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Review Article

Systematic Review of Plants Used Against Respiratory Diseases Related to COVID-19 in Africa

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Abstract

Background: Respiratory disorders are known to affect the airways including the nasal passages, bronchi and lungs causing blockages. The advent of COVID-19 has further aggravated the complications of the respiratory systems where conventional medicine is not reachable or affordable by the majority poor in Africa. Hence, the over 80% of the African population who turn to traditional medicine for their primary health care.

Objective: This review is aimed to identify plants directed against respiratory diseases which can be useful in the fight against COVID-19.

Methodology: Scientific articles selected in this study span the last ten years (2011-2021). Keywords such as “ethnobotany in Africa”, “ethnobotany and respiratory diseases” “medicinal plants and respiratory diseases”, “traditional medicine and COVID-19” were searched in open access search engines such as: Science Direct, Research Gate, Google Scholar, Pubmed, Web of Science, Scopus. The ethnobotanical indices were then calculated using Microsoft excel to determine the plants with the most therapeutic potential to be considered for the local management of COVID-19.

Results: Data obtained were classified according to country of origin of the author of the publication, the botanical family and the respiratory pathology being treated. Thirteen (13) references were finally selected with the represented country being Benin Republic. One hundred and forty-three plant species belonging to 60 families were registered. The most recurrent families were the Fabaceae and Lamiaceae (18 citations each). The plants in these families were used for the management of fifteen diseases and / or symptoms relating to the respiratory system. The most cited plants were: *Ocimum gratissimum* L. (4 citations), *Entandrophragma cylindricum* (Sprague), *Scyphocephalum ochococa* Warb., *Rubia cordifolia* and *Allium sativum* L. (3 citations each).

Conclusion: Based on the data obtained in this review *Ocimum gratissimum* stands out as the most used plant for the treatment of respiratory disorders.

Keywords: Respiratory diseases, Medicinal plants, COVID-19

INTRODUCTION

Respiratory diseases are known to affect the airways including the nasal passages, bronchi and lungs. It is very often difficult to classify them because they have different levels of severity and are closely dependent on the patient's age. They can be bronchitis, pneumonia, asthma, tuberculosis, sinusitis, and rhinitis representing the main factors of morbidity and mortality in both developed and developing nations of the world ¹ Respiratory infections account for up to 38.6% of infectious diseases and are responsible for the death of around 14.9% of children in Africa ².

Coronaviruses are emerging and reemerging enveloped RNA viruses that are distributed broadly among humans, mammals and birds. Coronaviruses vary significantly in the pathogenicity, and include highly pathogenic species such as MERS-CoV and COVID-19, and relatively harmless species such as the common cold. Severe Acute Respiratory

Syndrome Corona Virus (SARS-COV) is the causal agent of the outbreaks in 2002, 2003 in China ³. In December 2019, a new epidemic of SARS-COV was detected in several local health facilities from patients with pneumonia in Wuhan, Hubei Province, China ³. COVID-19 is a species of coronavirus (CoVs), an etiologic agent which can systemically cause disorder in the respiratory and digestive tract, resulting in severe infections in both humans and animals ⁴. Currently, no specific therapies for COVID-19 are available and investigations regarding the treatment of COVID-19 are still limited to preventive and supportive therapies, designed to prevent further complications and organ damage ⁵. The main symptoms described for COVID-19 were those of malaria (fever, fatigue, body aches, etc.), accompanied by symptoms of respiratory disorders (dry cough, breathing difficulties, chest pain, sore throat, etc.) and flu ⁶. After the panic caused by the first cases of contamination in Cameroon in March 2020, the population in search of preventive and even curative measures for COVID-19, flocked the traditional pharmacopoeia ⁷ in search

of traditional medicine which have properties against any of the symptoms. The plants most in demand were largely those with anti-influenza, antimalarial and immunomodulatory properties including those with reported effects on respiratory disorders.

In another study, some plant-sourced antioxidant and immune-boosters, kaempferol, quercetin, luteolin-7-glucoside, demethoxycurcumin, naringenin, apigenin-7-glucoside, oleuropein, curcumin, catechin, epicatechin-gallate, zingerol, gingerol, and allicin were investigated as potential inhibitor candidates for COVID-19, in comparison to antiretroviral protease inhibitors⁸. It was found that these plant products could act as potential inhibitors, meaning the source plants could be exploited as potential candidates for the development of improved traditional medicines (ITMs) as inhibitors of COVID-19.

The use of traditional medicine dates back to prehistoric times and remains the major accessible and affordable treatment for the population in African countries. Today medicinal plants which are the main component of traditional medicine have been transformed into conventional drugs that are sold in pharmacies worldwide. Many other plants are currently undergoing investigation to ascertain their therapeutic efficacies and safety. Medicinal plants have long been known for their curative or protective effects against a broad range of microorganisms, such as viruses, protozoa, bacteria and parasites⁹⁻¹¹. There are reports stating the protective effect of plant extracts against viral diseases, such as HIV 1&2; Herpes simplex virus, Hepatitis B & C virus¹²⁻¹⁴ just to name a few. Considering that COVID-19 is a respiratory disorder, the present study systematically reviewed the plants used in Africa for the treatment of respiratory disorders.

