[42]
69.	*Commiphora edulis* (Klotzsch) Engl.	Barks	Infusion	Chest pains and cough	Orally	Tree	LC	Stable	[48]
70.	*Commiphora baluensis* Engl.	Barks	Infusion	Pneumonia	Orally	Tree	LC	Unknown	[36]
	Combretaceae								
71.	*Combretum molle* R.Br. ex G.Don	Stems/leaves/ roots	Decoction	Cough	Orally	Tree	LC	Stable	[44,43]
72.	*Terminalia brownii* Fresen	Barks	Decoction	Asthma, pneumonia, common cold, and cough.	Orally/chewing	Tree	NR	NR	[42,26]
73.	*Combretum hereroense* Schinz	Leaves	Unspecified	Tuberculosis and cough	Chewing	Shrub	LC	Stable	[48]
74.	*Combretum exalatum* Engl.	Roots	Unspecified	Cough	Chewing	Shrub/ tree	NR	NR	[36]
	Canellaceae								
75.	*Warburgia ugandensis* Sprague	Barks/roots/ stems/leaves	Decoction	Chest complains common cold, cough, flu, asthma, and pneumonia.	Orally	Tree	NR	NR	([35]; Wk et al., 2022)
76.	*Warburgia salutaris* (G. Bertol.) Chiov.	Barks	Decoction	Asthma, respiratory allergies, chest pain, and pneumonia	Orally	Tree	EN	Unspecified	[26]
	Capparaceae								

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
77.	*Maerua subcordata* (Gilg) De Wolf	Leaves	Crushing	Pneumonia	Topically	Shrub/ tree	NR	NR	[42]
78.	*Maerua kirkii (Oliv.)* F.White	Roots	Decoction	Chest pains	Orally	Shrub/ tree	NR	NR	[36]
	Caricaceae								
79.	*Carica papaya* L.	Roots/leaves	Decoction	Bronchitis	Orally	Tree	DD	Decreasing	[26]
	Celastraceae								
80.	*Catha edulis* Forssk.	Barks/roots	Decoction	Tuberculosis	Orally	Shrub	LC	Unspecified	[41]
81.	*Gymnosporia senegalensis* (Lam.) Loes.	Stems	Sap	Tonsils	Topically	Shrub/ tree	LC	Stable	[25]
	Convolvulaceae								
82.	*Ipomoea kituiensis* Vatke	Leaves	Decoction	Cough	Orally	Shrub	NR	NR	[26]
83.	*Ipomoea cairica* (L.) Sweet	Leaves	Decoction	Common cold	Orally	Climber	NR	NR	[40]
	Cucurbitaceae								
84.	*Zehneria minutiflora* (Cogn.) C. Jeffrey	Roots	Decoction	Pneumonia	Orally	Liana	NR	NR	[11]
85.	*Zehneria scabra* (L.f.) Sond.	Leaves	Decoction	Common cold	Orally	Climber	NR	NR	[25]
86.	*Momordica rostrata* Zimm.	Tubers	Concoction	Tuberculosis	Orally	Climber	NR	NR	[34]
87.	*Momordica foetida* Schumach.	Leaves	Crushing	Tonsils	Chewing	Climber	NR	NR	[25]
88.	*Cucumis dipsaceus* Ehrenb. ex Spach.	Fruits	Decoction	Asthma	Orally	Climber	NR	NR	[36]
	Cuppressaceae								
89.	*Juniperus procera* Endl.	Roots/fruits/ barks	Decoction/ pounding	Breathing difficulties and common cold	Orally/chewing	Tree	LC	Decreasing	[25,41]
	Cyperaceae								
90.	*Cyperus richardii* Steud.	Leaves	Crushing	Tonsils	Chewing	Herb	LC	Stable	[25]
	Ebenaceae								
91.	*Euclea divinorum* Hiern.	Roots	Decoction/infusion	Asthma, pneumonia, cough, and chest pain	Orally	Shrub	LC	Stable	[26,36]
	Euphorbiaceae								
92.	*Croton megalocarpus* Del.	Leaves Barks/roots	Decoction Pounding	Pneumonia Cough and tonsils	Orally Chewing	Tree	LC -	Stable -	[26,25]
93.	*Croton macrostachyus* Delile	Barks/leaves/ roots	Decoction/crushing	Asthma	Orally	Tree	LC	Stable	[40]
94.	*Shirakiopsis elliptica* (Hochst.) Esser	Barks/roots	Decoction	Asthma	Orally	Tree	NR	NR	[40]
95.	*Euphorbia scarlatina* S.Carter	Stems	Unspecified	Common cold and tuberculosis	Unspecified	Shrub	NR	NR	[46]
96.	*Euphorbia hirta* L.	Leaves	Decoction	Asthma	Orally	Herb	NR	NR	[40]
97.	*Euphorbia murielii* N.E.Br.	Stems	Decoction	Pneumonia	Orally	Tree	NR	NR	[36]
98.	*Neoboutonia macrocalyx* Pax	Barks/roots	Decoction	Cough, common cold, and chest pains	Orally	Tree	LC	Stable	[35]
99.	*Jatropha podagrica* Hook.	Leaves	Decoction	Chest problems	Orally	Shrub	NR	NR	[40]
100.	*Macaranga kilimandscharica* Pax	Leaves	Decoction	Cough	Orally	Tree	NR	NR	[34]
101.	*Ricinus communis* L.	Seeds	Decoction	Cough	Orally	Shrub/ tree	NR	NR	[25]
102.	*Euphorbia joyae* P.R.O.Bally & S. Carter	Stems	Decoction	Tonsils	Orally	Shrub	VU	Unknown	[25]
103.	*Euphorbia tirucalli* L.	Leaves/roots	Decoction/infusion	Asthma and pneumonia	Orally	Shrub/ tree	LC	Stable	[36]
104.	*Clutia abyssinica* Jaub. & Spach	Leaves	Decoction	Tonsils	Orally	Shrub	LC	Stable	[25]

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Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
105.	*Croton dichogamus* Pax	Barks	Infusion	Cough	Orally	Herb/	LC	Stable	[26,48]
		Roots/flowers	Decoction	Chest congestion and asthma	Orally	Tree	-	-	[49]
	Fabaceae								
106.	*Abrus fruticulosus* Wall. ex Wight & Arn.	Roots	Decoction	Pneumonia	Orally	Climber	DD	Unknown	[37]
107.	*Vachellia nilotica* (L.) P.J.H.Hurter & Mabb.	Roots/barks	Infusion	Chest pains, cough, pneumonia, and tuberculosis	Orally	Tree	LC	Unknown	[39,38,50]
108.	*Senegalia mellifera* (Vahl) Seigler & Ebinger	Barks	Decoction/infusion	Pneumonia, chest pains, and cough	Orally/chewing	Shrub	LC	Stable	[37,39,38]
109.	*Senna occidentalis* L.	Roots	Decoction	Cough	Orally	Shrub	LC	Unknown	[40]
110.	*Senna didymobotrya* (Fresen.) Irwin & Barneby	Leaves	Decoction	Tonsils	Orally	Shrub	LC	Stable	[25]
111.	*Senna singueana* (Delile) Lock	Leaves/roots	Decoction	Pneumonia	Orally	Tree	LC	Stable	[36]
112.	*Guilandina volkensii* (Harms) G.P. Lewis	Roots	Sap	Common cold	Orally	Liana	NR	NR	[25]
113.	*Vachellia robusta* (Burch.) Kyal. & Boatwr.	Barks	Concoction	Bronchial obstruction	Orally	Tree	LC	Stable	[26]
114.	*Albizia zygia* (DC.) J.J.Macbr.	Barks	Decoction	Pneumonia	Orally	Tree	LC	Decreasing	[26]
115.	*Craibia brownii* Dunn	Roots	Unspecified	Cough	Chewing	Tree	NR	NR	[42]
116.	*Albizia gummifera* (J.F. Gmel.) C.A. Sm.	Barks/stems	Decoction	Cough	Orally	Tree	LC	Unknown	[40]
117.	*Rhynchosia elegans* var. *elegans*	Tubers	Concoction	Cough	Orally	Herb	NR	NR	[26]
118.	*Tamarindus indica* L.	Fruits/barks	Decoction	Cough and tonsils	Orally	Tree	LC	Unknown	[[26,48]
119.	*Tylosema fassoglense* (Kotschy ex Schweinf.) Torre & Hillc.	Roots	Decoction	Flu, pneumonia, and asthma	Orally	Climber	NR	NR	[26]
120.	*Mucuna gigantea* (Willd) D.C	Leaves	Burning to ashes	Cough.	Unspecified	Herb	NR	NR	[41]
121.	*Abrus precatorius* L.	Whole plant	Burning to ashes	Cough.	Orally	Climber	NR	NR	[40]
122.	*Senegalia ataxacantha* (DC.) Kyal. & Boatwr.	Roots	Unspecified	Cough.	Chewing	Shrub	LC	Unknown	[42]
123.	*Albizia anthelmitica* Brongn.	Stems	Unspecified	Asthma and tuberculosis	Unspecified	Tree	NR	NR	[46]
124.	*Vachellia abyssinica* (Hochst. ex Benth.) Kyal. & Boatwr.	Barks	Decoction	Common cold and flu	Inhalation	Tree	NR	NR	[37]
125.	*Cajanus cajan* (L.) Huth.	Leaves	Decoction	Flu	Orally	Shrub	NT	Unknown	[40]
126.	*Indigofera lupatana* Baker f.	Roots	Unspecified	Cough	Chewing	Shrub	NR	NR	[42]
127.	*Indigofera arrecta* Hochst. ex A.Rich.	Leaves/barks	Decoction	Asthma	Orally	Shrub	NR	NR	[40]
128.	*Indigofera spicata* Forssk.	Roots	Infusion/sap	Cough	Unspecified	Shrub	NR	NR	[36]
129.	*Albizia coriaria* Welw. Ex Oliv.	Roots	Decoction	Tonsils	Orally	Tree	LC	Unknown	[11]
130.	*Vachellia hockii* (De Wild.) Seigler & Ebinger	Barks	Decoction	Common cold and flu	Inhalation	Shrub/ tree	NR	NR	[37]
131.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	Barks/roots	Decoction/burning to ashes	Cough, pneumonia, common cold, and sore throat	Orally/inhalation/ chewing	Tree	LC	Unknown	[48]
132.	*Vachellia horrida* (L.) Kyal. & Boatwr.	Barks	Unspecified	Tuberculosis	Unspecified	Shrub/ tree	NR	NR	[46]
133.	*Albizia amara* (Roxb.) Boivin	Stems/barks	Unspecified	Cough	Unspecified	Tree	LC	Stable	[43]
134.	*Senegalia brevispica* (Harms) Seigler & Ebinger	Leaves	Infusion	Cough	Orally	Tree	NR	NR	[38]
135.	*Senegalia senegal* (L.) Britton	Barks	Unspecified	Tuberculosis	Unspecified	Tree	NR	NR	[46]
136.	*Vachellia lahai* (Steud. & Hochst. ex Benth.) Kyal. & Boatwr.	Barks	Decoction	Pneumonia and cough	Orally	Tree	NR	NR	[11]

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
137.	*Erythrina abyssinica* Lam.	Barks/roots	Decoction	Pneumonia, cough, and chest problems	Orally	Tree	LC	Stable	[25,11]
138.	*Pterolobium stellatum* (Forssk.) Brenan	Roots	Decoction	Common cold	Orally	Liana	NR	NR	[25]
139.	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Barks	Pounding	Cough	Orally	Tree	NR	NR	[25]
140.	*Dalbergia lactea* Vatke	Leaves	Sap	Asthma	Topically	Shrub/ tree	LC	Unknown	[25]
141.	*Cassia abbreviata* Oliv.	Stems/barks	Decoction/infusion	Common cold and cough	Orally	Tree	LC	Stable	[48]
142.	*Mimosa pudica* L.	Roots	Decoction	Asthma	Orally	Herb	LC	Stable	[35]
143.	*Dichrostachys cinerea* (L.) Wight & Arn.	Barks	Unspecified	Cough	Chewing	Shrub	LC	Stable	[48]
		Roots	Infusion	Chest pains	Orally				[36]
	Hypericaceae								
144.	*Harungana madagascariensis* Lam. Ex Poi	Leaves	Concoction	Cough	Orally	Tree	LC	Stable	[26]
	Iridaceae								
145.	*Gladiolus dalenii* Van Geel	Corm	Powdered	Asthma and respiratory allergies	Inhalation	Corm	NR	NR	[26]
	Juncaceae								
146.	*Juncus effusus* L.	Roots	Decoction	Pneumonia	Orally	Shrub	NR	NR	[11]
	Lamiaceae								
147.	*Ajuga integrifolia* Buch-Ham. ex D. Don	Leaves/roots	Decoction	Cough and common cold	Orally	Herb	NR	NR	[35,25]
148.	*Leucas grandis* Vatke	Leaves	Unspecified	Common colds and cough	Unspecified	Herb/ shrub	NR	NR	[51]
149.	*Ocimum gratissimum* L.	Leaves	Decoction	Blocked nose and common cold	Unspecified	Shrub	NR	NR	[38]
150.	*Ocimum basilicum* L.	Leaves	Decoction	Common cold	Orally	Herb	NR	NR	[25]
151.	*Vitex doniana* Sweet	Leaves/ stems/barks	Decoction	Common cold and respiratory allergies	Orally	Tree	LC	Unknown	[26]
152.	*Coleus barbatus* (Andrews) Benth. ex G.Don	Leaves/roots	Decoction	Pneumonia, asthma, and chest problems	Orally	Herb/ shrub	NR	NR	[26,40]
153.	*Hoslundia opposita* Vahl	Leaves	Decoction	Common cold and flu	Inhalation	Shrub	NR	NR	[37]
154.	*Rotheca myricoides* (Hochst.) Steane & Mabb.	Roots/leaves	Decoction	Tonsils and common cold	Orally/inhalation	Shrub	LC	Stable	[37,10]
155.	*Clerodendrum myricoides* R.Br.	Roots	Decoction/sap	Pneumonia, chest pains, and cough	Orally	Shrub	NR	NR	[37,46,36]
156.	*Micromeria biflora* (Buch.-Ham. ex D. Don) Benth.	Roots/whole plant	Decoction	Pneumonia	Orally	Herb	NR	NR	[34]
157.	*Leucas calostachys* Oliv.	Leaves	Pounding	Common cold	Unspecified	Herb	NR	NR	[41]
	Lauraceae								
158.	*Kuloa usambarensis* (Engl.) Trofimov & Rohwer	Barks	Decoction	Chest problems and coughs	Orally	Tree	NR	NR	[25]
	Liliaceae								
159.	*Crinum macowanii* Baker	Tubers	Decoction	Asthma	Topically	Herb	NR	NR	[25]
	Loganiaceae								
160.	*Strychnos spinosa* Lam.	Roots	Infusion	Common cold, flu	Orally	Tree	NR	NR	[38]
161.	*Strychnos henningsii* Gilg	Leaves/barks	Decoction/infusion	Pneumonia, asthma, and tuberculosis	Orally	Tree	LC	Stable	[48,36]
162.	*Strychnos madagascariensis* Poir.	Roots	Decoction	Asthma and tuberculosis	Unspecified	Tree	NR	NR	[36]

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Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
	Loranthaceae								
163.	*Plicosepalus acaciae* (Zucc.) Wiens & Polhill	Whole plant	Unspecified	Chest problems	Unspecified	Tree	NR	NR	[46]
164.	*Englerina woodfordioides* (Schweinf.) Balle ex M.G.Gilbert	Whole plant	Decoction	Common cold	Orally	Shrub	NR	NR	[25]
	Malvaceae								
165.	*Hibiscus fuscus* Garcke	Leaves/roots	Unspecified	Chest problems	Unspecified	Herb	NR	NR	[42,40]
166.	*Grewia bicolor* Juss.	Roots	Decoction	Chest complaints and common cold	Orally	Shrub/ tree	NR	NR	
167.	*Sida schimperiana* Hochst. ex A.Rich.	Roots	Unspecified	Sore throat	Chewing	Herb	NR	NR	[41]
	Meliaceae								
168.	*Azadirachta indica* A.Juss.	Leaves	Decoction	Common cold, cough, and tonsils	Orally	Tree	LC	Stable	[26,25]
169.	*Khaya senegalensis* Desr. A. Juss	Barks	Decoction	Common cold and cough.	Orally	Tree	VU	Unspecified	[26]
170.	*Ekebergia capensis* Sparrm.	Barks/leaves	Decoction	Pneumonia, coughs, and common cold	Orally	Tree	LC	Stable	[35]
	Melianthaceae								
171.	*Bersama abyssinica* Fressen	Leaves/seeds	Decoction	Pneumonia and tuberculosis	Orally/chewing	Tree	LC	Stable	[41]
	Molluginaceae								
172.	*Paramollugo nudicaulis* (Lam.) Thulin	Leaves	Decoction	Cough	Orally/chewing	Herb	NR	NR	[26]
	Myricaceae								
173.	*Myrica salicifolia* Hochst. ex A.Rich.	Barks	Unspecified	Tonsillitis and throat infections	Unspecified	Tree	NR	NR	[43]
	Myrtaceae								
174.	*Eucalyptus camaldulensis* Dehnh.	Leaves	Decoction	Common cold	Orally	Tree	NR	NR	[26]
175.	*Eucalyptus globulus* Labill.	Barks/leaves	Decoction/infusion	Asthma, pneumonia, common cold, and flu	Orally/inhalation	Tree	LC	Stable	[35,37]
176.	*Eucalyptus saligna* Sm.	Leaves	Decoction	Common cold and flu	Inhalation	Tree	LC	Stable	[37]
177.	*Psidium guajava* L.	Leaves	Decoction	Common cold and asthma	Orally	Tree	LC	Unknown	[25]
	Oleaceae								
178.	*Olea europaea* L.	Stems/barks	Unspecified	Common cold, flu, and pneumonia	Unspecified	Tree	NR	NR	[43,38]
179.	*Olea capensis* subsp. *macrocarpa* (C. H.Wright) I.Verd.	Barks/stems	Decoction	Common cold	Orally	Tree	NR	NR	[35]
180.	*Olea capensis* L.	Barks	Decoction/soaking	Coughs, breathing problems, and tuberculosis	Orally	Tree	LC	Stable	[41]
	Opiliaceae								
181.	*Opilia amentacea* Roxb.	Roots	Burning	Sore throat	Orally	Climber	NR	NR	[36]
	Passifloraceae								
182.	*Adenia gummifera* (Harv.) Harms	Roots	Decoction	Tuberculosis	Orally	Liana	NR	NR	[11]
	Penaeaceae								
183.	*Olinia rochetiana* A.Juss.	Barks/leaves	Decoction	Bronchitis, common cold, cough, and pneumonia	Orally/chewing	Tree	NR	NR	[34,10]
	Piperaceae								
184.	*Piper umbellatum* L.	Roots	Unspecified	Bronchitis and pneumonia	Chewing	Shrub			[34]
185.	*Piper capense* L.	Leaves	Decoction	Common cold	Orally	Shrub	LC	Stable	[25]
	Phyllanthaceae								
186.	*Flueggea virosa* (Roxb. ex Willd.) Royle	Leaves/roots	Decoction/crushing	Chest problems	Orally	Shrub	LC	Stable	[40]
	Plantaginaceae								

