British Journal of Pharmaceutical Research
16(2): 1-22, 2017; Article no.BJPR.32973
ISSN: 2231-2919, NLM ID: 101631759

SCIENCEDOMAIN *international*
www.sciencedomain.org

Plants in Respiratory Disorders I- Anti-asthmatics, A Review

Simeon K. Adesina[1*], Imoh Imeh Johnny[1] and Gbola Olayiwola[2]

[1]Department of Pharmacognosy and Natural Medicine, Faculty of Pharmacy, University of Uyo, Uyo, Akwa Ibom State, Nigeria.
[2]Department of Clinical Pharmacy and Pharmacy Administration, Faculty of Pharmacy, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author SKA designed the study. Authors SKA, IIJ and GO have contributed to the chemistry, ethnopharmacology and biological studies in this review and have also collaborated in literature search, data collection and referencing. Author SKA wrote the first draft of the manuscript. All the authors read through and approved the final manuscript for publication.

Article Information

DOI: 10.9734/BJPR/2017/32973
Editor(s):
(1) Vasudevan Mani, Universiti Teknologi MARA (UiTM), Selangor, Malaysia.
Reviewers:
(1) Yahya Elshimali, UCLA School of Medicine, Charles R. Drew University of Medicine and Science, USA.
(2) Vijayan Mini, Carmel College, India.
(3) Renshan Sun, Third Military Medical Unversity, China.
Complete Peer review History: http://www.sciencedomain.org/review-history/18911

Review Article

Received 25th March 2017
Accepted 29th April 2017
Published 4th May 2017

ABSTRACT

Aim of This Review: Respiratory disorders pose a big threat to life and constitute a major public health problem worldwide. This review is an attempt to bring together some of the common medicinal plants traditionally used to manage asthma. The review focuses on anti-asthmatic plants, their chemistry and pharmacology in an attempt to justify use and also provide a direction for future research.
Study Approach: Information on the above was sourced from published articles and reviews on the subject available from various data bases and journals. Fifty-six medicinal plants that have been investigated for anti-asthmatic properties have been reviewed.
Findings: Table 1 gives a list of plants reviewed and the mechanism of anti-asthmatic action. Herbal products are receiving increasing attention all over the world for the management of

**Corresponding author: E-mail: simkol2000@yahoo.com;*

respiratory disorders as these have shown anti-asthmatic, antihistaminic, anti-allergic, anti-anaphylactic and anti-inflammatory activities. The biochemistry and medicinal significance of polyphenols and flavonoids are now better appreciated in the management of respiratory disorders.

Conclusion: Medicinal plants remain the main ingredients of indigenous medicines; this review justifies the need for polyherbal formulations for use in the management of respiratory disorders.

Keywords: Respiratory disorders; anti-asthmatic plants; phytochemistry; ethnopharmacology, biological studies.

1. INTRODUCTION

Respiratory allergies are known to include allergic rhinitis and allergic asthma which always cause wheezing, coughing, shortness of breath, sneezing, running nose and sinus problems, and in some cases red, watery and itching eyes [1]. Respiratory disorder considered in this review is asthma- bronchial asthma, occupational asthma, allergic asthma, cough-variant asthma, exercise-induced asthma, nocturnal asthma and childhood asthma.

Asthma has been described as a chronic inflammatory disease of the airways usually characterized by variable and recurring symptoms which include coughing, wheezing and shortness of breath [2]. The National Institute of Health defines it as a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role, in particular, mast cells, eosinophils, T-lymphocytes, neutrophils and epithelial cells [3,4]. Asthmatic attacks may be mild, resulting from diffuse wheezes, adequate air exchange and mild dyspnoea; moderate, with respiratory distress at rest, marked wheezes but involving the use of accessory muscles or severe, when marked respiratory distress is expressed and characterized by marked wheezes and respiratory failure. When severe, respiratory distress, confusion and lethargy are experienced. Incidence of death may arise from very severe asthmatic attacks and respiratory failures.