1. METHODOLOGY

1.1. Collection of bibliographic data

The scientific articles selected were based on relation to respiratory diseases published within the last ten years (2011-2021). The open access search engines consulted included: Science Direct, Research gate, Google Scholar, Pubmed, Web of Science and Scopus. The plants listed were classified according to the country of origin of the author of the publication, the botanical family and the respiratory pathology being treated. Thus, a plant which treats 'n' distinct respiratory diseases will be cited 'n' times and is considered to most likely be effective against the coronavirus. Ethnobotanical indices were calculated to determine which plants may have their therapeutic potential related to management of COVID-19.

1.2. Ethnobotanical indices

- The relative frequency of plant species **Fr** was calculated according to the formula below:

$$Fr = Nc / Nt$$

where **Nc** is the number of citations of the species and **Nt** the total number of citations of all species;

- The performance index of each of the species (**PI**) described by Betti¹⁵ will theoretically identify which plants can be effective in the treatment of target respiratory diseases such as COVID-19. This index results from the interpretation of the following difference:

$$(Nc / N) - (Ncm / Nt)$$

Where **Nc** is the number of citations of a plant in the treatment of a respiratory pathology;

N: the total number of citations of all the plants used in the treatment of this respiratory pathology;

Ncm: the number of citations of the plant for all respiratory diseases and

Nt: the total number of citations.

PI = 0 if $(Nc / N) - (Ncm / Nt) < 0$ for zero performance

PI = 1 if $0 < (Nc / N) - (Ncm / Nt) \leq 1/3$ for average performance

PI = 2 if $1/3 < (Nc / N) - (Ncm / Nt) \leq 2/3$ for good performance

PI = 3 if $(Nc / N) - (Ncm / Nt) > 2/3$ for excellent performance

- The convergence score (**S**) of bibliographic use in the treatment of the main symptoms of COVID-19 and geographic use described by Chassagne¹⁶ and amended in this study, was calculated according to the following formula:

$$S = I1 / I2$$

With **I1**: Number of publications (on the bibliographic review used) which mention the use of the species in the management of respiratory diseases **I2**: Number of total publications.

1.3. Data analysis

The listed plants were then recorded on a Microsoft Excel 2013 spreadsheet and the ethnobotanical indices calculated. Descriptive statistics was used to express the data obtained (Tables and Figures).

2. RESULTS AND DISCUSSION

2.1. Bibliographic information on the scientific publications selected

The bibliographic search listed out seventy-five (75) publications from African authors. Of these, fourteen (14) discussed the use of medicinal plants in the management of respiratory diseases in Africa. The publications had authors from seven (07) African countries among which Benin (64), Cameroon (41), Morocco (33) and Gabon (27) were the most represented (Figure 1).

The fourteen (14) articles that reported the use of medicinal plants in the management of respiratory disorders were further analyzed. In a similar study in West Africa twelve articles were selected to produce a rich repertoire of plants used against respiratory diseases¹⁷. In their publication they identified African authors as follows: Benin (64), Cameroon (41), Morocco (33) and Gabon (27) whose publications discussed the use of plants for treatment of respiratory disorders. Thus, in the study of Haidara et al.¹⁷ Benin had the highest number of authors reporting on medicinal plants and respiratory disorder followed by Cameroon and then Morocco in the third place. This result corroborated our data that presents Benin as the country with the most cited authors with interest in medicinal plants for the management of respiratory disorders. This could be justified by the fact that the Beninese is much more attached to traditional medicine with plants as the main ingredient. This data is also indicative that there is a high prevalence of respiratory disorder and that it is of importance to Benin researchers.

Figure 1: Spectrum of the authors' countries of origin according to the number of citations.

Figure 2: Spectrum of references used as a function of the number of citations.

Figure 2 presented the spectrum of references reviewed in this study and their number of citations. Of the fourteen (14) references retained for this review, Kouchadé et al. ¹⁸ was the most cited revealing several plants used against respiratory diseases. Kouchadé et al. ¹⁸ cited over 55 times and Mathouet et al. ¹⁹ cited over 30 times signifies the importance and impact of the results of these groups of researchers in the use of medicinal plants against respiratory diseases.

2.2. Characterization of plants directed against respiratory tract diseases

In the 14 articles reviewed, one hundred and seventy-nine (179) research citations were registered on the use of plants species in the treatment of respiratory disorders in Africa. A total of one hundred and forty-three (143) plants species were reportedly used in Africa in the management of respiratory diseases. However, we reported only those plants species that were cited at least twice (Figure 3). The most cited plants across board were: *Ocimum gratissimum* L. (04 citations), *Entandrophragma cylindrium* (Sprague), *Scyphocephalum ochocoa* Warb. *Rubia cordifolia* and *Allium sativum* L. (03 citations each) (Figure 3). A similar study in West Africa recorded 145 species while North Africa reported 57 species implicated in the treatment of respiratory disorder ^{20, 21}. Equally, 24 species were reported in Gabon to have therapeutic effect on respiratory disorders ¹⁹. Hence West Africa may have a well-organized traditional medicine system that promotes traditional medicine.