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
187.	*Plantago palmata* Hook.fil	Roots	Decoction	Pneumonia and tonsils	Orally	Shrub/ herb	NR	NR	[33,10]
	Plumbaginaceae								
188.	*Plumbago dawei* Rolfe.	Barks	Unspecified	Tuberculosis	Unspecified	Shrub	NR	NR	[45]
	Poaceae								
189.	*Cymbopogon citratus* (DC.) Stapf	Leaves	Decoction	Common cold and flu	Orally/inhalation	Herb	NR	NR	[40]
190.	*Sporobolus pyramidalis* P.Beauv.	Roots	Decoction	Cough	Orally	Herb	NR	NR	[25]
	Polygonaceae								
191.	*Oxygonum sinuatum* (Hochst. & Steud. ex Meisn.) Damm.	Stems	Decoction	Tonsillitis	Orally	Herb	NR	NR	[44]
	Primulaceae								
192.	*Embelia schimperi* Vatke	Stems	Decoction	Tuberculosis, pneumonia, and common cold	Orally	Tree	LC	Stable	[34]
	Ranunculaceae								
193.	*Clematis hirsuta* Guill. & Perr	Leaves	Decoction	Common cold	Orally	Climber	NR	NR	[26]
194.	*Clematis brachiata* Thunb.	Leaves	Decoction	Common cold	Inhalation	Shrub	NR	NR	[25]
	Rosaceae								
195.	*Rubus apetalus* Poir	Fruits/leaves	Decoction	Tonsils	Orally	Shrub	NR	NR	[25]
	Rubiaceae								
196.	*Meyna tetraphylla* (Schweinf. Ex Hiern) Robyns	Fruits	Unspecified	Chest congestion	Chewing	Shrub	LC	Unknown	[47]
197.	*Gardenia ternifolia* Schumach. & Thonn.	Roots	Decoction	Cough and pneumonia	Orally	Shrub	LC	Stable	[26]
198.	*Syzygium cumini* (L.) Skeels	Barks	Concoction	Cough	Orally	Shrub	LC	Stable	[26]
199.	*Keetia gueinzii* (Sond.) Bridson	Root barks	Powdered	Asthma, pneumonia, and cough	Inhalation	Shrub	LC	Stable	[26]
200.	*Coptosperma graveolens* (S.Moore) Degreef	Roots	Decoction	Tonsillitis	Orally	Shrub	NR	NR	[11]
201.	*Rubia cordifolia* L.	Whole plant	Burning to ashes	Pneumonia and tonsils	Orally	Liana	NR	NR	[11]
		Leaves/ stems/roots	Burning to ashes	Cough	Orally				[40]
202.	*Coffea arabica* L.	Roots	Decoction	Cough	Orally	Shrub	EN	Decreasing	[25]
	Rhamnaceae								
203.	*Rhamnus staddo* A.Rich.	Stems/barks/ leaves/roots	Unspecified	Common cold and flu	Unspecified	Shrub	LC	Stable	[43]
204.	*Rhamnus prinoides* L'Herit	Roots/leaves/ stems	Decoction	Chest problems, common cold, and tonsils	Orally	Shrub	LC	Stable	[25]
	Rutaceae								
205.	*Zanthoxylum gilletii* (De Wild.) Waterman	Barks	Decoction	Tuberculosis and common cold	Orally	Tree	LC	Decreasing	[26,11]
206.	*Harrisonia abyssinica* Oliv.	Roots	Decoction	Cough, pneumonia, and asthma	Orally	Shrub	LC	Stable	[42,26]
207.	*Zanthoxylum asiaticum* (L.) Appelhans, Groppo & J.Wen	Leaves/roots	Decoction	Common cold and cough	Orally/inhalation	Shrub	NR	NR	[25]
		Whole plant	Unspecified	Bronchial pain and common cold	Unspecified				[38]
208.	*Clausena anisata* (Willd.) Hook.fil., De Wild. & Staner	Roots	Decoction	Cough	Orally	Shrub/ tree	LC	Stable	[44]
209.	*Vepris simplicifolia* (Engl.) Mziray	Root/whole plant	Unspecified	Pneumonia	Unspecified	Tree	LC	Stable	[38]
210.	*Vepris nobilis* (Delile) Mziray	Roots/leaves	Decoction	Asthma and common cold	Orally	Tree	NR	NR	[26]
211.	*Vepris lanceolata* (Lam.) G. Don	Roots	Decoction/infusion	Chest pains and tuberculosis	Unspecified	Shrub	NR	NR	[36]

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
212.	*Zanthoxylum chalybaeum* Engl.	Barks	Decoction/infusion	Pneumonia and cough	Orally	Tree	LC	Stable	[48]
		Fruits	Infusion	Cough	Orally	-	-	-	[48]
213.	*Zanthoxylum usambarense* (Engl.) Kokwaro	Barks/stems	Decoction	Common cold, cough, and asthma	Orally/chewing	Tree	NR	NR	[52]
		Leaves	Decoction	Common cold	Orally	-	-	-	[25]
214.	*Fagaropsis hildebrandtii* (Engl.) Milne-Redh.	Roots	Decoction	Tuberculosis, asthma, cough, and pneumonia	Orally	Tree	NR	NR	[36]
215.	*Citrus limon* (L.) Burm.fil.	Fruits	Infusion	Cough and common cold	Orally	Tree	NR	NR	[53,39]
216.	*Citrus aurantiifolia* (Christm.) Swingle	Fruits	Decoction	Common cold and asthma	Orally	Shrub/ tree	NR	NR	[25]
	Salicaceae								
217.	*Dovyalis abyssinica* (A.Rich.) Warb.	Roots	Concoction	Chest problems	Orally	Shrub	LC	Stable	[34]
	Salvadoraceae								
218.	*Salvadora persica* L.	Roots/barks	Decoction	Chest pain, common cold, flu, blocked nose, and cough	Orally	Tree	LC	Stable	[42,38]
	Santalaceae								
219.	*Osyris lanceolata* Hochst. & Steud.	Leaves	Decoction	Throat problems	Orally	Shrub/ tree	LC	Unknown	[25]
	Sapindaceae								
220.	*Zanha africana* (Radlk.) Exell	Roots	Decoction	Pneumonia, tuberculosis, and asthma	Orally	Tree	NR	NR	[37,36]
	Solanaceae								
221.	*Solanum incanum* L.	Fruits	Decoction	Common cold and flu	Inhalation	Shrub	LC	Stable	[43]
222.	*Solanum americanum* Mill.	Leaves	Infusion	Tonsils	Orally/chewing	Herb	NR	NR	[42]
223.	*Physalis peruviana* L.	Fruits/leaves	Decoction	Chest problems and asthma	Orally	Shrub	NR	NR	[25,40]
224.	*Solanum mauense* Bitter	Seeds	Decoction	Chest pain and tuberculosis	Orally	Shrub	LC	Stable	[34]
225.	*Solanum aculeastrum* Dunal	Roots	Decoction	Tonsils	Orally	Shrub	LC	Stable	[25]
226.	*Nicotiana tabacum* L.	Leaves	Powder	Common cold	Inhalation	Herb	NR	NR	[36]
227.	*Withania somnifera* (L.) Dunal	Roots/leaves	Decoction	Asthma and common cold	Orally	Shrub	NR	NR	[24,40]
	Sterculiaceae								
228.	*Dombeya burgessiae* Gerrard ex Harv. & Sond.	Barks	Pounding	Cough	Chewing	Shrub/ tree	NR	NR	[25]
	Stilbaceae								
229.	*Nuxia congesta* R.Br.	Roots/barks	Decoction	Flu and chest complications	Chewing	Tree	LC	Stable	[49,51]
	Ulmaceae								
230.	*Trema orientalis* (L.) Blume.	Roots	Decoction	Asthma	Orally	Tree	LC	Unknown	[35]
	Urticaceae								
231.	*Urtica massaica* Mildbr	Whole plant/ leaves	Decoction	Cough and common cold	Orally	Herb	NR	NR	[53,10,25]
	Ximeniaceae								
232.	*Ximenia americana* L.	Roots/barks	Concoction	Cough	Orally	Shrub/ tree	LC	Stable	[26,36]
	Verbenaceae								
233.	*Lippia javanica* (Burm.f.) Spreng	Whole plant/ leaves/seeds	Unspecified	Blocked nose bronchitis, common cold, coughs, and flu	Unspecified	Shrub	NR	NR	[38]
234.	*Lantana camara* L.	Leaves	Crushing/ decoction/infusion	Breathing problems, cough, sore throat, and common cold	Orally/topically/ inhalation	Shrub	NR	NR	[44,25,40]
235.	*Lantana trifolia* L.	Leaves/roots	Decoction	Chest problems	Orally	Shrub	NR	NR	[40]

(*continued on next page*)

Table 1 (*continued*)

	Family/Species	Parts used	Preparation method	Traditional use	Administration method	Habit	Conservation status	Population trend	References
236.	*Cissus rotundifolia* (Forssk.) Vahl	Leaves	Decoction	Throat infection, pneumonia, and coughs	Orally	Climber	NR	NR	[26]
	Vitaceae								
237.	*Cyphostemma ukerewense* (Gilg) Desc.	Leaves	Crushing	Tonsils	Orally	Climber	NR	NR	[40]
238.	*Cissus aphyllantha* Gilg ex Gilg & Brandt	Roots	Infusion	Pneumonia	Orally	Liana	NR	NR	[48]

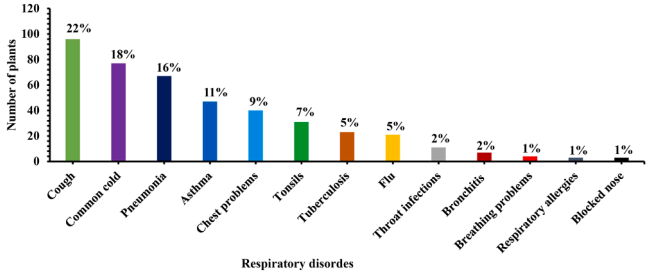

Fig. 4. Common respiratory disease treated by medicinal plants in Kenya.

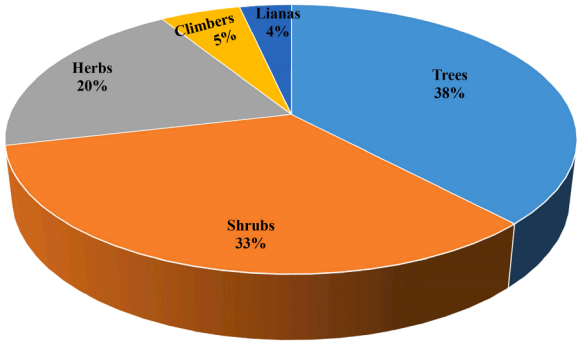

Fig. 5. Growth forms of medicinal plants used to treat respiratory diseases.

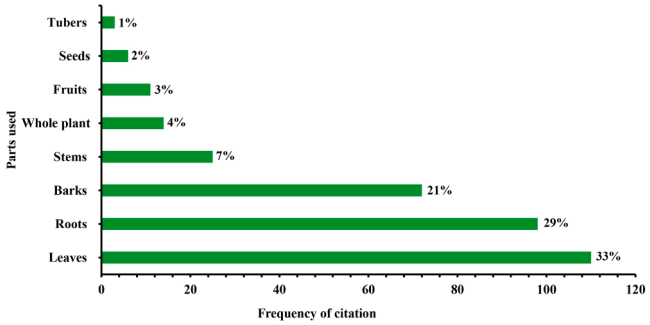

Fig. 6. Plant parts used to manage diseases of the respiratory system in Kenya.

utilized plant part in managing respiratory disorders in Ethiopia. Similar results were obtained in the ethnobotanical surveys of medicinal plants used against respiratory illnesses in Pakistan [2], Peru [57], Nigeria [58], South Africa [59], Mauritius [60], and Morocco [61]. Nevertheless, the outcome of this study differs from other findings that reported seeds [62], stems [43], and roots [16]

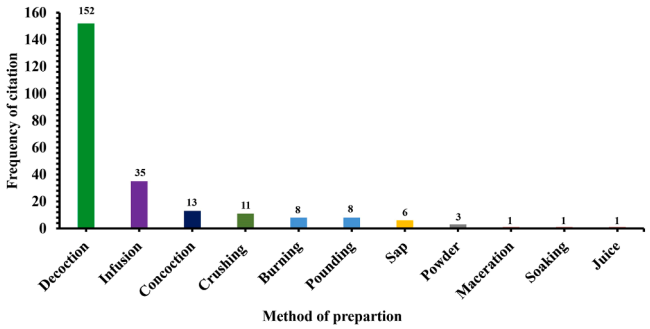

Fig. 7. Methods of preparing herbal recipes used to manage respiratory disorders.

as the most commonly utilized plant parts against respiratory disorders. The leaves are highly preferred since they are perceived as a readily renewable source and their harvesting methods are less destructive compared to roots, hence promoting the conservation of medicinally significant plants [41]. This is contrary to several studies on traditional medicines in Kenya that indicated that roots were the commonly used part in some areas to treat different illnesses [35,26,38]. The preference for roots may be due to their higher concentration of bioactive compounds compared to other plant parts [38]. Phumthum et al. [63] reported that roots can retain bioactive substances for a long time even after they have been harvested, an argument that could have triggered high exploration of these resources by some communities. The inclination towards using plant roots as a primary source of medicines, as opposed to other plant parts, may be unsustainable, and it might threaten their availability in the future.

Methods of preparation and administration of plants used to remedy respiratory infections

Plant materials used in the preparation of herbal medicines were mostly in form of decoction (64%) and infusion (15%) (Fig. 7). Other recipes used to prepare herbal medicines include concoction (6%), crushing (5%), burning (3%), pounding (3%), sap (3%), powder (1%), and others (Fig. 7). Overwhelming studies reported the popularity of decoction ethnomedicinal recipe [64,58,60,65]. However, the findings of this research differ from the results obtained by Haile et al. [1], which indicated that pounding and crushing were the main methods of herbal preparation used to cure respiratory ailments in Ethiopia. Decoction is among the popular methods of preparing ethnomedicinal recipes because of the simplicity involved in the process, which entails heating or boiling of plant materials [58]. Table 2 indicates that medicinal plant resources were utilized to prepare herbal recipes for managing respiratory disorders using multiple methods, while others were only prepared using a single method (Table 2).

The largest proportion of traditional herbal therapies used to treat respiratory ailments are administered orally (65%), followed by chewing (9%) and inhalation (6%) (Table 3). Although a variety of methods are employed in the uptake of herbal medicines to remedy infections related to respiratory disorders, oral administration was reported as a prevalent method in Nigeria [58] and Ethiopia [54], among other regions [66,24,67,60], congruent with the findings of this study. The widespread use of oral administration may be attributed to the predominance of treatments targeting internal respiratory disorders [54].

Pharmacological evaluations

We explored the biological activities of the listed medicinal plants based on existing literature. Of the 238 documented plant species, pharmacological assessments have been reported in 177 species. Among the exhibited biological activities, antimicrobial, anti-inflammatory and analgesic, anti-allergic and anti-asthmatic, antitussive, anti-obesity/antidiabetic, immunomodulatory, antipyretic, and antioxidant properties (Table 4) confirm their traditional medicinal uses to remedy respiratory disorders such as influenza, pneumonia, tuberculosis, sore throat, tonsils, common cold, and asthma (Table 1). These properties are essential in the treatment of ailments related to respiratory conditions [2]. However, more pharmacological investigations are required to confirm the folkloric claims of unexplored plants.

Antimicrobial activity

Respiratory illnesses might be caused by bacteria, fungi, or viruses and are commonly delivered into the respiratory tract through inhalation (Fig. 8). For instance, the causative agent for bronchitis may be respiratory syncytial virus (RSV) and parainfluenza virus

Table 2
Detailed proportions of preparation methods used to remedy respiratory disorders.

Mode of preparation	Frequency of citation	Proportion (%)
Decoction	131	53%
Infusion	20	8%
Decoction/infusion	12	5%
Concoction	10	4%
Burning to ashes	7	3%
Crushing	7	3%
Pounding	6	2%
Sap	4	2%
Powder	3	1%
Decoction/crushing	3	1%
Crushing/decoction/infusion	1	
Concoction/decoction/pounding	1	
Maceration/concoction	1	
Decoction/burning	1	
Decoction/pounding	1	4%
Decoction/soaking	1	
Decoction/sap	1	
Infusion/sap	1	
Concoction/infusion	1	
Juice	1	
Unspecified	35	14%

Table 3
Routes of traditional herbal administration and relative frequency of citation.

Routes of administration	Frequency of citation	%
Orally	161	65
Chewing	22	9
Inhalation	14	6
Orally/chewing	11	4
Topically	4	2
Orally/inhalation	4	1
Orally/topically	1	1
Orally/topically/inhalation	1	
Orally/inhalation/chewing	1	0
Poultice	1	0
Unspecified	30	12
Total	**250**	**100**

[68]. Besides, common cold is normally triggered by viral infections (i.e., rhinovirus, influenza viruses, adenoviruses, human parainfluenza viruses, and human coronaviruses, among others) affecting the upper respiratory tract. An inflammatory condition of the lungs, commonly referred to as pneumonia, affects the air sacs and is usually caused by *S. pneumoniae* and viruses. In addition, tuberculosis is normally caused by several strains of mycobacteria, primarily *M. tuberculosis* [68]. Plants can efficiently manage the above ailments and other respiratory disorders with bioactive constituents possessing strong antifungal, antibacterial, antiviral, immunomodulatory, antitussive, and antioxidant properties.

Several studies have shown the efficacy of medicinal plants in treating microbial-related respiratory illnesses [69,70]. The traditionally used *E. camaldulensis* to remedy influenza, sore throat, common cold, and coughs was found to possess active leaf (0.2 – 200 mg/ml) and bark (0.5 mg/ml) extracts against *C. albicans* [71], which may indirectly contribute to respiratory diseases [72]. The antibacterial activity of the methanol leaf extracts of *E. camaldulensis* at the concentration of 10 mg/ml displayed remarkable activity against *Yersinia enterocolitica, Klebsiella spp, S. typhi, P. aeruginosa, S. aureus*, and *B. subtilis* with the minimum inhibitory concentration (MIC) values ranging from 0.04 to 10 mg/ml [73].

The aqueous and methanol root extracts of *T. orientalis*, a widely utilized plant to remedy asthma, coughs, bronchitis, pneumonia, and sore throats [68], showed significant antibacterial activity. Tao et al. [74] reported that the aqueous extracts prepared from *A. Annua* at a concentration of 0.976 mg/ml displayed significant inhibitory effects against *S. aureus, E. coli, C. albicans,* and cytopathy caused by influenza A virus. *Withania somnifera* was also revealed to modulate toll-like receptors (TLRs) through inhibition of influenza A virus-induced stimulation of TLR2/4 and mRNA expression of TLR2 and TLR4 [75]. Besides, the agar diffusion technique showed that crude ethanolic extracts derived from *E. hirta* at the concentration of 50 – 250 mg/ml inhibited the growth of *E. coli, S. aureus, P. aeruginosa,* and *B. subtillis* (MIC. 58.09, 22.55, 57.64, and 74.61 mg/ml, respectively) [76], justifying the traditional use in the treatment of flu. The aqueous extract prepared from *I. cairica* displayed *in vitro* anti-RSV (Respiratory Syncytial Virus), and thus confirms its use in treating cold-like symptoms [77].

Nimbeshaho et al. [78] showed that the dichloromethane extracts obtained from the leaves and barks of *C. edulis* were active against *M. smegmatis* with the MIC value of 50 mg/ml, justifying its ethnomedicinal use in the treatment of tuberculosis. Hexane extract at the concentration of 20 mg/ml exhibited a significant antibacterial effect against *Salmonella enterica, Brevibacterium flavum, Staphylococcus xylosus, K. pneumoniae, E. cloacae, S. epidermidis, E. coli*, and *S. aureus* (MIC. 15.62 – 125 μg/ml) [79]. Further, dichloromethane and ethyl acetate root extracts obtained from *A. pubescens* exhibited antimicrobial activity against *B. anthracis, S. faecalis, S. agalactiae, P. aeruginosa, S. aureus, B. subtilis, S. typhi,* and *C. albicans* (MIC 1.6 – 6.25 mg/ml), and support its therapeutic use as a remedy to pneumonia [80].

Ojerinde et al. [81] examined the antibacterial potential of various extracts, including dichloromethane, aqueous, and hexane extracts prepared from the stems of *S. araliacea* at 10 and 20 mg/ml concentrations. The results showed that hexane (17.0, 19.0, and 22.0 mm) and dichloromethane (20.0, 10.0, and 25.0 mm) extracts exhibited strong inhibitory effect against *S. aureus, E. coli,* and *S. typhi* respectively at 20 mg/ml, comparable to the positive control gentamicin (28.0, 30.0, and 30.0 mm) [81]. The antimicrobial activity of selected medicinal plants, including *C. holstii* was investigated using agar well and disc diffusion methods against several microorganisms [82]. The crude extracts at the concentration of 100 – 400 mg/ml displayed inhibition against methicillin-resistant *Staphylococcus aureus* (MRSA) (MIC – 15.625 mg/ml) and *C. albicans* (MIC – 62.5 mg/ml). A study by Swetha et al. [83] showed that the leaf extract obtained from *T. zeylanicum* at 100 g/ml concentration was effective against *B. subtilis* with an inhibition zone of about 15mm. The embelin (**1**) metabolite obtained from *E. schimperi* seed and leaf ethanol extracts at 25 – 300 μg/ml concentration showed combinatory antibacterial effects together with oxacillin and tetracycline against *S. aureus* [84]. Quercetagetin-7-arabinosyl-galactoside (**2**) isolated from the methanol leaf extract of *T. minuta* at 4 –500 μg/ml displayed significant antimicrobial effects against *B. subtilis, S. aureus, S. epidermidis, P. aeruginosa*, and *E. coli* [85]. These findings support the traditional use of diverse medicinal plants to remedy respiratory-related conditions such as tuberculosis, sore throat, flu, and pneumonia. However, clinical studies are required to ascertain the efficacy of these plants in managing microbial-related respiratory illnesses.