Asthma is said to be caused by a combination of genetic and environmental factors. A major risk factor for developing asthma is the genetic disposition of the individual; asthma symptoms are known to be due to liberation of endogenous and intrinsic mediators-histamine, leukotrienes, nitric oxide, chemokines and endothelin from mast cells, inflammation of the airway in the lungs etc. Asthma has been triggered by various other factors; viral respiratory infections, chemicals including certain medications, air-borne allergens, occupational sensitizers, smoke, air pollution etc. [2]. As noted by Singh et al. [5], stress and acute anxiety or an extreme emotional arousal may also trigger asthmatic attacks. Asthma can be grouped as extrinsic when caused by allergic responses to such things as dust, certain foods, animal fur etc. causing 10 – 20% of adult asthma, or intrinsic when caused by genetics, infections, pollutants and physiological and psychological stress, making about 30 – 50% of adult asthma [5].

Clinically, asthma has been described as airway obstruction that involves inflammation of the pulmonary airway and bronchial hyper-responsiveness that is usually reversible [6].

2. HERBAL THERAPY FOR ASTHMA

The pharmacological management of asthma depends largely on (i) bronchodilators – β – adrenergic agonists, anticholinergics and methylxanthines and (ii) steroidal anti-inflammatory agents – corticosteroids and anti-leucotrienes [7]. Many medicinal plants have been identified as capable of treating respiratory disorders. These herbs in asthma therapy are used to relieve convulsive bronchitis and bronchial asthma. These disorders are thought to be caused by a continuous contraction of bronchial smooth muscles usually accompanied by mucosal oedema and increased secretions. Asthma as an inflammatory rather than a bronchospatic disorder needs the medicinal plants with constituents that can control underlying airway inflammation as well.

Most anti-asthmatic herbs act by stimulating β-adrenergic receptors causing relaxation of the bronchial smooth muscles, thus acting as bronchodilators. Some act as mast cell stabilizers, anti-allergics, anti-anaphylactic, anti-inflammatory agents, anti-spasmodic agents, inhibition mediators – leukotrienes, lipoxygenase, cyclooxygenase, cytokine etc. and even as immunomodulatory agents in the treatment of

asthma. The implications of these are that medicinal plants that must be used for the treatment of asthma should have anti-inflammatory, immunomodulatory, antihistaminic, smooth-muscle relaxant and allergic activity [7,8]. Where a remedy of four or more plants' parts is prescribed for a treatment, the multifaceted roles these herbs will play, suggesting different modes of action within the body will assist greatly in the management of the disease effectively.

2.1 Plants Used in the Management of Asthma

2.1.1 *Acanthus ilicifolius* Linn, Acanthaceae (Holy leaved acanthus)

Plant is well known in traditional medicine for the management of asthma, hepatitis, rheumatoid arthritis and as a diuretic [9].

The plant contains the alkaloids – acanthicifoline, trigonelline, 2 – benzoxazolinone, benzoxazin-3-one etc., aliphatic glycosides, flavonoids, and lignan glycosides [9].

A. ilicifolius aerial parts and root extract showed strong antimicrobial and antifungal activities. 6-Hydroxy benzoxazolinone, (Z) – 4-coumaric acid 4-0-β-D-glucopyranoside and 3,5-Dimethoxy – 4-hydroxymethyl benzoate isolated from the plant were identified as the antibacterial constituents of *A. ilicifolius*. The alkaloids 2-Benzoxazolinone and benzoxazinoids were identified as anti-inflammatory agents. The ethanol root extract partially prevented anaphylactic shock induced in guinea pigs by antigen injection. It also showed a brief non-specific antispasmodic action on isolated tissues [10].

2.1.2 *Asystasia gangetica* (L.) T. Anderson, Acanthaceae (Chinese Violet)

A. gangetica is used traditionally to manage or treat rheumatism, skin allergies etc. The leaves are reported to be highly effective in the treatment of asthma [11].

The aerial parts gave asysgangoside, salidroside, benzyl β – D-glucopyranoside, ajugol and flavonoids [12].

A. gangetica was investigated for antiasthmatic property. The hexane, ethylacetate and methanol soxhlet-extracted fractions exhibited anti-inflammatory activity. The bronchospasmolytic constituent caused 82% inhibition of maximum contraction produced by histamine (400 µg/ml). On histamine (8 µg/ml) precoated trachea, cumulative doses of the fractions evoked a dose-dependent relaxation [13],

2.1.3 *Aloe vera* Linn, Aloaceae (Aloe, aloe vera)

Ancient Egyptian papyrus and Mesopotamia clay tablets described *Aloe* as useful in curing infections, treating skin problems and as a laxative. There are reports about anti-tuberculosis activity of *A. vera* [14].