Figure 3: Spectrum of plants citations used in the treatment of respiratory diseases in Africa.

Figure 4: Frequency of citation of plants families in the management of respiratory disorder.

Sixty (60) plant families were reported in the present study. Twenty-three (23) families were cited at least three times. Amongst the 23 families Lamiaceae (18 citations) had the highest citation for respiratory disorders followed by the Fabaceae (08) and Myrtaceae (08) and then Solanaceae (07) (Figure 4). The rest of the families had below 7 citations. In

African traditional medicine, the population uses plants that are within their immediate surrounding for treatment. This is the case of the Lamiaceae for Morocco and the Fabaceae for the countries of Central and West Africa. A typical example is that of *Alchornea cordifolia* that finds application as therapeutic agent in the respiratory system ²².

Figure 5: Number of plants cited for the treatment of respiratory disorders.

Fifteen respiratory conditions were listed from the literature search (Figure 5). Of the fifteen respiratory conditions listed, the generalized respiratory infections appear first (43 citations), followed by rhino-bronchitis (42 citations), cough (30 citations), lung infection (20 citations), asthma (19 citations) and angina (10 citations). These respiratory infections are those mostly seen in moderate to severe COVID-19 infection. One of the most important respiratory pathogens in COVID-19 is the human rhinovirus known to cause rhino-bronchitis ²³ meanwhile cough is one of the most common presenting symptoms of COVID-19, along with fever and loss of taste and smell ²⁴. When persist for weeks or months after SARS-CoV-2 infection, cough is accompanied by chronic fatigue, cognitive impairment, dyspnea, or pain ²⁴. The situation of COVID-19 worsens in

patients with preexisting conditions such as asthma and can be very fatal ²⁵. COVID-19 infection gets worst with lung infections such as pneumonia. This is because the lungs responsible for gaseous exchange are compromised by pneumonia and COVID-19. Plants with therapeutic effects against these conditions could be of help to COVID-19 patients.

2.3. Ethnobotanical clues on the uses of plants in the management of respiratory tract diseases.

2.3.1. Citation Frequencies and Scores

The frequencies and citation scores obtained for the different plants were presented in Table 1.

Table 1: Frequencies and citations scores of plants used against respiratory diseases

Medicinal plants	Number of citations	Score	Quotation frequencies
<i>Abrus precatorius</i> L.	1	0.071	0.006
<i>Acacia nilotica</i> (L.) Wild. Ex Delile	2	0.143	0.011
<i>Acmella caulirhiza</i> (Wal.ex DC.) R.K. Jansen	1	0.071	0.006
<i>Adenopus breviflorus</i> Benth.	1	0.071	0.006
<i>Aframomum septrum</i> (Oliv & D.Hans) K.Schum.	1	0.071	0.006
<i>Afrostryax lepidophyllus</i> Mildbr.	1	0.071	0.006
<i>Alchornea cordifolia</i> (Schum.&T Thonn.) Müll.Arg.	1	0.071	0.006
<i>Alchornea floribunda</i> Müll.Arg.	1	0.071	0.006
<i>Allium cepa</i> L.	1	0.071	0.006
<i>Allium sativum</i> L.	3	0.214	0.017
<i>Amphimas ferrugineus</i> Pierre ex Pellegr.	2	0.143	0.011
<i>Anacardium occidentale</i> L.	1	0.071	0.006
<i>Annona muricata</i> L.	1	0.071	0.006
<i>Anogeissus leiocarpa</i> (D.C.) Guill&Perr.	1	0.071	0.006
<i>Apium graveolens</i> L.	1	0.071	0.006
<i>Argemone mexicana</i> L.	2	0.143	0.011
<i>Aucoumea klaineana</i> Pierre	1	0.071	0.006
<i>Baillonella toxisperma</i> Pierre	1	0.071	0.006
<i>Beilschmiedia</i> sp	1	0.071	0.006
<i>Berhavia diffusa</i> L.	1	0.071	0.006
<i>Bidens pilosa</i> L.	1	0.071	0.006
<i>Bombax costatum</i> Pellegr. & Vuillet	1	0.071	0.006
<i>Brassica napus</i> L.	1	0.071	0.006
<i>Brassica oleacea</i> L.	1	0.071	0.006
<i>Brassica rapa</i> L.	1	0.071	0.006
<i>Bridelia ferruginea</i> Benth.	1	0.071	0.006
<i>Buchholzia coriacea</i> Engl.	1	0.071	0.006
<i>Caesalpinia bonduc</i> (L.) Roxb.	1	0.071	0.006
<i>Canabis sativa</i> L.	1	0.071	0.006
<i>Capsicum annum</i> L.	2	0.143	0.011