Antioxidant activity

Recently, there has been an upsurge in chronic communicable and non-communicable illnesses, a considerable number of which

Table 4
Pharmacological and toxicological evaluation of medicinal plants used to manage respiratory illnesses.

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
	Acanthaceae						
1.	*Acanthus polystachyus* Delile	Methanol and essential oil	50 - 400 mg/ml	*Acenetobacter baumannii, Pseudomonas aeruginosa,* and *Staphylococcus aureus*	Antimicrobial effect	Safe LD50 > 4000 mg/kg bw in mice	[132,26,133]
2.	*Asystasia schimperi* T.Anderson	–	–	–	No records found	No records found	–
3.	*Lepidagathis scariosa* Nees.	–	–	–	No records found	No records found	–
4.	*Acanthus pubescens* (Oliv.) Engl.	Dichloromethane and ethyl acetate	1.6 - 6.25 mg/ml	*Bacillus subtilis, Bacillus anthracis, Salmonella typhi, Streptococcus faecalis, Streptococcus agalactiae, Candida albicans, P. aeruginosa,* and *S. aureus*	Antimicrobial activity	Safe LC_{50} > 1000 µg/ml in brine shrimp	[80]
5.	*Hypoestes aristata* (Vahl) Sol. ex Roem. & Schult.	Ethyl acetate	10 mg/ml	HIV-1 protease enzyme	Antiviral activity	No records found	[134]
6.	*Justicia flava* (Forssk.) Vahl	Aqueous	62.5 - 500 mg/kg	Rats	Anti-inflammatory action	No records found	[135,136]
		Methanol	125 mg/ml	*Escherichia coli, P. aeruginosa, B. subtilis, S. aureus,* and *C. albicans*	Antimicrobial effect		[135]
7.	*Thunbergia alata* Sims	Methanol	50 – 300 µg/ml	RAW 264.7 macrophages	Anti-inflammatory activity	No records found	[137,138]
8.	*Justicia betonica* L.	Ethanol and alcoholic	150 & 300 mg/kg	Rats	Anti-inflammatory and analgesic activities	No records found	[139]
		Petroleum ether, benzene, chloroform, ethyl acetate, methanol, aqueous and chloramphenicol	10 mg/ml	*Aeromonas hydrophila, Vibrio cholera, Vibrio parahemolyticus, E. coli, Salmonella typhi,* and *S. aureus*	Antimicrobial action		[139]
	Amaranthaceae						
9.	*Achyranthes aspera* L.	Methanol	40 mg/ml	*B. subtilis, E. coli*, and *P. aeruginosa*	Antimicrobial effect	Safe LD_{50} > 4000 mg/kg bw in mice	[140,141]
		Petroleum ether	200 mg/kg	Mice	Anti-allergic activity		[140]
		Alcohol	375 & 500 mg/kg	Rats	Anti-inflammatory action		[140]
		Methanol	–	Mice	Antipyretic effect		[140]
		Ethanol, petroleum ether, and chloroform	100 & 200mg/kg	Fish	Immunomodulatory activity		[140]
		Methanol	–	Rats	Bronchoprotective activity		[140]
		Alcoholic	100 mg/kg	Rabbit	Antidiabetic action		[140]
	Amaryllidaceae						
10.	*Allium sativum* L.	Ethanol, acetone, and aqueous	10 - 20 mg/ml	*E. coli* and *S. typhi*	Antimicrobial activity	Safe LD_{50} > 2000 mg/kg bw in mice	(El-Saber [142–144])
		Hydroalcoholic and aqueous	1 – 100 µg/ml	Ulcerative colitis	Anti-inflammatory activity		[145]
		Hydroalcoholic and aqueous	1 – 100 µg/ml	Mice	Antioxidant activity		[145]
11.	*Allium ampeloprasum* L.	Ethanol	–	Mice	Antioxidant effect	Weak/mildly toxic LD_{50} 1,202 + 55 mg/kg bw in mice	[146,147]
	Anacardiaceae						

(*continued on next page*)

Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
12.	*Searsia natalensis* (Bernh. ex C.Krauss) F.A. Barkley	–	–	–	No records found	No records found	–
13.	*Lannea schweinfurthii* (Engl.) Engl.	Hexane, dichloromethane, ethyl acetate, and methanol	1000 µg/ml	*Salmonella typhimurium, Enterococcus faecalis, Enterococcus faecium, P. aeruginosa,* and *S. aureus*	Antimicrobial activity	No records found	[148]
14.	*Searsia pyroides* (Burch.) Moffett	–	–	–	No records found	No records found	–
15.	*Mangifera indica* L.	Aqueous	50 – 250 mg/kg	Rat	Anti-asthmatic and anti-allergic effects	Safe LD_{50} > 2000 mg/kg bw in rats	[2,16,111]
16.	*Pistacia aethiopica* Kokwaro	Ethanol	20 – 100 mg/ml	Rat	Antidiabetic effect	Toxic LD_{50} > 250 mg/kg bw in mice	[149]
17.	*Lannea triphylla* (Hochst.) Engl.	–	–	–	No records found	No records found	–
	Annonaceae						
18.	*Uvaria scheffleri* Diels	Ethanol and dichloromethane	31.25 – 1000 µg/ml	*Aspergillus fumigatus, Penicillium* species, *C. albicans*, and *S. aureus*	Antimicrobial property	Highly toxic IC_{50} - 65.46 µg/ml	[150]
	Apiaceae						
19.	*Coriandrum sativum* L.	Ethyl acetate and dichloromethane	30, 100 & 300 mg/kg	Mice	Anti-inflammatory activity	Safe or non-toxic LD_{50} - 3000 mg/kg bw in mice	[151–153]
		Aqueous	50, 100 & 200 mg/kg	Mice	Analgesic activity		[154]
		Ethyl acetate	125, 250 & 500 µL/L	*Stenotropomonas maltophilia, Penicillium expansum,* and *B. subtilis*	Antimicrobial activity		[155]
		Methanol	25 & 50 mg/kg		Antioxidant activity		[156]
20.	*Daucus incognitus* (C.Norman) Spalik, Reduron & Banasiak	–	–	–	No records found	No records found	–
21.	*Steganotaenia araliacea* Hochst.	Hexane, dichloromethane, and aqueous	0.06125 – 500 µg/ml	1,1-Diphenyl-2-picrylhydrazyl (DPPH)	Antioxidant activity	No records found	[81]
		Hexane, dichloromethane, and aqueous	10 & 20mg/ml	*S. aureus, S. typhi*, and *E. coli*	Antimicrobial effect		[81]
	Araceae						
22.	*Culcasia falcifolia* Engl.	Ethanol	200 & 400 mg/kg	DPPH	Antioxidant activity	No records found	[157,92]
	Araliaceae						
23.	*Cussonia holstii* Engl.	Dichloromethane	100, 200 & 400 mg/ml	*S. aureus, B. cereus, E. coli, P. aeruginosa,* and *C. albicans*	Antimicrobial effect	No records found	[82]
	Asteraceae						
24.	*Launaea cornuta* (Hochst. ex Oliv. & Hiern) C.Jeffrey	Aqueous	0.01, 0.1, 1,10, 100 & 1000µg/ml	Mice	Anti-inflammatory activity	Safe LD_{50} > 2000 mg/kg bw in mice	[158–160]
		Aqueous	0.01, 0.1, 1,10, 100 & 1000µg/ml	DPPH and Ferric reducing antioxidant power (FRAP)	Antioxidant effect		[158]
25.	*Solanecio mannii* (Hook.fil.) C. Jeffrey	Ethanol, methanol, and cyclohexane	1000 & 1600 µg/ml	*Shigella dysenteriae, Klebsiella pneumoniae, Candida krusei, C. albicans, S. faecalis S.*	Antimicrobial action	No records found	[161,162]

(*continued on next page*)

Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
				aureus, B. cereus, B. sabtilis, and *P. aeruginosa*			
26.	*Hoffmannanthus abbotianus* (O. Hoffm.) H.Rob., S. C.Keeley & Skvarla	–	–	–	No records found	No records found	–
27.	*Tagetes minuta* L.	Chloroform, ethyl acetate, and water.	500 mg/ml	*Staphylococcus epidermidis, B. subtilis, E. coli, P. aeruginosa,* and *S. aureus*	Antimicrobial action	Safe $LD_{50} > 3400$ mg/kg bw in mice	[85]
		–	–	–	Antitussive activity		[163]
		–	1 – 50 µg/ml	Lipopolysaccharide (LPS)-stimulated macrophages	Anti-inflammatory effect		[164]
		–	1 – 50 µg/ml	ROS, H_2O_2, and NO	Antioxidant activity		[164]
28.	*Lactuca inermis* Forssk.	–	–	–	No records found	No records found	-
29.	*Artemisia annua* L.	–	10 & 30 mg/kg	Mice	Anti-asthmatic and antiallergic effects	Safe LD_{50} - 2000 mg/kg bw in mice	[165,166]
		Methanol	10, 50, 100 & 200 µg/mL	Mice	Antidiabetic action		[167]
		Methanol	10, 50, 100 & 200 µg/ml	DPPH	Antioxidant effect		[167]
		Water, ethyl-acetate, and n-butyl alcohol	–	Mice	Antipyretic action		[168]
		Water, ethyl-acetate, and n-butyl alcohol	–	Mice	Anti-inflammatory effect		[168]
		Aqueous	7.81 – 500 mg/ml	*S. aureus, E. coli*, and *C. albicans*	Antimicrobial activity		[74]
30.	*Microglossa pyrifolia* (Lam.) Kuntze	Aqueous	0.976 – 3.9 mg/ml	*Shigella sonnei, E. coli, P. aeruginosa, S. aureus,* and *S. typhimurium*	Antimicrobial action	Safe $LD_{50} \geq 2367$ mg/kg bw in mice	[169]
31.	*Tithonia diversifolia* (Hemsl.) A. Gray	Aqueous	400 mg/kg	Rat	Anti-inflammatory and analgesic effects	Moderately toxic LD_{50} - 400 mg/kg bw in rat	[170,171]
		Aqueous	–	*Saccharomyces cerevisiae, P. aeruginosa, S. aureus,* and *E. coli.*	Antimicrobial effect		[170]
		Methanol	25, 250 & 500 mg/kg	Rat	Antidiabetic activity		[172]
		Aqueous	145.87 and 73.67 µg/ml	RAW264.7 cells	Immunomodulatory activity		[173]
		Methanol	40 mg/ml	DPPH	Antioxidant activity		[170]
32.	*Aspilia mossambicensis* (Oliv.) Wild	–	–	–	No records found	No records found	–
33.	*Chrysanthemum americanum* (L.) Vatke ex Weberl. & Lagos	–	–	–	No records found	No records found	–
34.	*Galinsoga parviflora* Cav.	Ethyl acetate	150 mg/ml	DPPH	Antioxidant action	No records found	[174]
		Ethanolic, ethyl acetate, and petroleum ether	150 mg/ml	*K. pneumoniae, E. coli, P. aeruginosa, S. typhimurium, A. niger*, and *C. albicans*	Antimicrobial effects		[174]
		Ethanol	400 mg/kg	Rat	Antidiabetic property		[174]
		Hydroalcoholic	0.5 – 1.0 mg/ml	Endothelial cell	Anti-inflammatory effect		[175]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
35.	*Vernonia brachycalyx* C. Hoffm.	Hexane, dichloromethane, ethyl acetate, and methanol	8 – 256 µg/ml	*E. faecium* and *P. aeruginosa*	Antimicrobial effect	No records found	[176]
36.	*Emilia discifolia* (Oliv.) C.Jeffrey	Methanol and aqueous	200 – 600 mg/kg	–	Antimicrobial activity	No records found	[177]
37.	*Acmella caulirhiza* Delile	Aqueous, methanol, and ethanol	8 – 32 mg/ml	DPPH	Antioxidant activity	No records found	[178]
		Aqueous, methanol, and ethanol	8 – 32 mg/ml	*P. aeruginosa, S. aureus,* and *K. pneumonia*	Antibacterial activity		[178]
		Aqueous	100, 200 & 400 mg/kg	Rat	Antipyretic effect		[178]
38.	*Baccharoides lasiopus* (O.Hoffm.) H.Rob.	–	–	–	No records found	No records found	[179]
39.	*Sonchus asper* (L.) Hill	Hexane, ethyl acetate, and chloroform, and methanol	1 – 250 µg/ml	DPPH	Antioxidant property	Safe LD_{50} - 3500 mg/kg bw in mice.	[180,181]
40.	*Sonchus oleraceus* L.	Methanol	–	–	Anti-inflammatory activity	Weak/mildly toxic $LD_{50} \leq 2000$ mg/kg bw in mice	[182,183]
		Acetone, methanol, and aqueous	0.1, 0.5, 1.0, 2.5 & 5.0 mg/ml	*Micrococcus kristinae, Streptococcus pyrogens, B. cereus,* and *S. aureus*	Antimicrobial action		[183]
		Acetone, methanol, and aqueous	1 mg/ml	FRAP, DPPH, and 3-ethyl-benzo-thiazoline-6-sulfonic acid (ABTS)	Antioxidant effect		[183]
41.	*Psiadia punctulata* (DC.) Oliv. & Hiern ex Vatke	Ethyl acetate and ethanol	100 – 400 mg/kg	Rat	Anti-inflammation and analgesic effect	Safe LD50 - 5000 mg/kg bw in rats	[184,185]
		Ethyl acetate and ethanol	400 mg/kg	Rat	Antipyretic property		[185]
		Methanol	10 – 100 µg/ml	DPPH	Antioxidant effect		[184]
42.	*Eschenbachia subscaposa* (O. Hoffm.) G.L.Nesom	–	–	–	No records found	No records found	–
43.	*Erigeron sumatrensis* Retz.	Dichloromethane	–	*Trachophyton mentagrophytes, P. aeruginosa, E. coli, B. subtilis, S. aureus, C. albicans,* and *A. niger*	Antimicrobial action	No records found	[186]
		Ethyl acetate and aqueous	20 – 100 µg/ml	DPPH	Antioxidant activity		[187]
44.	*Ageratum conyzoides* L.	Ethanol	100 & 300 mg/kg	Rat	Anti-inflammatory and analgesic effects	Moderately toxic LD_{50} - 1000 mg/kg bw in rats	[188–190]
		Aqueous	–		Antidiabetic action		
		Methanol	–	*Clostridium perfringes, E. coli,* and *S. aureus*	Antimicrobial property		[190]
		Ethanol	2.937 – 5.10 µg/ml	DPPH	Antioxidant effect		[190]
45.	*Tarchonanthus camphoratus* L.	–	100 & 50 µg/ml	*S. aureus* and *C. albicans*	Antimicrobial effect	Highly toxic LC_{50} - 216 µg/ml in brine shrimp	[191,192]
		Aqueous, methanol, ethyl acetate, and dichloromethane	10 – 100 mg/ml	DPPH and ABTS	Antioxidant property		[192]
46.	*Schkuhria pinnata* (Lam.) Kuntze	Dichloromethane and methanol	10 mg/ml	DPPH	Antioxidant action	Moderately toxic LD_{50} - 1500	[193,194]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
						mg/kg bw in mice	
		Dichloromethane and methanol	10 mg/ml	*Mycobacterium smegmatis*	Antimicrobial action		[193]
47.	*Aspilia pluriseta* Schweinf.	Petroleum ether, ethyl acetate, and aqueous	–	*Trichphyton rubrum, Microsporum canis, Epidermophyton floccosum*, and *C. albicans*	Antimicrobial action	No records found	[195]
48.	*Kleinia squarrosa* Cufod.	Aqueous	50, 100 & 150 mg/kg	Mice	Antidiabetic effect	No records found	[196]
	Apocynaceae						
49.	*Acokanthera schimperi* (A.DC.) Schweinf.	Dichloromethane, chloroform, petroleum ether, and ethyl acetate	200 mg/ml	*K. pneumoniae, E. coli*, and *S. aureus*	Antimicrobial effect	No records found	[197]
50.	*Carissa spinarum* L.	Aqueous	38 µg/ml	DPPH	Antioxidant action	Safe LD_{50} - 2000 mg/kg bw in rats	[198]
		Ethanol	2 g/kg	Rat	Antidiabetic action		[198]
		Ethanol	100, 200 & 400 mg/kg	Rat	Antipyretic property		[198]
		Petroleum ether, chloroform, alcoholic, and aqueous	200 mg/kg	Rat	Anti-inflammatory action		[198]
		Aqueous	250 mg/kg	*P. aeruginosa* and *S. aureus*	Antimicrobial effect		[198]
51.	*Tabernaemontana stapfiana* Britten	Hexane, dichloromethane, ethyl acetate, and methanol	15.6 – 500 mg/ml	*S. aureus, E. faecalis, B. subtilis, S. typhi, P. Aeruginosa,* and *K. pneumoniae*	Antimicrobial activity	No records found	[199]
	Asclepiadaceae						
52.	*Periploca linearifolia* Dill.& A. Rich.	Petroleum ether, chloroform, acetone and methanol	5 – 10 mg/ml	*P. Aeruginosa, E. coli, S. aureus,* and *S. pyrogens*	Antimicrobial activity	Safe $LD_{50} \geq 2000$ mg/kg bw in mice	[200,201]
	Asparagaceae						
53.	*Asparagus racemosus* Willd	Methanol	0.5 – 10.0 mg/ml	DPPH	Antioxidant action	Safe LD_{50} - 3200 mg/kg bw in mice and rats	[202,203]
		Methanol	–	Mice	Antidiabetic effect		Shaha & Bellankimath [203]
		Methanol	–	Rat	Immunomodulatory action		[202]
		Methanol	200 & 400 mg/kg	Mice	Antitussive effect		[202]
		Methanol	50, 100 & 150 mg/ml	*Pseudomonas pectida, Shigella dysenteriae, Vibrio cholerae, S. sonnei, S. flexneri, E. coli, S. typhi, S. typhimurium, B. Subtilis,* and *S. aureus*	Antimicrobial action		[202]
		–	200 mg/kg	Mice	Anti-inflammatory activity		[202]
54.	*Asparagus setaceus* (Kunth) Jessop	Dichloromethane	9.3 – 35 mg/ml	DPPH	Antioxidant effect	No records found	[204]
		Methanol and dichloromethane	3000 µg/ml	*E. coli, B. subtillis. S.* aureus, *P. aeruginosa*, and *S. typhi*	Antimicrobial action		[204]
		–	1 – 100 µg/ml	–	Anti-inflammatory effect		[204]
	Asphodelaceae						
55.	*Aloe volkensii* Engl.	Aqueous	50 – 150 mg/kg	Mice	Anti-inflammatory and analgesic effects	No records found	[205]
		Aqueous	–	Mice	Antipyretic effect		[205]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Methanol	100 mg/ml	*Fusarium oxysporum, Erwinia carotovora, S. aureus, B. subtilis, K. pneumonia, E. coli*, and *C. albicans*	Antimicrobial action		[206]
56.	*Aloe kedongensis* Reynold	–	–	–	No records found	No records found	–
57.	*Aloe ballyi* Reynolds	–	–	–	No records found	No records found	–
58.	*Aloe secundiflora* Engl.	–	–	–	No records found	No records found	–
59.	*Aloe turkanensis* Christian	–	–	–	No records found	No records found	–
	Basellaceae						
60.	*Basella alba* L.	–	500 & 100 mg/kg	Rats	Anti-inflammatory effect	No records found	[207]
	Bignoniaceae						
61.	*Kigelia africana* (Lam.) Benth.	Methanol	150 mg/kg	Rat	Anti-inflammatory and analgesic effects	Moderately toxic $LC_{50} < 300$ µg/ml. LD_{50} - 785.65 ± 24 mg/kg bw in mice	[16,208]
		Methanol	50 – 150 mg/kg	Rat	Antipyretic action		[208]
		Methanol	100 – 400 mg/kg	Rat	Antidiabetic activity		[208]
		Methanol	10, 20 & 50 mg/ml	*C. albicans*	Antimicrobial activity		[208]
62.	*Spathodea campanulata* Beauverd	Methanol	500 mg/kg	Mice	Antidiabetic action	Safe LD_{50} - 5000 mg/kg bw in mice and rats	[209,210]
		–	100 µg/ml	HIV-1 protease	Antimicrobial effect		[210]
		–	250 – 1,000 mg/kg	Rat	Anti-inflammatory and analgesic action		[210]
		–	500 µg/ml	DPPH	Antioxidant action		[210]
	Boraginaceae						
63.	*Cordia sinensis* Lam.	Methanol	100 mg/kg	Rat	Anti-inflammatory action	Moderately toxic LC_{50} - 262.138 µg/ml in brine shrimp	[211,212]
		Methanol	50 mg/ml	*B. subtillis, S. aureus, Klebsiella, P. aeruginosa, C. albicans*, and *A. niger*	Antimicrobial effect		[212]
		Methanol, ethyl acetate, chloroform, and petroleum ether	-	DPPH	Antioxidant effect		[212]
64.	*Cordia africana* Lam.	Ethanol	20.12 – 0.38 µg/ml	DPPH	Antioxidant action	Safe LD_{50} - 2000 mg/kg bw in mice	[213,100]
		Methanol	16 µg/ml	*S. typhimurium* and *E. coli*	Antimicrobial effect		[100]
		Ethanol	340 mg/kg	Rat	Anti-inflammatory action		[100]
65.	*Trichodesma zeylanicum* (Burm. fil.) R.Br.	Chloroform	50, 100 & 200 mg/kg	Mice	Anti-inflammatory and analgesic actions	No records found	[83]
		–	200 – 400 mg/kg	Rat	Antidiabetic property		[83]
		–	100 g/ml	*E. coli, P. aeruginosa, K. pneumonia, B. subtilis*, and *S. pyrogens*	Antimicrobial effect		[83]
		Dichloromethane	75 mg/L	Mice	Antitussive effect		[83]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Ethanol	100, 200 & 400 mg/kg	Rat	Antipyretic action		[83]
66.	*Ehretia cymosa* Thonn.	Methanol	100, 200 & 400 mg/kg	Rats	Anti-inflammatory and analgesic effects	Safe $LD_{50} \geq 2000$ mg/kg bw in mice and rats	[214]
	Burseraceae						
67.	*Commiphora africana* (A.Rich.) Engl.	n-hexane, dichloromethane, acetonitrile, ethyl acetate, methanol, and n-butanol	100 µg/ml	COX-1 and COX-2	Anti-inflammatory action	Safe LD_{50} - 5000 mg/kg bw in mice	[215,26]
		n-hexane, dichloromethane, acetonitrile, ethyl acetate, methanol, and n-butanol	100 µg/ml	DPPH	Antioxidant effect		[215]
		Ethanol	1 – 100 mg/ml	–	Antimicrobial action		[26]
68.	*Commiphora rostrata* Engl.	–	–	–	No records found	No records found	–
69.	*Commiphora edulis* (Klotzsch) Engl.	–	7.31 & 26.92 mg/ml	DPPH	Antioxidation action	No records found	[78,216]
		Aqueous	100 mg/ml	*M. smegmatis*	Antimicrobial effect		[78]
70.	*Commiphora baluensis* Engl.	–	–	–	No records found	No records found	–
	Canellaceae						
71.	*Warburgia ugandensis* Sprague	Methanol	6.59 µg/ml	DPPH	Antioxidant activity	Safe $LD_{50} > 5000$ mg/kg bw in mice	[217,218]
		Dichloromethane	1 - 10 mg/ml	*Shigella boydii, S. Aureus, C. albicans*, and *K. pneumoniae*	Antimicrobial effect		[218]
72.	*Warburgia salutaris* (G. Bertol.) Chiov.	Ethanol, ethyl acetate, and hexane	12.5 – 100 µg/ml	*S. aureus, B. subtilis*, and *E. coli*	Antimicrobial effect	No records found	[218]
		Methanol and aqueous	33 mg/ml	–	Anti-inflammatory action		[218]
		Methanol	–	DPPH	Antioxidant action		[218]
	Capparaceae		–				
73.	*Maerua subcordata* (Gilg) De Wolf	–	–	–	No records found	No records found	–
74.	*Maerua kirkii* (Oliv.) F.White	–	–	–	No records found	No records found	–
	Caricaceae						
75.	*Carica papaya* L.	Methanol	–	*S. aureus, B. subtilis, E. coli,* and *P. aeruginosa*	Antimicrobial effect	Safe LD_{50} - 3200 mg/kg bw in mice	[102,219, 220]
		Aqueous, methanol, and ethanol	–	DPPH	Antioxidant action		[220]
		Aqueous	100 – 400 mg/kg	–	Antidiabetic activity		[102]
		Aqueous	100 & 200 mg/kg	Mice	Anti-inflammatory effect		[102]
		Aqueous	400 & 800 mg/kg	Rats	Immunomodulatory action		[102]
	Celastraceae						
76.	*Catha edulis* Forssk.	Aqueous	100 µg/ml	*Bacillus magaterium, Micrococcus luteus, Brevundimonas diminuta, Aspergillus varicoluor, Penicillum solitum, Penicillum brevicompactum,*	Antimicrobial action	Safe LD_{50} - 2500 mg/kg bw in rats	(Mohamed [221,222])