<i>Capsicum frutescens</i> L.	1	0.071	0.006
<i>Carapa procera</i> DC.	1	0.071	0.006
<i>Carica papaya</i> L.	1	0.071	0.006
<i>Casuarina equisetifolia</i> L.	1	0.071	0.006
<i>Catharanthus roseus</i> (L.) G.Don.	1	0.071	0.006
<i>Chamaecrista rotundifolia</i> (Pers.) Greene	1	0.071	0.006
<i>Citrus limon</i> L.	1	0.071	0.006
<i>Citrus medica</i> L.	1	0.071	0.006
<i>Clausena anisata</i> (Wild.) Hook.F. ex Benth.	1	0.071	0.006
<i>Clerodendrum capitatum</i> (Wild.)	1	0.071	0.006
<i>Coffea arabica</i> L.	1	0.071	0.006
<i>Cola anomala</i> K.Schum.	2	0.143	0.011
<i>Combretum micranthum</i> G.Don.	1	0.071	0.006
<i>Corrigiola telephiifolia</i> (Pourr.) Briq.	2	0.143	0.011
<i>Costus afer</i> Ker-Gawl	1	0.071	0.006
<i>Costus lucanusianus</i> J.Braun.	1	0.071	0.006
<i>Costus tappentabeckianus</i> J. Braun	1	0.071	0.006
<i>Crocus sativus</i> L.	1	0.071	0.006
<i>Cuminum cyminum</i> L.	1	0.071	0.006
<i>Cynometra megalophylla</i> Harms	1	0.071	0.006
<i>Detarium microcarpum</i> Guill. & Perr.	1	0.071	0.006
<i>Dialium guineense</i> Wild.	1	0.071	0.006
<i>Dichaetanthera africana</i> (Hook.f.) Jacq.	1	0.071	0.006
<i>Dichapetaleum madagascariensis</i> Poir.	1	0.071	0.006
<i>Discopodium penninervum</i> (Hochst.)	1	0.071	0.006
<i>Emilia coccinea</i> (Sims) G.Don	1	0.071	0.006
<i>Entandrophragma cylindrium</i> (Sprague)	3	0.214	0.017
<i>Eucalyptus camaldulensis</i> Dehn.	1	0.071	0.006
<i>Eucalyptus globulus</i> Labill.	2	0.143	0.011
<i>Eucalyptus</i> sp	2	0.143	0.011
<i>Eugenia caryophyllata</i> Bullock & S.G. Harrison	1	0.071	0.006
<i>Euphorbia falcata</i> L.	1	0.071	0.006
<i>Ficus cyathistipula</i> Warb.	1	0.071	0.006
<i>Ficus exasperata</i> P.Beauv.	1	0.071	0.006
<i>Ficus sur</i> Forssk	1	0.071	0.006
<i>Ficus thonningii</i> Blume	1	0.071	0.006
<i>Flueggea virosa</i> (Roxb. Ex Wild)	1	0.071	0.006
<i>Foeniculum vulgare</i> Mill. Subsp.	1	0.071	0.006
<i>Garcinia kola</i> Heckel	1	0.071	0.006
<i>Gossypium arboreus</i> L.	1	0.071	0.006
<i>Gossypium barbadense</i> L.	2	0.143	0.011
<i>Grewia barombiensis</i> K.Schum.	1	0.071	0.006

<i>Grewia ferruginea</i> A.Rich.	1	0.071	0.006
<i>Hallea ledermannii</i> (K.Krause) Verdc.	1	0.071	0.006
<i>Heterotis rotundifolia</i> (Sm.) Jacq.Fel.	1	0.071	0.006
<i>Hyptis suaveolens</i> (L.) Poit.	1	0.071	0.006
<i>Illicium verum</i> Hook.	1	0.071	0.006
<i>Kalanchoe crenata</i> (Andrews) Haw.	1	0.071	0.006
<i>Kaya senegalensis</i> (Desr.) A.Juss.	1	0.071	0.006
<i>Lactuca capensis</i> Thunb	2	0.143	0.011
<i>Laggera alata</i> (D.Don) Sch.Bip.Oliv.	1	0.071	0.006
<i>Lantana camara</i> L.	1	0.071	0.006
<i>Laportea aestuans</i> (L.) Chew	1	0.071	0.006
<i>Lavandula multifida</i> L.	1	0.071	0.006
<i>Lavandula stoechas</i> ssp.	1	0.071	0.006
<i>Lippia multiflora</i> Maldenke	1	0.071	0.006
<i>Magnistipula tessmannii</i> Engl.	2	0.143	0.011
<i>Mangifera indica</i> L.	2	0.143	0.011
<i>Marrubium vulgare</i> L.	2	0.143	0.011
<i>Memecylon zenkeri</i> Gilg	1	0.071	0.006
<i>Mentha pulegium</i> L.	1	0.071	0.006
<i>Monodora myristica</i> (Gaertn.) Dunal	2	0.143	0.011
<i>Nicotiana tabacum</i> L.	1	0.071	0.006
<i>Nigella sativa</i> L.	2	0.143	0.011
<i>Ocimum basilicum</i> L.	2	0.143	0.011
<i>Ocimum gratissimum</i> L.	4	0.286	0.022
<i>Origanum compactum</i> (Benth.)	1	0.071	0.006
<i>Parkia bigloboa</i> (Jacq.) R.Br. Ex Benth.	2	0.143	0.011
<i>Paullinia pinnata</i> L.	1	0.071	0.006
<i>Pergularia daemia</i> (Forssk.) C.	1	0.071	0.006
<i>Persea americana</i> Mill.	1	0.071	0.006
<i>Piper guineense</i> Schumach. & Thonn.	2	0.143	0.011
<i>Piper nigrum</i> L.	1	0.071	0.006
<i>Piptadeniastrum africanum</i> (Hook.F.) Brenan	1	0.071	0.006
<i>Podocarpus falcatus</i> (Thunb.) R.Br.ex Mirb	1	0.071	0.006
<i>Polyscias fulva</i> (Hiern) Harms	1	0.071	0.006
<i>Propolis africana</i> (Guill.&Perr.) Taub	1	0.071	0.006
<i>Psychotria psychotrioides</i> (D.C.) Roberty	1	0.071	0.006
<i>Pterocarpus erinaceus</i> Poir.	1	0.071	0.006
<i>Pycnanthus angolensis</i> (Welw.) Warb.	1	0.071	0.006
<i>Rauvolfia vomitoria</i> Afz.	1	0.071	0.006
<i>Rubia cordifolia</i> L.	3	0.214	0.017
<i>Ruta chalepensis</i> L.	1	0.071	0.006
<i>Saccharum officinarum</i> L.	2	0.143	0.011

<i>Salvia verbenaca</i> L.	1	0.071	0.006
<i>Satureja calamintha</i> (L.)	1	0.071	0.006
<i>Schwenckia americana</i> L.	1	0.071	0.006
<i>Scoparia dulcis</i> L.	2	0.143	0.011
<i>Scyphocephalum ochocoa</i> Warb.	3	0.214	0.017
<i>Securidata longepedunculata</i> Fresen	2	0.143	0.011
<i>Senna occidentalis</i> (L.) Link	1	0.071	0.006
<i>Senna septentrionalis</i> (Viv.)	1	0.071	0.006
<i>Solanum nigrum</i> L.	1	0.071	0.006
<i>Spondias monbin</i> L.	1	0.071	0.006
<i>Sporopermum glaberrimum</i> Hoch.	1	0.071	0.006
<i>Staudtia gabonensis</i> Warb.	1	0.071	0.006
<i>Strombosiopsis tetrandra</i> Engl.	1	0.071	0.006
<i>Syzygium aromaticum</i> Merrill.	2	0.143	0.011
<i>Terminalia glaucescens</i> Planc.ex Benth.	1	0.071	0.006
<i>Terminalia laxiflora</i> Engl.	1	0.071	0.006
<i>Tetradenia riparia</i> (Hochst.)	1	0.071	0.006
<i>Tetrapleura tetraptera</i> (Schmach. & Thonn.) Thonn.	1	0.071	0.006
<i>Thonningia sanguinea</i> Vahl.	1	0.071	0.006
<i>Tragia ssenegalensis</i> Müll.Arg.	1	0.071	0.006
<i>Treculia obovoidea</i> N.E.Br.	1	0.071	0.006
<i>Trigonella foenum-graecum</i> L.	1	0.071	0.006
<i>Vernonia amygdalina</i> Delile	1	0.071	0.006
<i>Vicia faba</i> L.	1	0.071	0.006
<i>Vitellaria paradoxa</i> C.F.Gaertn.ssp. <i>paradoxa</i>	2	0.143	0.011
<i>Vitex doniana</i> Sweet	2	0.143	0.011
<i>Xylopia aethiopica</i> (Dunal) A.Rich.	1	0.071	0.006
<i>Zingiber officinale</i> Roscoe	2	0.143	0.011
<i>Ziziphus spina-christi</i> (L.)	1	0.071	0.006

Citation frequency = No citation of a species/No. of citation of all samples

The relative frequency of plant species is the ratio between the number of citations of the species and the total number of citations of all species. Hence the lower the frequency the lower the importance of the species. It emerged from this table that almost all of the plants listed have a low frequency, low citations and a low convergence score. However, certain plants were able to stand out: *Ocimum gratissimum* (score of 0.286 and 0.022 frequency), *Allium sativum* (score of 0.214 and 0.017 frequency), *Entandrophragma cylindricum* (score of 0.214 and 0.017 frequency), *Rubia cordifolia* (score of 0.214 and 0.017 Frequency) and *Scyphocephalum ochocoa* (score of 0.214 and frequency 0.017).

Ocimum gratissimum is an aromatic plant used in the treatment of several diseases in many countries and has been reported to contain 8 major groups of different metabolites ²⁶ which may be related to its medicinal properties.

2.3.2. Theoretical performance of plants against respiratory diseases

The performance indices were calculated (Table 2) and only plants involved in several respiratory pathologies (in this case, the most cited pathologies) and which were in competition with others were taken into account.