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
				Acanthamoeba castellanii, and *E. coli*			
77.	*Gymnosporia senegalensis* (Lam.) Loes.	Ethanol	75 & 150 mg/kg	Mice	Anti-inflammatory and analgesic properties	No records found	[223]
	Combretaceae						
78.	*Combretum molle* R. Br. ex G.Don	–	50mg/kg	DPPH	Antioxidant effect	Moderately toxic LD_{50} - 700 mg/kg bw in rats	[224,171]
		Ethanol	0.5 mg/kg	*P. aeruginosa, S. aureus,* and *E. coli*	Antimicrobial action		[171]
		–	5 – 80 mg/kg	COX-1	Anti-inflammatory effect		[225]
		–	50mg/kg	Mice	Antidiabetic effect		[224]
79.	*Terminalia brownii* Fresen	Methanol	50, 100 & 150 mg/kg	Rat	Anti-inflammatory and analgesic effects	Safe LC_{50} - 1458.81 µg/ml in brine shrimp	[171,226]
		Aqueous	1 g/ml	*S. aureus, B. subtilis*, and *E. coli*	Antimicrobial action		[171]
		Methanol	50, 100 & 150 mg/kg	Rat	Antipyretic activity		[227]
		Ethyl acetate and aqueous	500 mg/kg	Mice	Antidiabetic effect		[228]
80.	*Combretum hereroense* Schinz	Methanol	2.5, 2.5, 2.5, and 1.25 mg/mL	*A. fumigates*	Antimicrobial action	Safe LD_{50} - 2000 mg/kg bw in rats.	[229,225]
		Ethanol	75 & 150 mg/kg	COX-1	Anti-inflammatory effect		[225]
81.	*Combretum exalatum* Engl.	–	–	–	No records found	No records found	–
	Convolvulaceae						
82.	*Ipomoea kituiensis* Vatke	–	–	–	No records found	No records found	–
83.	*Ipomoea cairica* (L.) Sweet	Aqueous	–	Respiratory syncytial virus	Antimicrobial action	No records found	[77]
	Cucurbitaceae						
84.	*Zehneria minutiflora* (Cogn.) C.Jeffrey	–	–	–	No records found	No records found	–
85.	*Zehneria scabra* (L. f.) Sond.	Ethanol	100, 200 & 400 mg/kg	Mice	Anti-inflammatory action	Safe LD_{50} -2000mg/kg bw in mice	[230,231]
		Ethanol	9, 18 & 37 mg/kg	DPPH	Antioxidant property		[232]
		Ethanol	12.5 – 100 mg/ml	*B. subtilis, S. aureus, S. pneumoniae, K. pneumoniae, E. aerogenes, E. coli,* and *P. aeruginosa*	Antimicrobial action		[233]
86.	*Momordica rostrata* Zimm.	–	–	–	No records found	No records found	–
87.	*Momordica foetida* Schumach.	Ethanol	3.33 – 330mg/ml	DPPH	Antioxidant action	Safe $LD_{50} > 5000$ mg/kg bw in rats	[234,235]
		Aqueous, dichloromethane, and methane	1 mg/kg	Rat	Antidiabetic effect		[234]
		Aqueous, butanol, chloroform, ethyl acetate, and hexane	0.156 – 5.0 mg/ml	*B. subtilis, S. aureus,* and *S. pneumoniae*	Antimicrobial effect		[234]
88.	*Cucumis dipsaceus* Ehrenb. ex Spach.	Methanolic and aqueous	50 – 150 mg/kg	Rat	Anti-inflammatory and analgesic actions	No records found	[236]
		Methanol	10.37 µg/ml	DPPH	Antioxidant action		[236]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Methanolic and aqueous	3.125 µg/ml	*P. aeruginosa, S. enteriditis, E. Coli, C. albicans,* and *B. subtilis*	Antimicrobial effect		[236]
	Cuppressaceae						
89.	*Juniperus procera* Endl.	Methanol	30, 60 & 90 mg/ml	*A. flavus*	Antimicrobial activity	No records found	[237,238]
		Ethanol	200 mg/kg	Rat	Anti-inflammatory effect		[238]
	Cyperaceae						
90.	*Cyperus richardii* Steud.	–	–	–	No records found	No records found	–
	Ebenaceae						
91.	*Euclea divinorum* Hiern.	Methanol	4000 µg/ml	*Cryptococcus neoformans* and *C. albicans*	Antimicrobial activity	Highly toxic IC_{50} - 27.5 ±3.6 µg/ml	[26,239]
		Methanol and aqueous	2000 mg/ml	DPPH	Antioxidant action		[239]
		Dichloromethane, ethyl acetate, and methanol	10 µg/ml	COX-2	Anti-inflammatory effect		[239]
	Euphorbiaceae						
92.	*Croton megalocarpus* Del.	Aqueous, hexane, and methanol	500 µg/ml	COX-1	Anti-inflammatory action	Safe $LD_{50} \geq 2000$ mg/kg bw in mice	[240,241]
		Hexane and methanol	100 mg/ml	*B. subtilis* and *S. aureus*	Antimicrobial effect		[241]
		Methanol	–	–	Antioxidant action		[241]
93.	*Croton macrostachyus* Delile	Methanol	0.11 mg/ml	DPPH	Antioxidant property	Safe LD_{50} - 2000 mg/kg bw in mice	[242,243]
		Methanol	250, 500, 1000 & 2000 µg/ml	*Neisseria gonorrhoeae*	Antimicrobial activity		[242]
		Aqueous	25, 48.4, 93.5, 180.9, & 350 mg/kg	Mice	Antidiabetic effect		[242]
		Aqueous and methanol	150, 300, and 600 mg/kg	Mice	Anti-inflammatory effect		[242]
94.	*Shirakiopsis elliptica* (Hochst.) Esser	–	–	–	No records found	No records found	–
95.	*Euphorbia scarlatina* S.Carter	–	–	–	No records found	No records found	–
96.	*Euphorbia hirta* L.	Ethanol	50 – 250 mg/ml	*E. coli, S. aureus, P. aeruginosa,* and *B. subtillis*	Antimicrobial activity	Highly toxic LC_{50} - 228.11 µg/ml in brine shrimp	[244,76,245]
		n-hexane	20 & 25 mg/kg	–	Anti-inflammatory effect		[244]
		n-hexane	100 & 400 mg/kg	–	Antipyretic activity		[244]
		Aqueous	0.25 mg/ml	–	Antioxidant property		[245]
		Aqueous	–	–	Anti-asthmatic action		[244]
		Ethanol	100 – 1000 mg/kg	Rat	Anti-allergic effect		[107]
97.	*Euphorbia murielii* N.E.Br.	–	–	–	No records found	No records found	–
98.	*Neoboutonia macrocalyx* Pax	Methanol	0.78 – 200 mg/ml	*Mucus miehei* and *C. albicans*	Antimicrobial activity	Highly toxic LC_{50} - 10.0 ± 0.9 µg/ml in brine shrimp	[246]
99.	*Jatropha podagrica* Hook.	Ethanol and methanol	194.51 – 238.85 µg/ml	DPPH	Antioxidant effect	Highly toxic LC_{50} - 194.51 µg/ml in brine shrimp	[247,245]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Ethyl acetate	5, 20, 30, 20 & 25 mg/ml	*Listeria monocytogenes, Proteus mirabilis, B. subtilis, S. aureus, E. coli*, and *K. pneumoniae*	Antimicrobial activity		[247]
100.	*Macaranga kilimandscharica* Pax	–	–	–	No records found	No records found	–
101.	*Ricinus communis* L.	Methanol	–	DPPH	Antioxidant effect	Safe or nontoxic LD_{50} - 2000 mg/kg bw in rats	[248,16]
		Aqueous	500 mg/kg	Rat	Antidiabetic action		[248]
		Aqueous	100 – 200 mg/kg	Mice	Anti-inflammatory action		[248]
		Aqueous, hexane, and methanol	200 mg/ml	*A. niger, B. subtilis, C. albicans E. coli, P. vulgaris, P. aeruginosa, S. Aureus,* and *S. typhimurium*	Antimicrobial effect		[248]
		Aqueous	–	Mice	Anti-asthmatic action		[248]
102.	*Euphorbia joyae* P. R.O.Bally & S. Carter	–	–	–	No records found	No records found	-
103.	*Euphorbia tirucalli* L.	Methanol	–	DPPH	Antioxidant effect	Safe $LD_{50} > 8000$ mg/kg bw in rats	[249,101]
		Aqueous, dichloromethane, methanol, and petroleum ether	30, 100 & 300 mg/kg	Mice	Analgesic and anti-inflammatory effects		[101]
		Ethanol	10 µg/ml	–	Immunomodulatory activity		[101]
		n-hexane	100 mg/ml	*A. flavus, C. Albicans,* and *C. glabrata*	Antimicrobial activity		[101]
104.	*Clutia abyssinica* Jaub. & Spach	Dichloromethane	50, 100, and 150 mg/kg	Mice	Anti-inflammatory and analgesic effects	Safe $LD_{50} > 2000$ mg/kg bw in rats	[250,251]
		Hexane, dichloromethane, methanol, and water	0.2 – 50.0 mg/ml	*E. coli, P. aeruginosa, S. Aureus,* and *K. pneumonia*	Antimicrobial action		[250]
		Dichloromethane	50, 100, and 150 mg/kg	Rat	Antipyretic effect		[250]
		Methanol, chloroform, and n-butanol	9.9 – 194.5 µg/ml	DPPH	Antioxidant effect		[250]
105.	*Croton dichogamus* Pax	Ethanol	1.25 mg/ml	*B. cereus, E. coli, P. aeruginosa, S. Aureus,* and *S. aureus*	Antimicrobial effect	Highly toxic $LC_{50} \leq$ 100 µg/ml in brine shrimp	[252]
		Methanol	–	DPPH	Antioxidant activity		[252]
		Hexane	–	COX-1 and COX-2	Anti-inflammatory action		[252]
	Fabaceae						
106.	*Abrus fruticulosus* Wall. ex Wight & Arn.	–	–	–	No records found	No records found	–
107.	*Vachellia nilotica* (L.) P.J.H.Hurter & Mabb.	Methanol	1 – 100 µg/ml	DPPH	Antioxidant effect	Safe LD_{50} - 3807.89 mg/kg bw in rats	[253,124]
		Aqueous	50 & 100 mg/kg, 150 & 300 mg/kg	Rat	Anti-inflammatory and analgesic activities		[124]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Aqueous	100, 200 & 400 mg/kg	Rat	Antipyretic effect		[124]
		Ethyl acetate	16 - 33 µg/ml	*K. pneumonia* and *E. coli*	Antimicrobial action		[124]
		Methanol and aqueous	500 & 1000 mg/kg	Rat	Antidiabetic effect		[124]
108.	*Senegalia mellifera* (Vahl) Seigler & Ebinger	Dichloromethane	50, 100 & 150mg/kg	Mice	Anti-inflammatory and analgesic actions	Moderately toxic LD_{50} – 800 mg/kg bw in mice	[127]
		Dichloromethane	50, 100 & 150mg/kg	Mice	Antipyretic effect		[127]
109.	*Senna occidentalis* L.	Methanol	25 – 1000 µg/ml	DPPH	Antioxidant activity	Safe LD_{50} - 3000mg/kg bw in rats	[254,126]
		Methanol	200, 300 & 450 mg/kg	Rat	Antidiabetic effect		[126]
		Ethanol	250 mg/kg	Mice	Anti-allergic property		[88]
		Ethanol	250 mg/kg	Mice	Anti-inflammatory activity		[88]
110.	*Senna didymobotrya* (Fresen.) Irwin & Barneby	Dichloromethane	250 mg/kg	Rat	Antipyretic activity	Weakly toxic LD_{50} – 1927 mg/kg bw in mice	[255–257]
		Methanol	50 mg/ml	*E. coli* and *S. aureus*	Antimicrobial effect		[257]
111.	*Senna singueana* (Delile) Lock	Methanol and ethyl acetate	–	DPPH	Antioxidant activity	Safe LD_{50} - 4000 mg/kg bw in mice	[258,257, 259]
		Aqueous	18.7 µg/ml	*C. albicans*	Antimicrobial action		[260]
112.	*Guilandina volkensii* (Harms) G.P.Lewis	–	–	–	No records found	No records found	[260]
113.	*Vachellia robusta* (Burch.) Kyal. & Boatwr.	Methanol	0.008 – 4 mg/ml	*Cryptococcus neoformans, Candida krusei, Candida tropicalis, Candida parapsilosis, C. albicans,* and *C. glabrata*	Antimicrobial effect	Highly toxic LC_{50} - 108.5 µg/ml in brine shrimp	[26]
114.	*Albizia zygia* (DC.) J.J.Macbr.	Ethanol	300 – 1000 mg/kg	Mice	Anti-inflammatory and analgesic effects	Highly toxic LC_{50} - 1.70 µg/ml in shrimp	[261,26]
		Hydroethanol	30 – 300 mg/kg	Mice	Antipyretic activity		[261]
		Methanol and hexane	50 mg/ml	*Rhizopus stolon, Penicillum notatum, E. coli, S. aereus, B. subtilis, P. aeruginosa, K. pneumonae, S. typhi, C. albicans,* and *A. niger*	Antimicrobial action		[26]
		Ethanol	0.114 – 18.27 µg/ml	DPPH	Antioxidant effect		[26]
115.	*Craibia brownii* Dunn	No records found	–	–	No records found	No records found	–
116.	*Albizia gummifera* (J.F. Gmel.) C.A. Sm.	Ethanol	500 – 1000 mg/ml		Antimicrobial effect	No records found	[262]
117.	*Rhynchosia elegans* var. *elegans*	Methanol	12.5 – 400 mg/ml	*S. aureus, B. cereus, E. coli,* and *C. albicans*	Antimicrobial effect	Moderately toxic LC_{50} - 422.09 µg/ml in brine shrimp	[263]
118.	*Tamarindus indica* L.	n-hexane	10 µg/ml	*P. mirabilis, P. aeruginosa,* and *E. coli*	Antimicrobial action	Safe $LD_{50} > 3000$ mg/kg bw in rats	[264,26]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Ethanol	0.2 mg/ml	DPPH	Antioxidant effect		[26]
		Petroleum ether	10 mg/kg	RAW 264.7 macrophages	Analgesic and anti-inflammatory actions		[263]
119.	*Tylosema fassoglense* (Kotschy ex Schweinf.) Torre & Hillc.	Petroleum ether, chloroform, and methanol	30 µg/disc	*C. albicans, B. cereus, S. typhimurium, S. aureus, E. coli* and *B. subtilis*	Antimicrobial property	Highly toxic LC_{50} > 7.58 - 203.66 µg/ml in brine shrimp	[265,26]
120.	*Mucuna gigantea* (Willd) D.C	Ethyl acetate and hydro-alcoholic	100 & 400 mg/kg	Rat	Anti-inflammatory and analgesic effects	No records found	[266]
121.	*Abrus precatorius* L.	Aqueous and ethanol	–	Rat	Immunomodulatory effect	Safe $LD_{50} \geq 5000$ mg/kg bw in mice	Maregesi et al. [267]; [267, 268]
		Ethanol	250 mg/kg	Mice	Anti-inflammatory action		
		Methanol	1 mg/ml	DPPH	Antioxidant activity		[268]
		Ethanol, methanol, and petroleum ether	4 – 512 µg/ml	*B. subtilis* and *S. aureus*	Antimicrobial action		[268]
		Ethanol	100, 200 & 400 mg/kg	Rat	Antidiabetic effect		[268]
122.	*Senegalia ataxacantha* (DC.) Kyal. & Boatwr.	Ethanol	125 mg/kg	Rat	Antidiabetic effect	Safe LD_{50} - 2000 mg/kg bw in rats	[269]
		Chloroform, ethyl acetate, methanol, and petroleum ether	2.5 – 10 mg/ml	DPPH	Antioxidant effect		[269]
		Methanol	100, 200 & 400 mg/kg	Mice	Anti-inflammatory action		[269]
		Chloroform, methanol, ethyl acetate, and petroleum ether	0.3 – 5 mg/ml	*E. faecalis, E. coli, P. aeruginosa, S. epidermidis,* and *S. aureus*	Antimicrobial activity		[269]
123.	*Albizia anthelmitica* Brongn.	Ethanol	200 & 400 mg/kg	Mice	Anti-inflammatory and analgesic effects	No records found	[89]
		Ethanol	29.49 µg/ml	DPPH	Antioxidant action		[89]
124.	*Vachellia abyssinica* (Hochst. ex Benth.) Kyal. & Boatwr.	–	–	–	No records found	No records found	–
125.	*Cajanus cajan* (L.) Huth.	Ethanol	–	DPPH	Antioxidant effect	Safe LD_{50} > 5000 mg/kg bw in rats	[270,271]
		Ethanol	–	*S. typhi, S. aureus,* and *E. coli*	Antimicrobial action		[270]
		Ethyl acetate and methanol	250 mg/kg	Rat	Antidiabetic effect		[270]
126.	*Indigofera lupatana* Baker f.	Hexane, ethyl acetate, and dichloromethane	21.9 – 750 mg/ml	*B. subtilis, S. aureus, B. cereus, E. coli, P. aeruginosa, S. typhimurium, K. pneumonia,* and *P. mirabilis*	Antimicrobial property	Safe $LC_{50} \geq$ 1000µg/ml in brine shrimp.	[272,273]
127.	*Indigofera arrecta* Hochst. ex A.Rich.	Petroleum ether, dichloromethane, and ethanol, and aqueous extracts	6.25 – 12.50 mg/ml	*M. aurum, K. pneumoniae,* and *S. aureus*	Antimicrobial action	Safe $LD_{50} \geq$ 5000 mg/kg bw in rats	[274,275]
		Aqueous	250 µg/ml	COX-2	Anti-inflammatory effect		[274]
128.	*Indigofera spicata* Forssk.	Hydro-methanolic	100, 200 & 400 mg/kg	Mice	Antidiabetic effect	No records found	[274]
129.	*Albizia coriaria* Welw. Ex Oliv.	Methanol	12.5 – 50 mg/ml	*S. aureus, S. pneumoniae,* and *P. aeruginosa*	Antimicrobial activity	No records found	[276]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Ethyl acetate and ethanol	22.98 ± 2.47 & 18.39 ± 2.23 µg/ml	DPPH	Antioxidant activity		[276]
130.	*Vachellia hockii* (De Wild.) Seigler & Ebinger	Ethanol	100.3 & 89.0 µg/ml	–	Antimicrobial effect	Safe LD_{50} - 2000 mg/kg bw in rats	[277]
131.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	–	500 & 1000 mg/kg	Rat	Antidiabetic action	Safe LD_{50} - 2000 mg/kg bw in rats	[277,278]
132.	*Vachellia horrida* (L.) Kyal. & Boatwr.	–	–	–	No records found	No records found	–
133.	*Albizia amara* (Roxb.) Boivin	Ethanol	200 mg/kg	Mice	Anti-inflammatory and analgesic effects	Safe LD_{50} - 2000 mg/kg bw in rats	[274,16]
		Methanol	–	DPPH	Antioxidant effect		[274]
		Methanol, chloroform, hydromethanolic, and methanol	1 mg/ml	*Xanthomonas campestris*	Antimicrobial action		[274]
134.	*Senegalia brevispica* (Harms) Seigler & Ebinger	–	–	–	No records found	No records found	–
135.	*Senegalia senegal* (L.) Britton	–	–	–	No records found	No records found	–