Table 2: Performance indices of plants directed against respiratory diseases

Scientific names/Illnesses treated	Anthrax	Asthma	Bronchitis	Chronic Bronchitis	Lung Cancer	Common Cold	Pulmonary infection	Respiratory Infection	Pneumonia	Rhino-bronchitis	Influenza	Sinusitis	Cough	Tuberculosis	Total citation/species
<i>Abrus precatorius</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Acacia nilotica</i> (L.) Wild. Ex Delile	-	2.00	-	-	-	-	-	-	-	1.00	-	-	-	-	2
<i>Acmella caulirhiza</i> (Wal.ex DC.) R.K. Jansen	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Adenopus breviflorus</i> Benth.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Aframomum septrum</i> (Oliv & D.Hans) K.Schum.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Afrostryax lepidophyllus</i> Mildbr.	-	-	-	-	-	-	3.00	-	-	-	-	-	-	-	1
<i>Alchornea cordifolia</i> (Schum.& Thonn.) Müll.Arg.	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	1
<i>Alchornea floribunda</i> Müll.Arg.	-	-	-	-	-	-	3.00	-	-	-	-	-	-	-	1
<i>Allium cepa</i> L.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Allium sativum</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	3
<i>Amphimas ferrugineus</i> Pierre ex Pellegr.	-	-	-	-	-	-	2.00	-	-	-	-	-	2.00	-	2
<i>Anacardium occidentale</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Annona muricata</i> L.	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Anogeissus leiocarpa</i> (D.C.) Guill&Perr.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Apium graveolens</i> L.	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	1
<i>Argemone mexicana</i> L.	-	-	-	-	-	-	2.00	-	-	-	-	-	2.00	-	2
<i>Aucoumea klaineana</i> Pierre	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Baillonella toxisperma</i> Pierre	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Beilschmiedia</i> sp	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Berhavia diffusa</i> L.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Bidens pilosa</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Bombax costatum</i> Pellegr.&Vuillet	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Brassica napus</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Brassica oleacea</i> L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Brassica rapa</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Bridelia ferruginea</i> Benth.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Buchholzia coriacea</i> Engl.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Caesalpinia bonduc</i> (L.) Roxb.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Canabis sativa</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Capsicum annuum</i> L.	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	2
<i>Capsicum frutescens</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Carapa procera</i> DC.	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Carica papaya</i> L.	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	1
<i>Casuarina equisetifolia</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Catharanthus roseus</i> (L.) G.Don.	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Chamaecrista rotundifolia</i> (Pers.) Greene	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Citrus limon</i> L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Citrus medica</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1

<i>Clausena anisata</i> (Wild.) Hook.F. ex Benth.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Clerodendrum capitatum</i> (Wild.)	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Coffea arabica</i> L.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Cola anomala</i> K.Schum.	-	2.00	-	-	-	-	-	-	-	-	-	-	2.00	-	2
<i>Combretum micranthum</i> G.Don.	-	-	-	-	-	3.00	-	-	-	-	-	-	-	-	1
<i>Corrigiola telephiifolia</i> (Pourr.) Briq.	-	-	-	-	-	2.00	-	-	-	-	-	-	1.00	-	2
<i>Costus afer</i> Ker-Gawl	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Costus lucanusianus</i> J.Braun.	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	1
<i>Costus tappentabeckianus</i> J. Braun	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Crocus sativus</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Cuminum cyminum</i> L.	-	-	-	-	-	3.00	-	-	-	-	-	-	-	-	1
<i>Cynometra megalophylla</i> Harms	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Detarium microcarpum</i> Guill.& Perr.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Dialium guineense</i> Wild.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Dichaetanthera africana</i> (Hook.f.) Jacq.	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Dichapetalum madagascariensis</i> Poir.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Discopodium penninervium</i> (Hochst.)	3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Emilia coccinea</i> (Sims) G.Don	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Entandrophragma cylindrium</i> (Sprague)	-	-	1.00	-	-	-	-	1.00	-	-	1.00	-	-	-	3
<i>Eucalyptus camaldulenis</i> Dehn.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Eucalyptus globulus</i> Labill.	-	-	-	-	-	2.00	-	1.00	-	-	-	-	-	-	2
<i>Eucalyptus</i> sp	-	-	-	-	-	-	-	1.00	-	-	-	-	2.00	-	2
<i>Eugenia caryophyllata</i> Bullock & S.G. Harrison	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Euphorbia falcata</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Euphorbia hirta</i> L.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Ficus cyathistipula</i> Warb.	-	-	-	-	-	-	3.00	-	-	-	-	-	-	-	1
<i>Ficus exasperata</i> P.Beauv.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Ficus sur</i> Forssk	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Ficus thonningii</i> Blume	-	-	-	-	-	-	-	-	3.00	-	-	-	-	-	1
<i>Flueggea virosa</i> (Roxb. Ex Wild)	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Foeniculum vulgare</i> Mill. Subsp.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Garcinia kola</i> Heckel	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Gossypium arboreus</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Gossypium barbadense</i> L.	-	2.00	2.00	-	-	-	-	-	-	-	-	-	-	-	2
<i>Grewia barombiensis</i> K.Schum.	-	-	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Grewia ferruginea</i> A.Rich.	-	3.00	-	-	-	-	-	-	-	-	-	-	3.00	-	1
<i>Hallea ledermannii</i> (K.Krause)Verdc.	-	-	-	-	-	-	3.00	-	-	-	-	-	-	-	1
<i>Heterotis rotundifolia</i> (Sm.) Jacq.Fel.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Hyptis suaveolens</i> (L.) Poit.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Illicium verum</i> Hook.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Kalanchoe crenata</i> (Andrews) Haw.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Kaya senegalensis</i> (Desr.) A.Juss.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Lactuca capensis</i> Thunb	-	-	-	2.00	-	-	-	-	-	-	-	-	2.00	-	2
<i>Laggera alata</i> (D.Don) Sch.Bip.Oliv.	-	-	-	-	-	-	3.00	-	-	-	-	-	-	-	1
<i>Lantana camara</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	2.00	-	1

<i>Laportea aestuans</i> (L.) Chew	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Lavandula multifida</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Lavandula stoechas</i> ssp.	-	-	-	-	-	-	-	3.00	-	-	-	-	3.00	-	1
<i>Lippia multiflora</i> Malденке	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Magnistipula tessmannii</i> Engl.	-	-	-	-	-	-	2.00	-	-	-	-	-	-	-	2
<i>Mangifera indica</i> L.	-	-	-	-	-	-	-	1.00	-	1.00	-	-	-	-	2
<i>Marrubium vulgare</i> L.	-	-	-	-	-	2.00	-	1.00	-	-	-	-	-	-	2
<i>Memecylon zenkeri</i> Gilg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Mentha pulegium</i> L.	-	-	-	-	-	3.00	-	-	-	-	-	-	3.00	-	1
<i>Monodora myristica</i> (Gaertn.) Dunal	-	2.00	-	-	-	-	-	-	-	1.00	-	-	-	-	2
<i>Nicotiana tabacum</i> L.	-	-	-	-	-	-	-	-	-	-	3.00	-	-	-	1
<i>Nigella sativa</i> L.	-	2.00	-	-	-	-	-	-	-	-	-	-	3.00	-	2
<i>Ocimum basilicum</i> L.	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	2
<i>Ocimum gratissimum</i> L.	-	-	-	-	-	-	-	1.00	-	1.00	-	-	-	-	4
<i>Origanum compactum</i> (Benth.)	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Parkia bigloba</i> (Jacq.) R.Br. Ex Benth.	-	-	-	-	-	-	-	1.00	-	1.00	-	-	2.00	-	2
<i>Paulinia pinnata</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Pergularia daemia</i> (Forssk.) C.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Persea americana</i> Mill.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Piper guineense</i> Schumacher & Thonn.	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	2
<i>Piper nigrum</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Piptadeniastrum africanum</i> (Hook.F.) Brenan	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Podocarpus falcatus</i> (Thunb.) R.Br. ex Mirb	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Polyscias fulva</i> (Hiern) Harms	-	-	-	-	-	-	-	-	-	-	-	3.00	-	-	1
<i>Propolis africana</i> (Guill. & Perr.) Taub	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Psychotria psychotrioides</i> (D.C.) Roberty	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Pterocarpus erinaceus</i> Poir.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Pycnanthus angolensis</i> (Welw.) Warb.	-	-	3.00	-	-	-	-	-	-	-	-	-	-	-	1
<i>Rauvolfia vomitoria</i> Afz.	-	-	-	-	-	-	3.00	-	-	-	-	-	3.00	-	1
<i>Rubia cordifolia</i> L.	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	3
<i>Ruta chalepensis</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Saccharum officinarum</i> L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
<i>Salvia verbenaca</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Satureja calamintha</i> (L.)	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Schwenckia americana</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Scoparia dulcis</i> L.	-	-	2.00	-	-	-	-	-	-	-	-	-	-	-	2
<i>Scyphocephalum ochocoa</i> Warb.	-	1.00	-	-	-	-	-	-	-	-	-	-	1.00	-	3
<i>Securidata longepedunculata</i> Fresen	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	2
<i>Senna occidentalis</i> (L.) Link	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Senna septentrionalis</i> (Viv.)	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	1
<i>Solanum nigrum</i> L.	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	1
<i>Spondias monbin</i> L.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Sporopermum glaberrimum</i> Hoch.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Staudtia gabonensis</i> Warb.	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	1
<i>Strombosiaopsis tetrandra</i> Engl.	-	-	-	-	-	-	3.00	-	-	-	-	-	-	-	1