136.	*Vachellia lahai* (Steud. & Hochst. ex Benth.) Kyal. & Boatwr.	–	–	–	No records found	No records found	–
137.	*Erythrina abyssinica* Lam.	Ethanol and methanol	10 – 320 µg/ml	DPPH	Antioxidant effect	Safe LC_{50} - 5440 µg/ml in brine shrimp	[274,16]
		Ethyl acetate and dichloromethane	62.5 – 500 µg/ml	*S. aureus* and *C. albicans*	Antimicrobial action		[274]
		Ethanol	5 – 100 mg/kg	Mice	Antidiabetic effect		[274]
		Aqueous	50 mg/kg	Mice	Anti-inflammatory property		[274]
		Methanol	200 mg/kg	Rat	Antipyretic effect		[274]
138.	*Pterolobium stellatum* (Forssk.) Brenan	Ethanol, methanol, and chloroform	2 mg/ml	*Mycobacterium kansasii, Mycobacterium fortuitum, Mycobacterium tuberculosis*, and *M. smegmatis*	Antimicrobial action	No records found	[274]
139.	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Aqueous and methanol	100 mg/kg	Mice	Anti-inflammatory and analgesic actions	Safe $LD_{50} > 5000$ mg/kg bw in rats	[274,16]
140.	*Dalbergia lactea* Vatke	–	–	–	No records found	No records found	–
141.	*Cassia abbreviata* Oliv.	Ethanol	0.5 mg/disc	*S. aureus*	Antimicrobial action	Safe $LD_{50} > 5000$ mg/kg bw in rats	[279]
		Methanol and aqueous	–	DPPH	Antioxidant property		[279]
		Acetone	6.4 mg/ml	Yeast α-glucosidase	Antidiabetic effect		[279]
142.	*Mimosa pudica* L.	Aqueous	2000 mg/kg	Mice	Bronchodilator in histamine-induced bronchospasm model	Safe $LD_{50} \leq 5000$ mg/kg bw in rats	[2]
		–	25 µg/ml		Antimicrobial action		[280]
		Hydroalcoholic	250 µg/ml	DPPH	Antioxidant effect		[280]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
143.	*Dichrostachys cinerea* (L.) Wight & Arn.	Aqueous	2.5 – 10.0 mg/ml	*P. aeruginosa, E. coli, S. aureus, K. Pneumoniae,* and *C. albicans*	Antimicrobial action	Safe LC_{50} - 4304.59 ± 685.69 µg/ml in brine shrimp	[16]
	Hypericaceae						
144.	*Harungana madagascariensis* Lam. Ex Poi	Aqueous	100 – 200 mg/kg	*B. subtilis, S. aureus, E. coli,* and *P. aeruginosa*	Antibacterial action	Toxic $LD_{50} > 200$ mg/kg bw in rats	[26]
	Iridaceae						
145.	*Gladiolus dalenii* Van Geel	Methanol	–	–	Antimicrobial effect	No records found	[281]
		Ethyl acetate and ethanol	1 mg/ml	DPPH	Antioxidant action		[282]
	Juncaceae						
146.	*Juncus effusus* L.	–	–	–	No records found	No records found	–
	Lamiaceae	–					
147.	*Ajuga integrifolia* Buch-Ham. ex D. Don	–	50 mg/L	DPPH	Antioxidant action	Safe $LD_{50} \geq 5000$ mg/kg bw in mice	[283,284]
		–	100 mg/L	COX-1 and COX-2	Anti-inflammatory effect		[284]
148.	*Leucas grandis* Vatke	–	–	–	No records found	No records found	–
149.	*Ocimum gratissimum* L.	Methanol and hexane	8 – 512 µg/ml	*E. coli* and *S. aureus*	Antimicrobial effect	Safe LD_{50} - 4242.64 mg/kg bw in mice	[285]
		–	17.4 – 470 g/ml	DPPH	Antioxidant activity		[285]
		Ethyl acetate	50 & 100 mg/kg	Rat	Anti-inflammatory		[285]
		Aqueous	500 – 1500 mg/kg	Rat	Antidiabetic effect		[285]
150.	*Ocimum basilicum* L.	Methanol and aqueous	3.0 – 10.0 mg/ml	Rabbit and guinea-pig	Bronchodilation and vasodilation actions	No records found	[2,286]
		Methanol, ethyl acetate, and butanol	10 mg/ml	Rat	Antidiabetic action		[286]
		Ethanol	1 mg/ml & 3 ml/kg	Mice	Anti-inflammatory and analgesic actions		[286]
		Methanol	–	*Perctobacterium carotovorum, Pseudomonas marginalis, Pseudomonas syringae, Rhizoctonia solani, Fusarium oxysporum*, and *Botrytis cinerea*	Antimicrobial effect		[286]
		Ethanol	20, 10, 5, 2.5 & 1.25 mg/ml	DPPH, ABTS, and FRAP	Antioxidant activity		[286]
		–	3 ml/kg	Rat	Antipyretic effect		[286]
		–	3 ml/kg	Human peripheral blood mononuclear cells	Immunomodulatory property		[286]
151.	*Vitex doniana* Sweet	Ethanol, hexane, ethyl acetate, butanol, and aqueous	100 – 1400 µg/ml	DPPH	Antioxidant action	Safe $LD_{50} \geq 5000$ mg/kg bw in mice	[287]
		Dichloromethane, hydromethanolic, and methanol	–	*A. terreus*	Antimicrobial effect		[287]
		–	100 mg/kg	Rat	Anti-inflammatory action		[287]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
152.	*Coleus barbatus* (Andrews) Benth. ex G.Don	Aqueous	100, 200 & 400 mg/kg	Rat	Antipyretic and analgesic effects	Safe LD_{50} > 10,000 mg/kg bw in rats	[288]
153.	*Hoslundia opposita* Vahl	Aqueous, methanol, and ethyl acetate	20 µg/ml	*Acinetobacter calcoacetica, Brochothrix thermosphacta, Flavobacterium suaveolens*, and *A. niger*	Antimicrobial action	No records found	[289]
154.	*Rotheca myricoides* (Hochst.) Steane & Mabb.	–	–	–	No records found	No records found	–
155.	*Clerodendrum myricoides* R.Br.	Methanol	1 g/ml	*A. niger*	Antimicrobial action	Safe LD_{50} - 3475 mg/kg bw in mice	[171]
156.	*Micromeria biflora* (Buch.-Ham. ex D. Don) Benth.	Hydroalcoholic	50 & 100 mg/kg	Mice	Antipyretic action	No records found	[290]
		Hydroalcoholic	50 & 100 mg/kg	Mice	anti-inflammatory and analgesic effects		[290]
157.	*Leucas calostachys* Oliv.	Ethyl acetate	10 mg/ml	COX-1 and COX-1	Anti-inflammatory effect	No records found	[291]
	Lauraceae						
158.	*Kuloa usambarensis* (Engl.) Trofimov & Rohwer	–	–	–	No records found	No records found	–
	Liliaceae						
159.	*Crinum macowanii* Baker	–	250 µg/ml	*B. subtilis, E. coli, K. pneumoniae,* and *S. aureus*	Antimicrobial effect	Safe LD_{50} - 3000 mg/kg bw in mice	[292]
	Loganiaceae						
160.	*Strychnos spinosa* Lam.	Dichloromethane and methanol	0.16 mg/ml	*A. fumigatus* and *C. neoformans*	Antimicrobial action	Safe LD_{50} > 5000 mg/kg bw in mice	[16,293]
		Acetone, methanol and dichloromethane	14.47 – 15.51 pg/mL	COX-1 and COX-2	Anti-inflammatory property		[293]
		Methanol	4.65 & 2.26 µg/ml	DPPH	Antioxidant activity		[293]
		Aqueous and methanol	196.9 ± 0.036 µg/ml	α-Glucosidase	Antidiabetic effect		[293]
161.	*Strychnos henningsii* Gilg	Aqueous	-	Mice	Anti-inflammatory and analgesic effects	Highly toxic LD_{50} - 101.2 µg/ml	[294]
		Aqueous	125, 250 & 500 mg/kg	Rat	Antidiabetic action		[294]
		Aqueous	0.02 – 0.7 mg/ml	DPPH	Antioxidant activity		[294]
162.	*Strychnos madagascariensis* Poir.	Ethanol	0.01 mg/ml	*B. subtilis, S. aureus,* and *P. aeruginosa*	Antimicrobial activity	No records found	[295]
		Methanol, hexane, and ethyl acetate	0 – 5 mg/ml	α-Amylase, α-glucosidase, and pancreatic lipase	Antidiabetic action		[295]
		Ethanol	9.6 µg/ml	DPPH	Antioxidant effect		[295]
	Loranthaceae						
163.	*Plicosepalus acaciae* (Zucc.) Wiens & Polhill	Ethanol	150 & 300 mg/kg	–	Antimicrobial activity	Safe LD_{50} - 2000 mg/kg bw in rats	([296]; Kotb [297])
		Ethanol	150 & 300 mg/kg	Rat	Antidiabetic effect		(Kotb [297])
164.	*Englerina woodfordioides*	Chloroform, ethyl acetate, and aqueous	100 mg/ml	*S. aureus, E. coli,* and *P. aeruginosa*	Antimicrobial property	Safe LD_{50} - 2000	[298]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
	(Schweinf.) Balle ex M.G.Gilbert					mg/kg bw in mice	
	Malvaceae						
165.	*Hibiscus fuscus* Garcke	–	–	–	No records found	No records found	–
166.	*Grewia bicolor* Juss.	Ethanol	–	–	–	Safe LD_{50} – 2663.92 mg/kg bw in rats	[299]
167.	*Sida schimperiana* Hochst. ex A.Rich.	–	–	–	No records found	Safe $LD_{50} \geq 2500$ mg/kg bw in rats	[300]
	Meliaceae						
168.	*Azadirachta indica* A.Juss.	Aqueous	–	–	Immunomodulatory activity	Highly toxic LC_{50} - 233.061 µg/ml in brine shrimp	[26,301]
		–	0.7 – 1 mg/ml	*V. vulnificus*	Antimicrobial activity		[301]
		–	–	–	Antioxidant effect		[301]
		Aqueous	0.25 – 2 ml/kg, 400 mg/kg	Mice	Anti-inflammatory and analgesic actions		[301]
		Aqueous	400 mg/kg	Rat	Antipyretic activity		[301]
		–	400 mg/kg	Rat	Antidiabetic effect		[301]
169.	*Khaya senegalensis* Desr. A. Juss	Methanol, ethanol, and aqueous	–	*S. aureus, S. feacalis,* and *C. albicans*	Antimicrobial activity	Safe $LD_{50} \geq 5000$ mg/kg bw in mice	[302,303] .
		Acetone, ethanol and methanol	–	DPPH	Antioxidant action		[302]
170.	*Ekebergia capensis* Sparrm.	Aqueous	100 & 200 mg/kg	Rat	Anti-inflammatory and analgesic effects	Highly toxic LC_{50} - 100 µg/ml in brine shrimp	[93]
		Aqueous	4.7 – 25.5 µg/ml	DPPH	Antioxidant effect		[93]
		Aqueous and methanol	2.0 - 4.0 mg/ml	*S. aureus, S. epidermis,* and *B. subtilis*	Antimicrobial activity		[93]
	Melianthaceae						
171.	*Bersama abyssinica* Fressen	Methanol, ethyl acetate, chloroform, and aqueous	100, 200 & 400 mg/kg	Mice	Antipyretic activity	Safe LD_{50} - 2000 mg/kg bw in mice	[129]
	Molluginaceae						
172.	*Paramollugo nudicaulis* (Lam.) Thulin	–	–	–	No records found	No records found	–
	Myricaceae						
173.	*Myrica salicifolia* Hochst. ex A.Rich.	Petroleum ether, chloroform, chloroform, and methanol	0.3, 0.2 & 0.2 g/ml	*Shigela flexneri, E. coli,* and *S. agalactiae*	Antimicrobial effect	Safe LD_{50} - 2000 mg/kg bw in rats	[304]
	Myrtaceae						
174.	*Eucalyptus camaldulensis* Dehnh.	Aqueous and acetone	20 mg/ml	DPPH	Antioxidant activity	Safe $LD_{50} \geq 5000$ mg/kg bw in rats	[305,16]
		Ethyl acetate and aqueous	200 mg/L	*S. aureus, P. aeruginosa, C. albicans,* and *A. niger*	Antimicrobial effect		[305]
175.	*Eucalyptus globulus* Labill.	Hexane	–	Rat	Anti-inflammatory property	Safe LD_{50} - 1650 mg/kg bw in rats	[103,306]
		Aqueous	0.5 g/l	Mice	Antidiabetic effect		[103]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Hexane	–	Rat	Anti-asthmatic action		[103]
		Ethanol	–	–	Antimicrobial activity		[103]
176.	*Eucalyptus saligna* Sm.	–	40 mg/kg	*E. coli, S. aureus,* and *C. albicans*	Antimicrobial activity	Safe LD_{50} - 2000 mg/kg bw in mice	[307]
		–	40 mg/kg	Mice	Anti-inflammatory effect		[307]
177.	*Psidium guajava* L.	Ethanol	–	DPPH	Antioxidant effect	Safe $LD_{50} \geq 5000$ mg/kg bw in rats	[16,91]
		–	25, 50 & 100 mg/kg	Rat	Anti-inflammatory action		[91]
		Aqueous	300 mg/kg	Rat	Antidiabetic effect		[91]
		Aqueous	125 – 1000 µg/ml	*E. faecalis* and *S. aureus*	Antimicrobial activity		[91]
	Oleaceae						
178.	*Olea europaea* L.	Aqueous	200 mg/kg	Rat	Antidiabetic effect	Safe LD_{50} - 2000 mg/kg bw in mice	[308,309]
		Ethanol	100 mg/L	DPPH	Antioxidant action		[309]
		Olive	100 – 300 mg/kg	Mice	Anti-inflammatory and analgesic effects		[309]
		Alcoholic	–	*Chromobacterium violaceum*	Antimicrobial activity		[309]
179.	*Olea capensis* subsp. *macrocarpa* (C.H. Wright) I.Verd.	–	–	–	No records found	No records found	–
180.	*Olea capensis* L.	–	–	–	No records found	No records found	–
	Opiliaceae						
181.	*Opilia amentacea* Roxb.	Ethanol	100 – 300 mg/ml	*S. pyogenes* and *S. agalactiae*	Antimicrobial action	Safe LD_{50} - 2000 mg/kg bw in mice	[310,311]
		Aqueous	1 mg/ml	DPPH and ABTS	Antioxidant effect		[310]
		Methanol	5 mg/ml	Mice	Antidiabetic action		[310]
		Aqueous	200, 400 & 600 mg/kg	Mice	Anti-inflammatory action		[310]
	Passifloraceae						
182.	*Adenia gummifera* (Harv.) Harms	Methanol	0.1 mg/ml	DPPH	Antioxidant action	No records found	[312]
		Acetone	0.4 – 12 mg/ml	*E. coli* and *S. aureus*	Antimicrobial effect		[312]
	Penaeaceae						
183.	*Olinia rochetiana* A. Juss.	Chloroform and ethanol	1.95 – 15.6 mg/ml	*E. coli, P. aeruginosa, S. aureus*, and *S. typhi*	Antimicrobial action	Safe LD_{50} - 2000 mg/kg bw in mice	[313,314]
	Piperaceae						
184.	*Piper umbellatum* L.	Methanol and aqueous	3.25 – 400 mg/ml	*C. albicans* and *C. neoformans*	Antimicrobial activity	Safe LD_{50} - 2000 mg/kg bw in mice	[315]
		Ethanol and aqueous	–	Mice	Analgesic and anti-inflammatory effects		[316]
		Methanol	–	DPPH	Antioxidant effect		[316]
185.	*Piper capense* L.	–	–	–	No records found	No records found	–
	Phyllanthaceae						
186.	*Flueggea virosa* (Roxb. ex Willd.) Royle	Methanol	100 mg/kg	Mice	Anti-inflammatory and analgesic actions	Safe LD_{50} - 2000 mg/kg bw in mice	[317,318]
		Methanol and ethanolic	–	*Trichytum mentagrophytes* and *C. albicans*	Antimicrobial activity		[318]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Methanol	100 mg/kg	DPPH	Antioxidant action		[317]
	Plantaginaceae						
187.	*Plantago palmata* Hook.fil	–	–	–	No records found	No records found	–
	Plumbaginaceae						
188.	*Plumbago dawei* Rolfe.	Methanol	18.75 – 75 mg/ml	*S. typhi, S. aureus, E. coli,* and *P. aeruginosa*	Antimicrobial effect	No records found	[319]
	Poaceae						
189.	*Cymbopogon citratus* (DC.) Stapf	–	200 kg/ml	Rat	Anti-obesity activity	Safe $LD_{50} > 2000$ mg/kg bw in rats	[320,321]
		Methanol	–	DPPH	Antioxidant action		[322]
		Methanol	–		Antimicrobial effect		[322]
190.	*Sporobolus pyramidalis* P. Beauv.	Ethanol	10, 25 & 50 mg/kg	DPPH	Antioxidation effect	No records found	[323]
	Polygonaceae						
191.	*Oxygonum sinuatum* (Hochst. & Steud. ex Meisn.) Damm.	–	–	–	No records found	No records found	–
	Primulaceae						
192.	*Embelia schimperi* Vatke	Ethanol	25.6 –51.2 mg/ml	*S. aureus*	Antimicrobial activity	Safe $LD_{50} \geq 5000$ mg/kg bw in mice	[324,84]
	Ranunculaceae						
193.	*Clematis hirsuta* Guill. & Perr	n-hexane, chloroform, and methanol	0.5 – 1.0 mg/ml	*S. aureus, E. coli, P. aeruginosa*, and *S. typhi*	Antimicrobial activity	Safe LD_{50} - 2000 mg/kg bw in mice	[325,326]
		Methanol	0.5 – 1.0 mg/ml	DPPH	Antioxidant action		[325]
194.	*Clematis brachiata* Thunb.	Aqueous	100, 200 & 400 mg/kg	Rat	Anti-inflammatory effect	No records found	[104]
		Aqueous	100, 200 & 400 mg/kg	Rat	Antipyretic action		[326]
	Rosaceae						
195.	*Rubus apetalus* Poir	–	150 & 300 mg/kg	DPPH	Antioxidant action	Safe $LD_{50} > 2000$ mg/kg bw in mice	[327,328]
		–	150 & 300 mg/kg	Rat	Antidiabetic effect		[327]
	Rubiaceae						
196.	*Meyna tetraphylla* (Schweinf. Ex Hiern) Robyns	–	–	–	No records found	No records found	–
197.	*Gardenia ternifolia* Schumach. & Thonn.	Methanol	62.5 µl/ml	*S. aureus*	Antimicrobial action	Safe $LD_{50} > 2000$ mg/kg bw in mice	[329,16]
		Methanol	10, 50 & 100 µg/ml	COX-2 and LPS-stimulated J774A.1 macrophages	Anti-inflammatory effect		[329]
		Ethanol	1.5 – 21.0 mg/ml	DPPH	Antioxidant action		[329]
198.	*Syzygium cumini* (L.) Skeels	Ethyl acetate and aqueous	–	DPPH	Antioxidant action	Safe $LD_{50} > 5000$ mg/kg bw in mice	[330,331]
		Ethanol	0.5 – 1 g/kg	Rat	Antidiabetic effect		[330]
		Ethyl acetate and methanol	0.2 and 0.4 g/kg	Mice	Anti-inflammatory action		[330]
		–	0.1 g/kg	Mice	Anti-allergic action		[330]
		Ethanol	6 mg/kg	Mice	Antipyretic action		[123]