<i>Syzygium aromaticum</i> Merrill.	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	2
<i>Terminalia glaucescens</i> Planc.ex Benth.	-	-	-	-	-	-	-	-	-	3.00	-	-	3.00	-	1
<i>Terminalia laxiflora</i> Engl.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Tetradenia riparia</i> (Hochst.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Tetrapleura tetraptera</i> (Schmach.&Thonn.) Thonn.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Thonningia sanguinea</i> Vahl.	-	3.00	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Tragia senegalensis</i> Müll.Arg.	-	-	-	-	-	-	-	-	-	3.00	-	-	2.00	-	1
<i>Treculia obovoidea</i> N.E.Br.	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	1
<i>Trigonella foenum-graecum</i> L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Vernonia amygdalina</i> Delile	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Vicia faba</i> L.	-	-	-	-	-	-	-	3.00	-	-	-	-	-	-	1
<i>Vitellaria paradoxa</i> C.F.Gaertn.ssp. <i>paradoxa</i>	-	-	-	-	-	-	-	1.00	-	1.00	-	-	-	-	2
<i>Vitex doniana</i> Sweet	-	2.00	-	-	-	-	-	-	-	-	-	-	3.00	-	2
<i>Xylopia aethiopica</i> (Dunal) A.Rich.	-	-	-	-	-	-	-	-	-	3.00	-	-	-	-	1
<i>Zingiber officinale</i> Roscoe	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	2
<i>Ziziphus spina-christi</i> (L.)	3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total citation/pathology	2	20	8	1	1	6	11	43	1	42	2	1	30	2	180

The numbers in the Table represents the Performance index (PI) of each plant species against a respiratory disorder. PI = 0 (-) signifies no performance, PI = 1 signifies average performance, PI = 2 signifies good performance and PI = 3 signifies excellent performance.

The performance index determines which plant species is most suitable for the management of respiratory disorders. A performance index of zero signifies no performance which means there is no relationship between the plant species and the cited pathology meanwhile performance index of one is indicative of an average performance meaning there are possibilities that the plant species will treat the respective respiratory disorder. A performance index of two signifies good performance meaning there is a high probability the plant will treat the referenced respiratory disorder meanwhile a performance index of three signifies excellent performance which means the plant treats the referenced respiratory disorder. A particular plant species can have an excellent performance index for one respiratory disorder and a zero or poor performance index in another. This was the case with *Acacia nilotica*, *Corrigiola telephifolia*, *Eucalyptus globulus*, *Lantana camara*, *Marrubium vulgare*, *Monodora myristica*, *Nigella sativa*, *Parkia bigloba*, *Tragia senegalensis* and *Vitex doniana* (Table 2). In the present study the highest performance index obtained was three (3) which means the said plants species is most likely to treat the particular respiratory disorder for which it has the index. All the plants presented in this study were at least cited once for a particular respiratory disorder hence spreading the performance which automatically become low. Meanwhile the respiratory disorder cited across board the higher the performance index. Hence, a plant that is cited many times for different respiratory disorders may end up with a low performance index for individual respiratory disorder meanwhile it has a wide coverage for different respiratory disorders. Similar observations have earlier been reported in a study specific to vaginal infections²⁷. This was the case with *Entandrophragma cylindrium*, *Ocimum gratissimum*, *Rubia cordifolia* and *Scyphocephalum ochocoa*. *Ocimum gratissimum* was the most cited plant indicated in the therapy of four respiratory disorders meanwhile *Entandrophragma cylindrium*, *Rubia cordifolia* and

Scyphocephalum ochocoa were indicated in three different pathologies. Thus, the frequency of citation is inversely proportional to the performance index. This is understood because performance index is related to a particular respiratory disorder while the frequency of citation of a plant is in relation to the fourteen respiratory disorders reported in this study. With respect to number of plants cited for the respective respiratory disorders, forty-three plants were cited to have therapeutic effect against respiratory infection without specifying the type of infection. Forty-two plants were cited to be effective against rhino-bronchitis, thirty plants against cough, twenty plants against Asthma, eleven against pulmonary infection and the rest were below seven citations.

The performance of plants, calculated according to their contribution, was able to demonstrate that only plants involved in several respiratory pathologies, which were in competition with others were taken into account. Similar observations were earlier presented by Ndjib et al.²⁷ that performance index should always take into account the coverage of a plant. Thus, the plants entering into the composition of a recipe whose performance index is greater than or equal to 2 will be said to be more effective for the pathology indicated. As an example, with regards to respiratory infections, *Capsicum annum* (PI = 1) has a poor performance unlike *Tragia senegalensis* Müll. Arg. (PI = 2) for the treatment of cough.

3. CONCLUSION

The aim of this review was to determine the plants most likely to treat respiratory disorders related to COVID-19 infection in Africa. Although not exhaustive, this study made it possible to identify 143 plant species belonging to 60 families of plants in the management of 15 diseases and / or symptoms relating to the respiratory system. The most cited plants are: *Ocimum gratissimum* L. (04 citations), *Entandrophragma cylindrium* (Sprague), *Scyphocephalum*

ochocoa Warb. *Rubia cordifolia* and *Allium sativum* L. (03 citations each). The most represented families are the Fabaceae and Lamiaceae (18 citations each). These plants are linked with the treatment of pneumonia, lung infection, cough and rhino-bronchitis which are associated with COVID-19. Hence, may be helpful in COVID-19 infection.

Data Availability: The datasets used and analyzed in the study are included in the review without any restriction.

Conflicts Of Interest: Authors declare that they have no conflicts of interest.

Authors' Contributions: GAA conceived and designed the review and participated in the collection of data and analysis; and revised the final form of the review. RCN carried out data collection and prepared the first draft of the review.

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