(*continued on next page*)

Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		Methanol	2 mg/ml	*P. aeruginosa, E. coli, S. aureus, C. albicans, B. subtilis* and *S. typhi*	Antimicrobial action		[331]
199.	*Keetia gueinzii* (Sond.) Bridson	Ethyl acetate, methanol, and chloroform	0.04 mg/ml	*Mycobacterium aurum, M. tuberculosis, M. smegmatis,* and *M. bovis*	Antimicrobial activity	Toxic LD_{50} - 300 mg/kg bw in mice	[26]
200.	*Coptosperma graveolens* (S. Moore) Degreef	–	–	–	No records found	No records found	–
201.	*Rubia cordifolia* L.	Hydro-alcoholic	300 & 600 mg/kg	Rat	Anti-inflammatory action	Moderately toxic LD_{50} - 1000 mg/kg bw in mice	[94]
		Ethanol	50 & 100 mg/kg	Mice	Antioxidant effect		[94]
		Methanol	1, 2.5, 5, 7.5 & 10 mg/ml	*B. cereus, B. pumilus, B. subtilis, M. luteus*, and *M. luteum*	Antimicrobial action		[94]
202.	*Coffea arabica* L.	Methanol	1 mg/ml	DPPH	Antioxidant action	Safe $LD_{50} > 2000$ mg/kg bw in rats	[332,333]
	Rhamnaceae						
203.	*Rhamnus staddo* A. Rich.	–	–	–	No records found	No records found	–
204.	*Rhamnus prinoides* L'Herit	–	19.5 – 78 mg/ml	*S. aureus, E. coli, B. cereus, P. aeroginosa,* and *S. faecalis*	Antimicrobial action	Safe $LD_{50} >$ 5000 mg/kg bw in rats	[334]
		Ethanol	0.286 mg/ml	DPPH	Antioxidant effect		[335]
		Ethanol	200 mg/kg	COX-2	Anti-inflammatory effect		[335]
	Rutaceae						
205.	*Zanthoxylum gilletii* (De Wild.) Waterman	Methanol	10 mg/ml	*E. coli, P. aeruginosa, S. aureus, B. subtilis*, and *C. albicans*	Antimicrobial activity	No records found	[336]
206.	*Harrisonia abyssinica* Oliv.	Ethanol, chloroform, and aqueous	1 mg/ml	*E. aerogenes, E. coli, P. vulgaris*, and *P. aeruginosa*	Antimicrobial action	Highly toxic LC_{50} -198.498 µg/ml in brine shrimp	[337,26]
207.	*Zanthoxylum asiaticum* (L.) Appelhans, Groppo & J.Wen	Methanol	1 – 50 µg/ml	Human lymphoblastic target cell line CEM-SS	Antimicrobial action	Weak toxicity $LD_{50} >$ 1000 mg/kg bw in mice	[338,171]
		–	0.8 ml/kg	Rat	Anti-inflammatory effect		[338]
		Ethanol	250 – 1000 mg/kg	Rat	Antipyretic effect		[338]
208.	*Clausena anisata* (Willd.) Hook.fil., De Wild. & Staner	Aqueous and chloroform	78 mg/kg	Mice	Analgesic effect	Moderately toxic LD_{50} - 393.70 ± 25.64 mg/kg bw in mice	[339]
209.	*Vepris simplicifolia* (Engl.) Mziray	–	–	–	No records found	No records found	–
210.	*Vepris nobilis* (Delile) Mziray	–	200 – 300 mg/kg		Anti-inflammatory and analgesic effects	Weak/low toxicity LD_{50} - 1600 mg/kg bw in mice	[125]
		–	50 mg/kg	Mice	Antipyretic action		[125]

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
		–	–	*P. gingivalis, B. megaterium,* and *S. mutans*	Antimicrobial actions		[125]
211.	*Vepris lanceolata* (Lam.) G. Don	–	–	–	No records found	No records found	-
212.	*Zanthoxylum chalybaeum* Engl.	Ethanol	–	*S. typhi* and *P. aeruginosa*	Antimicrobial effect	Weak/low toxicity $LC_{50} < 1000$ ug/ml in brine shrimp	[340]
			200 – 400 mg/kg	Rat	Antidiabetic property		[341]
213.	*Zanthoxylum usambarense* (Engl.) Kokwaro	Dichloromethane	–	*Coriolus versicolor, Coniophora puteana, Chaetomium globosum, Cladosporium resinae,* and *A. niger*	Antimicrobial action	No records found	[342]
214.	*Fagaropsis hildebrandtii* (Engl.) Milne-Redh.	Aqueous and hexane	200 & 400 mg/ml		Antimicrobial effect	Safe $LD_{50} > 5000$ mg/kg bw in mice	[343,344]
215.	*Citrus limon* (L.) Burm.fil.	–	400 mg/kg	DPPH	Antioxidant action	Safe $LD_{50} \geq 5000$ mg/kg bw in rats	[345,346]
		–	30 & 10 mg/kg	Mice	Anti-inflammatory action		[345]
		Aqueous	0.1 mg/ml	Rat	Anti-allergic action		[345]
		Acetone	4.5 mg/ml	*S. mutans*	Antimicrobial effect		[345]
		Ethanol	400 mg/kg	Rat	Antidiabetic activity		[345]
216.	*Citrus aurantiifolia* (Christm.) Swingle	–	2 mg/ml	*Malassezia furfur*	Antimicrobial effect	Safe $LD_{50} > 5000$ mg/kg bw in rats	[347–349]
		–	0 – 40 µg/ml	DPPH	Antioxidant action		[348]
	Salicaceae						
217.	*Dovyalis abyssinica* (A.Rich.) Warb.	n-hexane, dichloromethane, n-butanol, and aqueous	500, 1000 & 10,000 µg/ml	*E. coli, S. aureus,* and *E. faecalis*	Antimicrobial effect	Safe $LD_{50} >$ 1149.56 mg/kg bw in mice	[350,351]
		Methanol	1 mg/ml	DPPH	Antioxidant property		[352]
	Salvadoraceae						
218.	*Salvadora persica* L.	Ethanol	700 mg/kg	Rat	Anti-inflammatory and analgesic activities	Moderately toxic LD_{50} – 400 mg/kg bw in rats	[86,353]
		Ethanol, butanol, methanol, ethyl acetate, and hydro-alcoholic	–	DPPH	Antioxidant action		[86]
		Aqueous	–	*S. faecalis*	Antimicrobial effect		[86]
	Santalaceae						
219.	*Osyris lanceolata* Hochst. & Steud.	n-hexane, chloroform, methanol, and aqueous	0 – 300 µg/ml	DPPH	Antioxidant action	No records found	[354,355]
		Aqueous and methanol	294 – 301 µg/ml	*S. aureus*	Antimicrobial action		[354]
	Sapindaceae						
220.	*Zanha africana* (Radlk.) Exell	Methanol	0.1, 0.5, 1.0 & 5.0 mg/ml	*Seratia marcescens, Bacillus pumilus, Micrococcus kristinae, Enterobacter cloacae, Enterobacter aerogenes, E. coli, P. vulgaris, B. Cereus, B. subtilis,* and *S. aureus*	Antimicrobial effect	Highly toxic LC_{50} 41.1 - 240.0 µg/ml in brine shrimp	[356,16]
	Solanaceae						

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Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
221.	*Solanum incanum* L.	Methanol	–	DPPH	Antioxidant effect	Safe $LD_{50} > 2000$ mg/kg bw in mice	[357,16]
		Ethanol	–	*E. coli, S. pyogenes, S. aureus,* and *P. aeuruginosa*	Antimicrobial action		[357]
		Dichloromethane and methanol	50 & 100 mg/kg	Rat	Antipyretic effect		[357]
222.	*Solanum americanum* Mill.	–	–	–	No records found	No records found	–
223.	*Physalis peruviana* L.	Ethanol	0.5 – 2 mg/ml	*Lactococcus lactis, Chromobacterium violaceum, Erwinia herbicola, S. aureus, S. epidermidis,* and *E. coli*	Antibacterial action	Safe $LD_{50} > 5000$ mg/kg bw in rats	[358,359]
		Ethanol	100 & 1000 mg kg	Mice	Anti-inflammatory effect		[359]
		Ethanol	0.5 – 2 mg/ml	TEAC	Antioxidant effect		[358]
224.	*Solanum mauense* Bitter	–	–	–	No records found	No records found	–
225.	*Solanum aculeastrum* Dunal	–	–	*A. flavus, P. notatum A. niger, C. albicans*, and *F. oxysporum*	Antimicrobial action	No records found	[360]
226.	*Nicotiana tabacum* L.	Methanol	100, 200 & 300 mg/kg	Mice	Analgesic and anti-inflammatory effects	Highly toxic $LD_{50} > 1$ mg/kg bw in rat	[361,16]
		–	600 µg/ml	DPPH and ABTS	Antioxidant effect		[361]
		Hydro-ethanolic	40 & 80 mg/kg	Rat	Antidiabetic action		[361]
		Methanol and aqueous	25 – 100 mg/ml	*S. pyogenes* and *C. albicans*	Antimicrobial activity		[361]
227.	*Withania somnifera* (L.) Dunal	–	1.0 mg/kg	Mice	Immunomodulatory effect	Safe $LD_{50} > 2000$ mg/kg bw in mice	[362,363]
		Aqueous and hydro-methanolic	–	*Corynebacterium diphtheriae, S. aureus, S. epidermidis,* and *B. subtilis*	Antimicrobial action		[363]
		–	300 mg/kg	–	Anti-inflammatory activity		[364]
		Aqueous and hydro-methanolic	–	DPPH	Antioxidant action		[363]
	Sterculiaceae						
228.	*Dombeya burgessiae* Gerrard ex Harv. & Sond.	Ethanol and dichloromethane	12.5 – 0.098 mg/ml	*B. subtilis, S. aureus, E. coli,* and *K. pneumoniae*	Antimicrobial activity	No records found	[365]
	Stilbaceae						
229.	*Nuxia congesta* R. Br.	–	–	–	No records found	No records found	–
	Ulmaceae						
230.	*Trema orientalis* (L.) Blume.	Aqueous and methanol	–	DPPH	Antioxidant activity	Safe $LD_{50} > 2000$ mg/kg bw in mice	[366,367]
		Aqueous and chloroform	100 & 200 mg/ml	*S. aureus, K. pneumoniae, P. flourescens, P. mirabilis*, and *E. coli*	Antimicrobial action		[367]
		Methanol	200 & 400 mg/kg	Rat	Anti-inflammatory and analgesic effects		[367]
		Methanol	250 & 500 mg/kg	Rat	Antidiabetic activity		[367]
	Urticaceae						
231.	*Urtica massaica* Mildbr	Methanol	150 – 600 mg/ml	*E. coli, Salmonella sp*, and *S. aureus*	Antimicrobial effect	No records found	[368]
	Ximeniaceae						

(*continued on next page*)

Table 4 (*continued*)

	Family/Species	Extract/fraction	Doses	Experimental model	Pharmacological effect	Toxicity	References
232.	*Ximenia americana* L.	Methanol	100 mg/ml	*B. subtilis, S. aureus, E. coli* and *P. aeruginosa*	Antimicrobial activity	Safe LD_{50} > 5000 mg/kg bw in rats	[369,370]
		Methanol	20, 40, 60, 80, 100, 200 & 500 µg/ml	DPPH and FRAP	Antioxidant action		[371]
		Methanol and aqueous	100 – 500 µg/ml	Egg albumin	Anti-inflammatory actions		[372]
	Verbenaceae						
233.	*Lippia javanica* (Burm.f.) Spreng	–	12.08, 6.04, 3.02, 1.51 & 0.76 mg/ml	*E. coli, K. Pneumoniae, P. aeruginosa, S. Aureus, S. Pneumoniae,* and *C. albicans*	Antimicrobial action	Safe LC_{50} 1138 ± 1.33 µg/ ml in brine shrimp	[373,16]
234.	*Lantana camara* L.	Methanol, ethyl acetate, acetone, and chloroform	100 –1000 µg/ ml	DPPH	Antioxidant action	Safe LD_{50} - 5000 mg/kg bw in mice	[374,375]
		Acetone	0.39 – 6.3 mg/ml	*E. coli, P. aeruginosa, E. faecalis,* and *S. aureus*	Antimicrobial effect		[376]
		ethanol, dichloromethane, ethyl acetate, butanol and aqueous	30 mg/kg	Rat	Anti-inflammatory and analgesic actions		[376]
		Methanol	10 – 300 mg/kg	Rat	Antipyretic effect		[376]
235.	*Lantana trifolia* L.	Ethyl acetate, n-butanol, dichloromethane, hexane, and aqueous	30 mg/kg	Mice	Anti-inflammatory and analgesic effects	Safe LD_{50} > 2000 mg/kg bw mice	[377,378]
		Ethanol	18.75 mg/ ml	*S. aureus, S. epidermidis, E. faecalis, Corynebacterium sp., E. aerogenes, P. aeruginosa, Mycobacterium sp.,* and *E. coli*	Antimicrobial action		[379]
236.	*Cissus rotundifolia* (Forssk.) Vahl	Aqueous and methanol	12.5 – 50 mg/ml	α- Glycosidase	Antidiabetic action	Safe LD_{50} > 2000 mg/kg bw in mice	[380,381]
	Vitaceae						
237.	*Cyphostemma ukerewense* (Gilg) Desc.	–	–	–	No records found	No records found	–
238.	*Cissus aphyllantha* Gilg ex Gilg & Brandt	–	–	–	No records found	No records found	–

are associated with increased oxidative stress resulting from an imbalance between excess production of free radicals and antioxidant levels in the body [86]. Antioxidants are likely to have beneficial effects in managing chronic obstructive pulmonary disease [87]. Plant extracts offer protection against free radical-mediated lipid peroxidation and are valuable for their traditional utilization against allergic and inflammatory ailments. The antioxidative mechanisms of action are illustrated in Fig. 9.

An *in vitro*-based anti-lipid peroxidation study using ethanolic extracts derived from the whole plant of *S. occidentalis* using hepatic microsomes dose-dependently (50 – 100 µg/ml) showed a significant reduction in malondialdehyde level, indicating its antioxidant potential [88]. In a study by Mohamed & Khan [89], it was observed that the methanol extract derived from *S. persica* roots demonstrated scavenging activity in DPPH (half-maximal inhibitory concentration, IC_{50} = 4.8 µg/ml) and ABTS radicals (IC_{50} = 1.6 µg/ml). Three isolated metabolites from the methanol extract, including 2-furancarboxaldehyde-5-(hydroxymethyl) (**3**), furan-2-carboxylic acid-3-methyl-trimethylsilyl ester (**4**), and D-erythro-pentofuranose-2-deoxy-1,3,5-tris-O-(trimethylsilyl) (**5**), were suggested as phytoconstituents responsible for antioxidant effects [89]. Similarly, a study by Mohamed et al. [90] displayed that the ethanol extracts as well as several bioactive metabolites (quercetin-3-O-β-D-glucopyranoside (**6**), kaempferol-3-O-β-D-glucopyranoside (**7**), kaempferol-3-O-(6β-O-galloyl-β-D-glucopyranoside (**8**), and quercetin-3-O-(6-β-O-galloyl-β-D-glucopyranoside (**9**)) obtained from the leaves of *A. anthelminthica* had a potent scavenging effect towards DPPH. In addition, the isolated metabolites (guavinoside C (**10**), guavinoside F (**11**), quercetin (**12**), quercetin-3-O-a-L-arabinofuranoside (**13**),

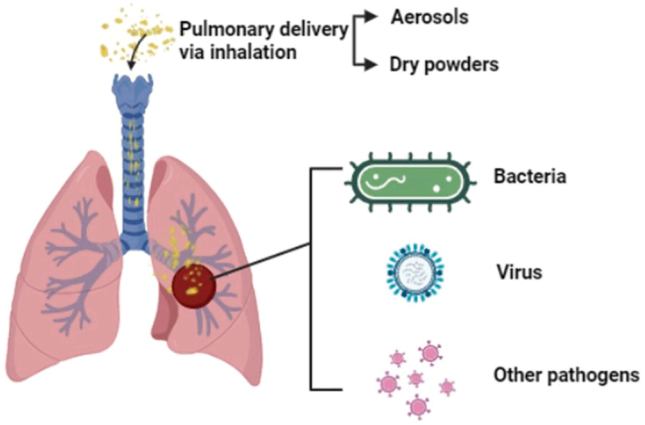

Fig. 8. Delivery strategy of microbial-agents related to respiratory ailments.

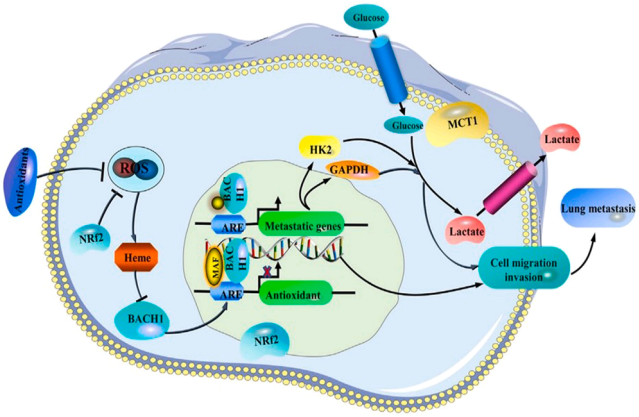

Fig. 9. Possible antioxidative mechanisms of action of medicinal plants [94].

and quercetin-3-O-a-L-arabinopyranoside (**14**)) from *P. guajava* (**Supplementary Table 3**) showed strong antioxidant properties in DPPH assay [91]. Some of their representative chemical structures are demonstrated in Fig. 13. Portia [92] showed that the orally administered *C. falcifolia* ethanol extract at 200 and 400 mg/kg doses exhibited *in vivo* antioxidant effect in mice after 14 days by increasing the levels of superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPX), glutathione reductase (GR), and decreasing malondialdehyde (MDA) levels in the brain significantly ($p < 0.05$). In addition, the *in vitro* assessment showed that the extract was able to scavenge free radicals (DPPH radical scavenging assay) and chelate metal (ferrous ion chelating assay), displaying maximum activity at the concentration of 5000 μg/ml.

Steganotaenia araliacea, primarily used in African traditional medicines to treat pneumonia, asthma, sore throat, and fever has been shown to possess antioxidant effects [81]. In this investigation, various extracts, including dichloromethane, aqueous, and hexane at varying concentrations (0.06125 – 500 μg/ml) obtained from the stems, were assessed for their capacity to scavenge DPPH. The findings indicated that hexane ($IC_{50} = 5.62$ μg/ml) and dichloromethane ($IC_{50} = 1.26$ μg/ml) extracts exhibited significant antioxidant activity [81]. The leaves of *T. zeylanicum* assessed for antioxidant potential using hexane, ethyl acetate, and methanol extracts by phosphomolybdenum, DPPH, metal chelating, and hydroxyl radical scavenging assays showed that the ethyl acetate fraction was observed to possess strong antioxidant activity ($p < 0.05$) [83]. Moreover, the DPPH scavenging assay of various extracts obtained from *E. capensis* displayed weak activity in dichloromethane extract ($IC_{50} = 366.6$ μg/ml), while ethyl acetate, butanol, and methanol extracts were active ($IC_{50} = 14.0 – 20.2$ μg/ml) [93].

Anti-inflammatory and analgesic activities

Inflammation occurs due to the defense mechanisms of innate immunity against invading agents like viruses, fungi, and bacteria. Respiratory inflammation is usually triggered by air-mediated illnesses induced by smoke, polluted air, bacteria, and viruses, which cause a variety of complications such as coughs, common cold, bronchitis, pneumonia, and breathing difficulties [95]. Chronic airway inflammation is linked to upregulated signalling pathways, cytokines, and transcriptional activity of NF-κB [96]. Remarkable anti-inflammatory activity of plant-derived natural products is exhibited through the inhibition of pro-inflammatory mediators (Fig. 10) [97].

For instance, the effect of withaferin-A (**15**) bioactive metabolite screened from *W. somnifera* was investigated on ovalbumin (OVA)-induced airway in mice. This phytocompound reduced inflammatory cell infiltration into the bronchoalveolar lavage fluid (BALF) and the expression of pro-inflammatory cytokine in the lung tissue. Further, it decreased OVA-induced lung fibrosis through TGF-β1 and ERK1/2 inactivation as well as suppressing the nucleotide-binding domain, leucine-rich–containing family, pyrin domain–containing-3 (NLRP3) activation [98]. The *in vivo* anti-inflammatory study using carrageenan mice showed that *C. occidentalis* significantly reduced inflammation through inhibition of paw oedema at a dose of 250 mg/kg, with flavonoids suggested to exert inhibitory effects on enzymes involved in the production of inflammatory mediators [88]. In another investigation, the orally administered ethyl acetate extract obtained from the leaves of *S. persica* at the concentration of 500 mg/kg bw showed significant anti-inflammatory activity against carrageen-induced paw oedema in rats (45.16%), comparable to indomethacin (51.61%) [99]. Several bioactive metabolites, including apigenin rhamno-glucoside (**16**), luteolin glucoside (**17**), and rutin (**18**) obtained from the ethyl acetate fraction of *S. persica* at 100 mg/kg exhibited anti-inflammatory property through diverse mechanisms of action (Fig. 10), when orally administered to adult rats [100]. In addition, euphol (**19**) administered in 30 and 100 mg/kg dose levels by carrageenan-induced mechanical hyperalgesia showed its potency in managing inflammatory conditions [101]. Besides, 200 mg/kg concentration of *C. papaya* leaf extracts showed maximum anti-inflammatory effect (6.7%) in carrageenan mice and was comparable with the reference drug indomethacin (11.4%) [102].

A study by Ahmad et al. [103] examined the anti-inflammatory actions of *A. sativum* ethanol extract in the prevention of lung damage in smoker rat model. Smoker rats were treated with the extract for 20 days, and the histological preparation of lung organs observed under a microscope. The findings showed improvement in lung structure in smoker group treated with *A. sativum* extract compared to the control groups (untreated ones and those exposed to smoke only). In addition, the treated group was found to have clean bronchi, decreased infiltration of inflammatory cells, reduced leucocytes, and a decrease in dilated alveoli from about 50% to less than 30% in surface area. These results showed the potency of *A. sativum* ethanol extract in the prevention of lung damage in smoker rat model [103]. The anti-inflammatory effect of *C. brachiata* aqueous extract at various concentrations (100, 200, and 400mg/kg) was investigated using carrageenan and histamine-induced edema models in rats. The extracts dose-dependently showed reduction in the volume of paw edema ($p < 0.05$) [104].

The anti-inflammatory efficacy of chloroform extract obtained from *T. Zeylanicum* roots was displayed in induced oedema by carrageenan, dextran, histamine, and serotonin against granulation tissue formation by cotton pellet in rats. The extract dose-

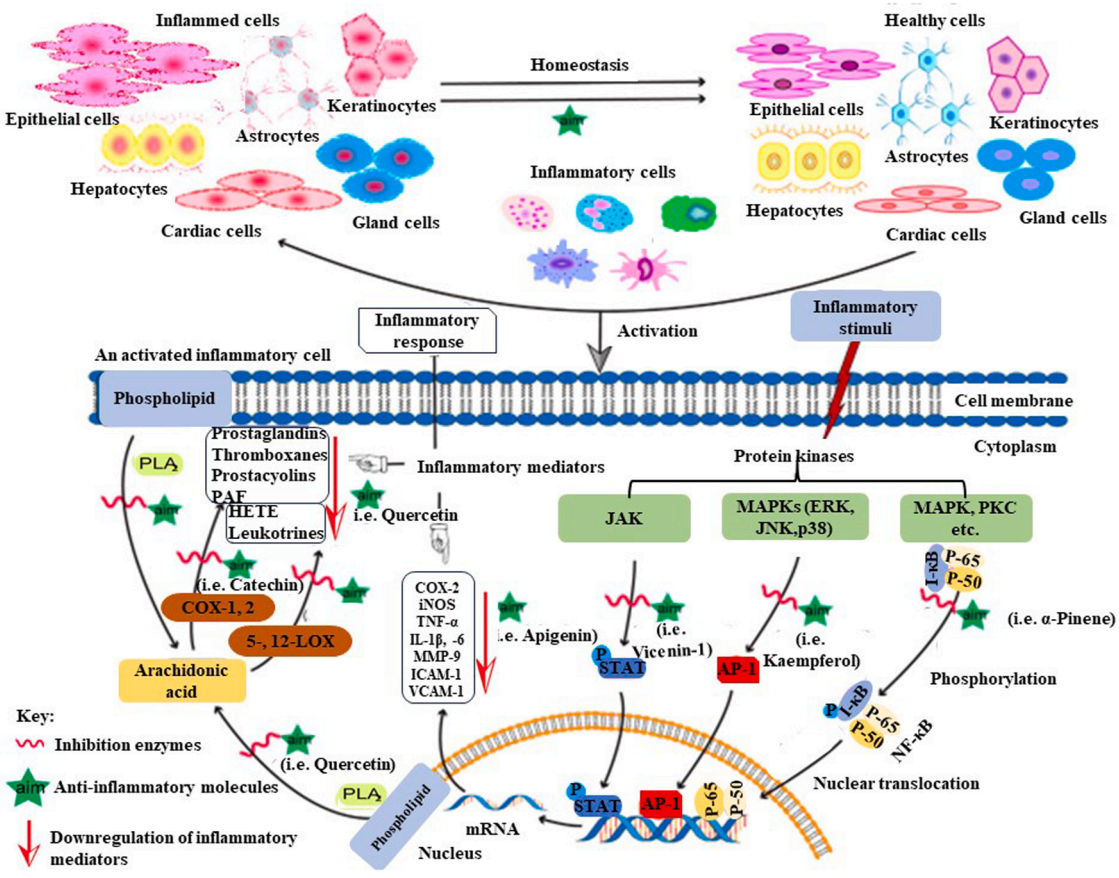

Fig. 10. Possible pathways representing mechanisms of anti-inflammatory molecules of medicinal plants.

dependently displayed significant anti-inflammatory activity ($p < 0.001$) in acute and chronic inflammatory models at the concentrations of 50, 100, and 200 mg/kg, and inhibited dextran, histamine, and serotonin-induced paw oedema in rats. The extracts inhibited granuloma weight by 15.42 and 21.12% at the concentrations of 100 and 200 mg/kg, respectively compared to indomethacin (29.29%) and dexamethasone (34.13%) [83]. In another investigation, the ethanol, dichloromethane, petroleum ether, and aqueous leaf and bark extracts obtained from *E. capensis* displayed moderate to high (40 – 90%) inhibitory activity towards COX-1 and insignificant to high (<20 – 85%) inhibition towards COX-2 at 250 μg/ml concentration [93]. In summary, these findings support the traditional uses of numerous medicinal plants as potential phyto-therapeutic agents against persistent inflammatory ailments such as bronchitis and pneumonitis.

Anti-allergic and anti-asthmatic activities

Excessive type 2 inflammation is related to diverse allergic illnesses, including asthma [105]. The prevalence of asthma has increased steadily in the last few decades [96]. Duechs et al. [106] showed that intratracheal stimulation of innate cells using adjuvants or immunomodulators at the concentration of 0.001 – 1.0 mg/kg skewed T-helper 2 (Th2) cell immune response to T-helper type 1 (Th1) response, causing attenuated allergic immunity, reduced histamine, and decreased eosinophil levels in allergic mice models. Diverse medicinal plants have been suggested as potential remedies in alleviating allergic conditions such as asthma triggered by type 2 inflammation. For instance, ethanol extract prepared from aerial parts of *E. hirta* was examined for anti-anaphylactic properties. Administration of 100 – 1000 mg/kg concentration of the extract to the mice inhibited passive cutaneous anaphylaxis. In addition, the suppressive effect of ethanol extract was exhibited through the release of tumour necrosis factor alpha (TNF-α) and Interleukin-6 (IL-6) from anti-DNP-HAS activated rat peritoneal mast cells, and thus is significant in managing asthma [107]. In another investigation, *E. hirta* was reported to possess antiashmatic property due to the relaxation effect on bronchial tubes [108]. Besides, the anti-asthmatic activity of the ethanol extracts obtained from the roots of *R. communis* at 100 – 150 mg/kg concentration was investigated on milk-induced leucocytosis, eosinophilia, and mast cell degranulation in mice as well as passive cutaneous anaphylaxis in rats [109]. In this study, the extracts significantly reduced milk-induced leucocytosis and eosinophilia. In addition, the extracts protected degranulation of mast cells in rats. The flavonoids {apigenin (**20**) and luteolin (**21**)} and saponin metabolites were regarded as potential mast cell stabilizing and anti-anaphylactic agents, showing the efficacy of *R. communis* in asthma prevention [109]. *In vivo* and *in vitro* animal models used to assess the anti-asthmatic activity of aqueous *M. pudica* extracts dose-dependently showed contraction of goat tracheal chain and protected degranulation of mast cells and histamine-induced bronchospasm [110].

The effects of extract prepared from *M. indica* extract and its major bioactive metabolite (mangiferin (**22**)) on lung inflammation response and production of Th2 cytokines were investigated in murine experimental model of allergic asthma in BALB/c mice [111]. The mice were orally administered with 50 – 250 mg/kg of the extract or 50 mg/kg mangiferin for 24 days, and anti-ovoalbumin (OVA) immunoglobulin E, interleukin (IL)-4, and IL-5 evaluated by enzyme-linked immunosorbent assay (ELISA). The findings showed that *M. indica* extracts and mangiferin (**22**) caused reduction in airway inflammation in bronchi and vessels, and inhibited IL-4 and IL-5 cytokines, thus essential therapy for asthma mice [111]. Ethanolic extract (500 mg/kg) obtained from *A. aspera* exhibited a bronchoprotective effect in toluene diisocyanate-induced occupational asthma in Wistar rats, with a significant decrease in neutrophils and eosinophils in blood [112]. In addition, petroleum ether extract at 200 mg/kg concentration displayed a significant antiallergic effect in milk-induced leukocytosis and eosinophilia in mice [83].

Isoflavanquinones (Abruquinone A (**23**), Abruquinone B (**24**), Abruquinone D (**25**), and Abruquinone F (**26**)) metabolites screened from the roots of *A. precatorius* showed a strong anti-allergic effect at the concentration of 10 μg/ml in mast cell degranulation tests, through their inhibition with the IC_{50} value of less than 1 μg/ml [113]. Administration of *S. occidentalis* extract at the concentration of 250 mg/kg displayed significant prevention of degranulation of mast cells compared to the standard drug disodium cromoglycate [88]. These results validate the traditional use of diverse plant extracts as remedies for asthmatic and allergic-related complaints.

Antitussive activity

Antitussives (commonly known as cough suppressants) are typically used to suppress irritating and dry coughs. Several medicinal plants have been identified as capable of managing respiratory ailments (Table 4). For instance, an investigation by Mandal et al. [114]

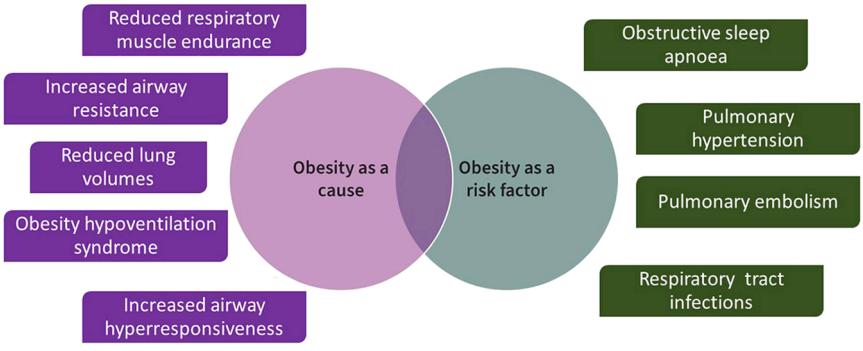

Fig. 11. Obesity as a causative and a risk factor in the respiratory system.

on methanol extract prepared from the roots of *A. racemosus* showed significant antitussive activity against sulfur dioxide-induced cough in mice. In this study, the orally administered extract at the concentration of 200 and 400 mg/kg dose-dependently produced 40 – 58.5% inhibition of SO_2-induced cough in mice, comparable to codeine phosphate standard (10 and 20 mg/kg, p.o), which showed 36 and 55.4% inhibition, respectively [114]. The tested methanolic extract obtained from the whole plant of *T. Zeylanicum* at 100 mg/l against sulphur oxide-induced cough reflex in Swiss albino mice displayed remarkable cough frequency suppression compared to codeine phosphate (conventional medication) [83]. These findings show that medicinal plants may be an alternative strategy for the development of novel antitussive agents.

Anti-obesity and antidiabetic activities

Obesity is a significant disease modifier and risk factor in numerous respiratory conditions. Normal functioning of the lungs is usually altered by the accumulation of fat in the mediastinum and chest wall, causing reduced airflow and airway hyperresponsiveness [115]. As a risk factor, obesity is associated with increased risks of pulmonary hypertension, obstructive sleep apnoea, pulmonary embolism, and respiratory tract infections (Fig. 11), such as asthma and its related symptoms like orthopnea, wheezing, and dyspnea [116].

Interestingly, a vast number of studies have documented the anti-obesity potency of diverse medicinal plants. For instance, Khan et al. [117] observed changes in high-density lipoprotein and triglyceride concentration in rats. In this study, the various extracts prepared from *S. persica* roots at a dose of 250 – 500 mg/kg presented a greater reduction in blood glucose levels (77%), comparable to the standard drug glibenclamide (79%). The aqueous extracts at 100 - 400 mg/kg concentration obtained from *C. papaya* seeds were effective in hypo-glycemia and hypo-lipidemia [102]. *Carica papaya* seeds have also been proven to be beneficial in treating type 2-diabetes mellitus through inhibition of α-amylase and α-glucosidase enzymes [118]. Antidiabetic efficacy of *T. zeylanicum* was examined using hexane, acetone, methanol, and aqueous extracts in type 2 diabetes mice induced by strepozotocin and nicotinamide *in vivo* and *in vitro* amylase assay at 200 and 400 mg/kg bw in rats [83]. The findings showed that methanolic extracts inhibited glucose absorption effectively. Additionally, the extract exhibited moderate anti-amylase action compared to acarbose, displaying the anti-diabetic potential of *T. zeylanicum* [83].

Immunomodulatory activity

Immunomodulatory substances can alter immune responses by either stimulating, suppressing, or modulating components of both the innate and adaptive immune system [105]. Immunomodulatory properties of medicinal plants have been extensively studied in recent years due to increasing awareness of modulation strategy of the immune system to combat infectious ailments such as viral infections. The mechanisms by which medicinal plants exert immunomodulatory activity are shown in Fig. 12 [118].

The orally administered doses at 400 and 800 mg/kg prepared from the aqueous leaves extract of *C. papaya* were tested on Wistar rats for 14 days. The results displayed a significant increase in paw edema (2.95 ± 0.107 - 3.73 ± 0.077 mm), comparable with levamisole standard (5.24 ± 0.045 mm), showing its potential immunomodulatory activity [102]. Bioactive metabolites (pheophorbide A (**27**) and saponins) isolated from the leaves of *C. papaya* showed cytotoxic activity on SCC25 cancer cells as well as stimulated cell- and antibody-mediated immunity, respectively [118]. In addition, the screened compound Withaferin A (**15**) from *W. somnifera* inhibited neutrophil adhesion, migration, and respiratory burst [105]. Similarly, the presence of tannins screened from the leaves of *R. communis* increased phagocytic function of human neutrophils, exerting immunomodulatory effects [119].

An investigation by Khanna et al. [120] showed that the alcoholic extract prepared from *A. aspera* at 100 mg/kg lowered serum cholesterol (60%), phospholipids (51%), triglyceride (33%), and total lipid (53%) levels. In another study, leaf extract obtained from *P. peruviana* was an effective inhibitor of LPS-induced nitric oxide (NO) generation, prostaglandin E2 (PGE2) production, and

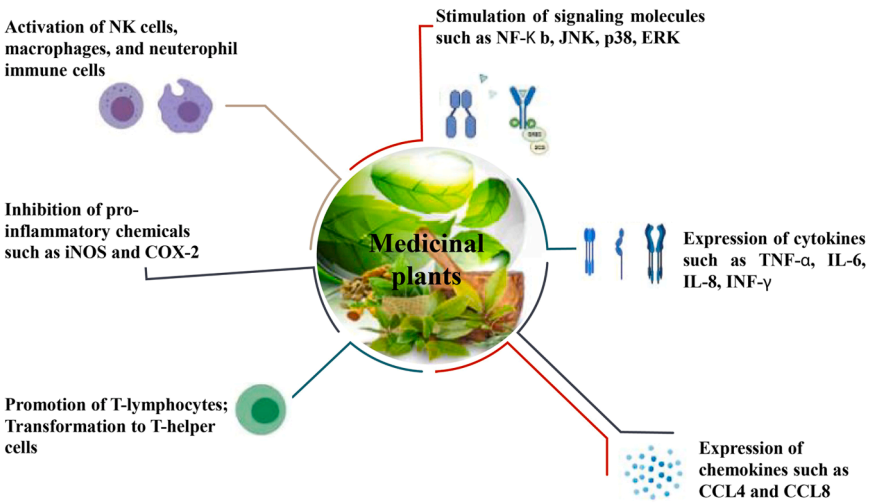

Fig. 12. General immunomodulation mechanisms shown by medicinal plants.

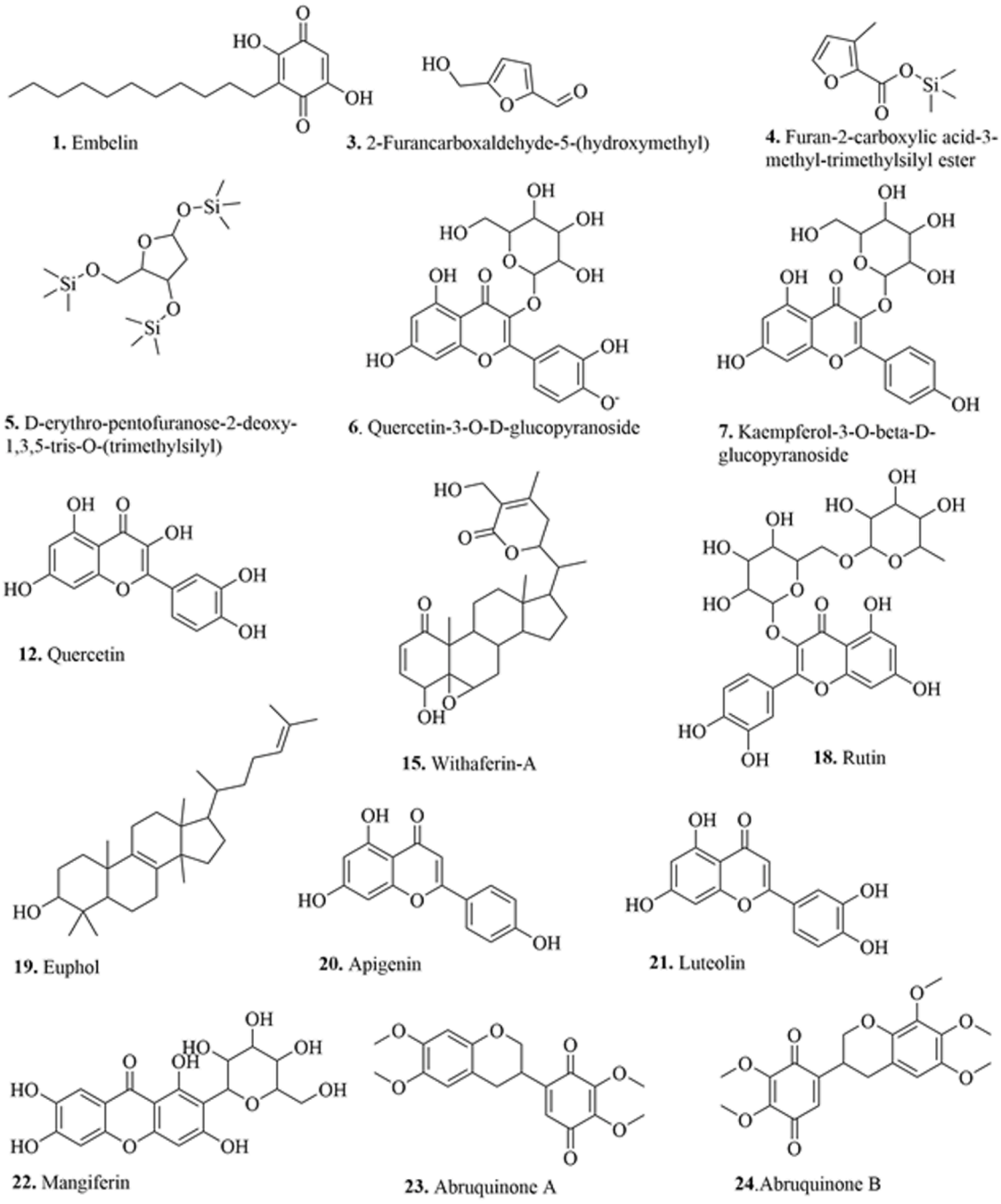

Fig. 13. Chemical structures of some bioactive metabolites.

pro-inflammatory enzymes (inducible nitric oxide synthase_iNOS and COX-2) [121]. On the other hand, the hydroalcoholic fruit extract dose-dependently (3.13 – 1000 μg/ml) reduced the release of IL-6, interleukin 8 (IL-8), and monocyte chemoattractant protein-1 (MCP-1) [122]. These findings are associated with the immunomodulatory/immunosuppressive activity of some medicinal plants, suggesting that they may have an adjuvant role in inflammatory airway and lung ailments.

Antipyretic activity

Pyrexia (fever) is an abnormal increase in body temperature above physiological range, and it's a common response to infection or inflammation [123]. An increase in biosynthesis of prostaglandin E2 (PGE2) in pre-optic region of hypothalamus alters the firing rate of neuron, inducing fever [124]. Anti-pyretic drugs usually inhibit COX-2 expression, causing reduced PGE2 biosynthesis, which is the

primary fever mediator [125]. Medicinal plants have been studied for antipyretic activity by different researchers [104,126,127]. Several investigations showed that diverse extracts obtained from *S. occidentalis* administered to yeast-induced hyperpyrexic rats at 150 – 400 mg/kg concentration resulted in yeast-induced fever reduction in rats [126]. Mostafa et al. [104] showed that the aqueous extract at various concentrations (100, 200, and 400 mg/kg) prepared from *C. brachiata* dose-dependently reduced brewer's yeast-provoked elevated body temperature significantly ($p < 0.05$) in brewer's yeast-induced hyperthermia model in rats. Several bioactive metabolites, including flavonoids, alkaloids, and saponins screened from *S. cumini* and *C. brachiata* have been implicated as antipyretic agents through TNF-α suppression [104,123]. Veronica et al. [127] showed that the dichloromethane stem bark extract obtained from *A. mellifera* exhibited antipyretic effects at 50, 100, and 150 mg/kg bw on experimental animal model (rat), with the screened metabolite {β-sitosterol (**28**)} demonstrating antipyretic activity through TNF-α inhibition. The methanolic, ethyl acetate, chloroform, and aqueous fractions prepared from the leaves of *B. abyssinica* at 100, 200 & 400 mg/kg concentration displayed significant antipyretic potential ($P<0.05$) against yeast-induced pyrexia in mice [128,129].

Bioactive metabolites contribute to the antipyretic effect primarily through cyclooxygenase enzyme inhibition and inflammatory prostaglandins synthesis interruption in hypothalamus [126]. Reducing pro-inflammatory mediators such as serotonin, histamine, and prostaglandin that boost antipyretic messages in brain as well as anti-inflammatory signals at injury sites may contribute to the antipyretic action of extracts/and bioactive compounds [130]. For instance, chrysophanol (**29**) contributed significantly to the reduction of body temperature compared to the methanol extract [131]. These studies support the folklore use of several medicinal plants in treatment and management of fever (Table 1 & 2).

The positive correlation between plant extracts/and bioactive metabolites contributes to the exhibited biological activities by medicinal plants (Fig. 14 & Table S4). Findings of this study on the pharmacological potential of therapeutic plants justify their role in managing respiratory disorders such as coughs, common colds, pneumonia, asthma, chest problems, and tonsils/tonsillitis, among others (Table 1 & 4).

The findings of this study indicate that antimicrobial potential of several medicinal plants used to remedy respiratory disorders is associated with their traditional use to remedy diverse ailments, including common cold, flu, tuberculosis, sore throat, and pneumonia. The anti-inflammatory and analgesic effects of these plants are related to their folkloric use to treat pneumonia, asthma, bronchial complications, and tonsillitis, among others. The therapeutic use of several medicinal plants to cure coughs is linked with their antitussive property. Traditional application of therapeutic plants to manage asthma-related ailments is attributed to their anti-allergic and anti-asthmatic properties. The immunomodulatory activity of diverse studied plants correlates with their folkloric application in managing diverse respiratory tract infections such as pneumonia, bronchial complications, asthma, tonsils/tonsillitis, cold, and flu. In addition, the antioxidation property confirms their traditional medicinal use to remedy pneumonia, bronchial complications, asthma, tonsils/tonsillitis, colds, and flu. Medicinal plants with antipyretic properties might alleviate respiratory conditions such as bronchitis and pneumonia that often show symptoms like fever. Additionally, numerous respiratory conditions like pulmonary hypertension, airway hyperresponsiveness, and asthma-related symptoms like orthopnea, wheezing, and dyspnea may be managed by medicinal plants with anti-obesity/anti-diabetic potential (Fig. 15, Table 1 & 4).

Our findings show that majority of the studies primarily focused on crude extracts, while the individual phytoconstituents responsible for biological effects are still unexplored. In addition, most investigations related to biological activities were merely random screenings with no scientific connotations between traditional uses and pharmacological properties. Nevertheless, more *in-vitro* and *in vivo* studies are required to establish the complete pharmacological profile of the studied medicinal plants to validate their efficacy in the treatment and/or management of respiratory ailments.

Toxicity

The belief that natural products are safer compared to conventional drugs has caused remarkable increase in their use by consumers in managing different ailments. Despite plants serving as rich sources of bioactive metabolites with promising pharmacological properties, some of them may be toxic and elicit adverse effects upon human consumption [89].

Among the medicinal plants documented to remedy respiratory disorders (Table 1), 127 (53%) species have been profiled for toxicity. In these investigations, rodent acute toxicity test and Brine Shrimp Lethality Test (BSLT) were the commonly used techniques among the studies. These tests were highly employed since they are probably simple to use, cost-effective, and provide reliable results [382]. Toxicity is usually categorized according to the concentration of herbal plant extracts that result in a 50% mortality rate among brine shrimps (LC_{50}) and mice or rats (LD_{50}) in toxicological studies [383,16].

Plant-derived extracts can be toxic at higher doses but induce therapeutic properties at low or non-toxic doses. At low doses, a toxic plant extract might have pharmacological benefits, while it might become toxic or harmful at higher doses. An extract is considered highly toxic if the LC_{50} is less than or equal to 249 µg/ml, moderately toxic if it's between 250 and 499 µg/ml, weak or low toxicity if it varies from 500 and 999 µg/ml, and safe or non-toxic if its greater than/or equal to 1000 µg/ml in BSLT test [383]. Moreover, the LD_{50} between 0 and 49 mg/kg bw is regarded as highly toxic, 50 – 299 mg/kg bw as toxic, 300 – 999 mg/kg bw as moderately toxic, 1000 – 1999 mg/kg bw as mildly toxic, while 2000 to greater than 5000 mg/kg bw is considered non-toxic in rodent acute toxicity tests [16]. In this study, the toxicological investigation among the listed medicinal plants utilized to remedy medicinal conditions showed that 92 plant species (39%) were safe or nontoxic, 16 plants (7%) were highly toxic, 10 plants (4%) were moderately toxic, 6 plants (3%) were weakly toxic, while 4 plants (2%) were toxic (**Supplementary Table 4**). However, there was no toxicological data on 100 (44%) documented plant species, although they are being ethno-medicinally utilized to remedy diverse ailments. Hence, it is essential to conduct toxicological screening for these plants.

Although herbal medicines are commonly presumed safe unless human-related risks are evident, a growing number of case reports

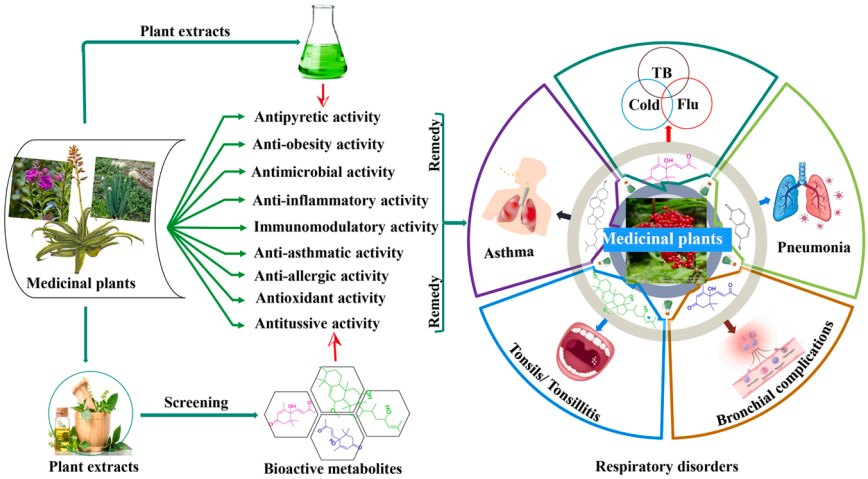

Fig. 14. Pharmacological properties of medicinal plants used to remedy respiratory infections.

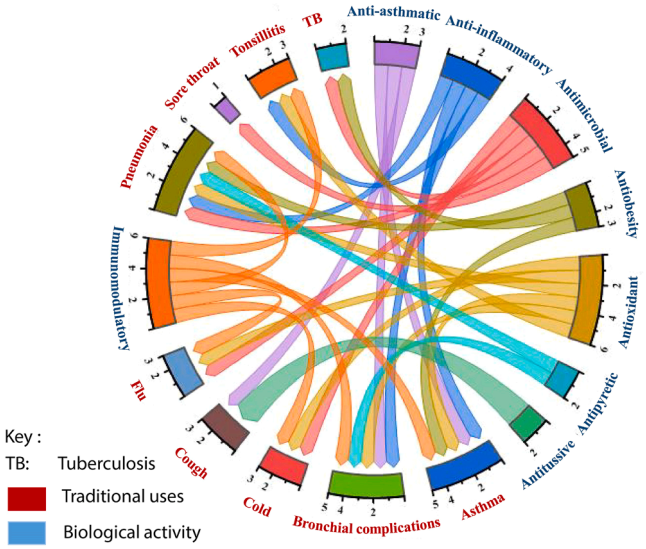

Fig. 15. Correlation between biological activities and traditional uses of medicinal plants used against respiratory ailments.

show instances of acute and chronic toxicity resulting from their usage [384]. Numerous factors such as certain phytochemical components, exposure to environmental contaminants, presence of adulterants, contamination by micro-organisms, dosage levels, method of extraction, preparation, and administration, and choice of animal species for testing, among others [385,16]. The toxicological effects vary from allergic reactions and mild gastrointestinal symptoms to carcinogenic effects, hepatic toxicity, cardiovascular, haematological, and neurological complications [384,386]. Local healers typically combat the high toxicity of plant extracts through various methods such as proper preparation, dosage control, and targeted formulations [16].

Conservation status

Increasing demand for medicinal plants in Kenya has caused excessive exploitation and indiscriminate over-harvesting of plant medicinal resources. Studies involving medicinal plants show a drastic decline in these resources due to unsustainable harvesting practices and habitat destruction (land fragmentation, deforestation, bushfires, land degradation, and overgrazing) primarily in the last two decades [14], which are linked to poverty and high unemployment rate. The extent to which medicinal plants are susceptible to overexploitation largely relies on the part utilized for medicinal purposes and harvesting techniques [50]. In the current study, leaves and roots were highly utilized in the preparation of herbal recipes. High preference for gathering the latter for traditional medicinal purposes poses a threat to the survival of target plants. Therefore, unsustainable harvesting of leaves and root organs can lead to species extinction [387].

In this study, the conservation assessment of 109 medicinal plant species used to manage respiratory disorders in Kenya has been reported based on the IUCN Red List criteria and categories. Among these species, 3 were data deficient (DD), 3 were endangered (EN), 2 were vulnerable (VU), 2 were nearly threatened (NT), and 88 were of least concern (LC) (Table 1). Besides, the population trends of these plants were stated as stable (70 species), unknown (18 species), decreasing (7 species), and unspecified (4 species). Some of the reported medicinal plants with decreasing populations include *A. ballyi, Z. gilletii, C. arabica, A. zygia, J. procera, C. papaya,* and *E. cymosa,* while those of *K. senegalensis, C. edulis, W. salutaris,* and *P. aethiopica* are unspecified.

The conservation priorities of medicinal plants have been investigated in different regions in Kenya. According to an investigation by Nankaya et al. [388], eight medicinal plant species that are used to treat symptoms related to respiratory infections were found to have the highest conservation priority. These species include *S. incanum, T. asiatica, R. prinoides, C. spinarum, V. kirkii, S. pyroides, D. abyssinica*, and *V. simplicifolia*. Additionally, the conservation priority of five other plant species, namely, *A. nilotica, O. europaea, W. salutaris, S. natalensis,* and *L. javanica* high in Loita area in southern Kenya. Moreover, *A. amara, A. secundiflora,* and *S. persica* were identified as having the highest priority, while *C. megalocarpus,* and *A. anthelmitica* were considered to have high priority in Mwingi district. Finally, *Z. chalybeum, W. ugandensis, T. brownii, A. indica,* and *R. communis* were ranked as species with moderate priority [389]. Table 1 shows the conservation status and population trends of medicinal plants used to remedy respiratory ailments in Kenya.

Integration of herbal medicines into national healthcare

Efforts aimed at incorporating herbal medicines into the national health care system have been necessitated by the inability of contemporary healthcare facilities to meet the health care demands of Kenya's growing population [390]. Their integration requires robust regulatory policies and incorporation protocols. Regulation of traditional medicinal practices by modern formulated laws and policy frameworks has recently served as a roadmap for their integration into the national healthcare system. Government regulatory frameworks such as Alma-Ata declaration, development plan, convention on biological diversity, national drug policy, national policy on traditional medicine, and regulation of herbal medicines, sessional paper on traditional medicines, and registration of herbal and complementary products have shaped the traditional medicinal practices [27]. However, the traditional medicine industry faces safety and health concerns in its integration into the primary health care system since most of the traditional medicine practitioners (TMPs) fail to disclose vital information about their trade to patients or even researchers. Besides, TMPs may be ignorant of the likelihood of herbal interactions that may cause adverse reactions or alter drug efficacy [391].

Conclusion

In this study, we assessed the use of 238 medicinal plant species in managing the symptoms related to respiratory conditions in Kenya and their ethnopharmacological relevance. The frequently reported families used to treat respiratory complications were Fabaceae (15%), followed by Asteraceae (10%), Euphorbiaceae (6%), Lamiaceae (5%), and Rutaceae (5%). As revealed by the present study, thirteen (13) distinct respiratory ailments are treatable by the listed medicinal plants, with coughs > common cold > pneumonia > asthma > chest problems, and tonsillitis being the most manageable disorders. In terms of life forms, the most frequently utilized medicinal plants for managing respiratory ailments were trees (38%), followed by shrubs (33%), herbs (20%), climbers (5%), and lianas (4%). Ethnomedicinal formulations were predominantly prepared from leaves (33%) and roots (29%), primarily in the form of decoctions.

Pharmacological investigations showed that the listed medicinal plants possess diverse biological activities. Among the exhibited properties, antimicrobial, anti-inflammatory, analgesic, antitussive, antipyretic, anti-obesity/antidiabetic, immunomodulatory, anti-oxidant, anti-allergic, and anti-asthmatic properties confirm their traditional medicinal uses in managing respiratory disorders such as influenza, pneumonia, tuberculosis, sore throat, tonsillitis/tonsils, common cold, and asthma. Toxicological studies among the listed medicinal plants utilized to remedy respiratory conditions showed that 92 plant species (39%) were safe or nontoxic, 16 plants (7%) were highly toxic, 10 plants (4%) were moderately toxic, 6 plants (3%) were weakly toxic, while 4 plants (2%) were toxic. The conservation status was documented for 106 plant species, among which 88 were of Least Concern (LC), 3 were Data Deficient (DD), 3 were Endangered (EN), 2 were Vulnerable (VU), and 2 were Nearly Threatened (NT). Anthropogenic pressures have greatly contributed to the local extinction of medicinal plants. The studied medicinal plants showed remarkable potential to treat different illnesses related to respiratory complications. Therefore, future clinical trials are necessary to clinically support the safety and efficacy of the extracts prepared from these plants.

Recommendations

The utilization of medicinal plant bio-resources has shown resilience in Kenya for many years. Nevertheless, their usage has not been fully integrated into mainstream healthcare, making its assimilation difficult. The country has not yet fully utilized the potential of traditional medicine to meet the health care needs of its population. According to the findings of this study, the use of herbal remedies derived from plants to alleviate common respiratory problems is still prevalent. Nevertheless, potential medicinal plants used to treat respiratory disorders remain unexplored in several regions. Therefore, further investigations are required to assess the utilization of herbal plant resources in these areas. It is important to create awareness for conservation, domestication strategies, and suitable propagation techniques of medicinal plants among communities since these beneficial resources are declining in Kenya. The compiled data obtained from this study can be used to identify the research gap focusing on ethnomedicinal uses, phytochemistry, and pharmacological properties of plant species utilized as herbal remedies, and serve as baseline information for further research. In

addition, the information on the medicinal potential of plants serves to create awareness in the conservation of useful plants implicated as remedies for the symptoms related to respiratory disorders.

CRediT authorship contribution statement

Emmanuel Nyongesa Waswa: Conceptualization, Data curation, Methodology, Writing - original draft, Software. **Fredrick Munyao Mutie:** Data curation, Writing - review & editing, **Jacinta Katunge Kawenze:** Writing - original draft, Methodology. **Elijah Mbandi Mkala:** Data curation, Investigation, Validation. **Elizabeth Syowai Mutinda:** Writing - review & editing, Software. **M.A.H. Fernandez Voortman:** Methodology, Validation. **Clovice Kankya:** Methodology, Validation. **Yerong Hu:** Project administration, Resources, Supervision, Validation. **Guangwan Hu:** Conceptualization, Funding acquisition, Resources, Supervision, Validation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding

This work was funded by the Key Project at Central Government Level: The Ability Establishment of Sustainable Use for Valuable Chinese Medicine Resources (2060302), the National Natural Science Foundation of China (32270228), the Biological Resources Program, Chinese Academy of Sciences (KFJ-BRP-017-098), the Key R&D Program of Hubei Jiangxia Laboratory (JXBS010), the Project of National Plant Specimen Resource Center (NPSRC) (E0117G1001), and the Sino-Africa Joint Research Center, CAS (SAJC202401).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sciaf.2026.e03495.

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