A. vera contains anthraquinones/anthrones, carbohydrates, chromones, enzymes and proteins – lectins and lectin-like substances [14].

Plant is allergenic and anti-asthmatic. Gupta et al. [15] evaluated the *in vitro* antitubercular activity of 5 medicinal plants one of which is *A. vera*. Extracts of *A. vera* exhibited anti-tuberculosis activity, the proportion of inhibition for *A. vera* was 32% for MDR (multi-drug resistant) isolate (DKU-156) and 85% for another MDR isolate (JAL- 1236) while for sensitive *M. tuberculosis* $H_{37}R_V$ strain, inhibition was 41%, at 4% v/v concentration in Lowenstein Jensen (L-J) medium.

2.1.4 *Achyranthes aspera* Linn., Amaranthaceae (Rough Chaf tree, Prickly chaff flower, Devil's horse whip)

Traditionally *A. aspera* is used in asthma and cough. A decoction of the whole plant is used in beriberi, pneumonia and cough. Fresh stem is chewed as tooth brush and root ashes mixed in water or honey is taken for cough. Unripe fruits may be taken thrice daily for general respiratory problems [16].

A. aspera aerial parts gave bisdesmosidic saponins I-III, flavonoids, triterpenoid saponins and volatile oil [16].

A. aspera petrol extract (200 mg/kg, i.p) showed significant anti-allergic activity [17]. Goyal et al. [18] investigated the bronchoprotective effect of *A. aspera* ethanol extract in Wistar rats. It was noted that sensitized rats exhibited asthmatic symptoms and both *A. aspera*- and dexamethasone – treated rats did not show airway abnormality.

2.1.5 *Aerva lanata* (L.) A. L. Juss. ex Schultes, Amaranthaceae

A. lanata whole plant decoction is taken to treat pneumonia, typhoid, fevers and cough. *A. lanata* is a well-known anti-asthmatic plant remedy [19].

A. lanata is rich in alkaloids, flavonoids and triterpenes – lupeol, α-amyrin, lupeol acetate, betulin, chrisin, β-sitosteryl acetate etc. [19].

The ethanol extract of *A. lanata* was investigated for anti-asthmatic activity [19] and the extracts exhibited significant dose-dependent anti-asthmatic activity *in vitro* and *in vivo* in animal models *A. lanata* also showed antimicrobial and anti-inflammatory activities [20].

2.1.6 *Amaranthus spinosus* Linn., Amaranthaceae (Thorn Pigweed, Spiny amaranth, needleburr, prickly amaranth, thorny amaranth)

The plant is used in folk medicine to treat cough and to relieve breathing in acute bronchitis [21].

A. spinosus contains flavonoids and phenolic acids, betacyanins and their isomers; lignans and catechuic tannins [21].

A. spinosus stem bark extracts exhibited antimicrobial, antifungal, (flower extracts were more potent), analgesic and anti-inflammatory properties [21]. *A. spinosus* aqueous MeOH extract was studied *in vivo* for bronchodilator and laxative properties and *in vitro* using isolated tissue preparations to assess the spasmolytic effect [22]. The plant extract possessed laxative activity and bronchodilator activity thought to be through a combination of β-adrenergic and Calcium channel blocking pathways.

2.1.7 *Anacardium occidentale* Linn. Anacardiaceae (Cashew)

The stem bark, leaves and shell oil of *A. occidentale* are used to treat respiratory disorders–asthma and bronchitis, diarrhea, dysentery and pain [23-25].

A. occidentale apple was reported to contain benzoic acid derivatives, flavonoids and fatty acids-n-hexadecanoic acid, 17-octadecynoic acid and octadecanoic acid [25].

A. occidentale had antimicrobial and anti-inflammatory properties. *A. occidentale* EtOH/ H_2O extract was evaluated for antiasthmatic activity [24] and the purified extract showed significant relaxant effects ($p < 0.01$) compared to histamine in both go-at tracheal and guinea pig ileum preparations. The ethanol extract showed maximum protection ($p<0.01$) against catalepsy (375 mg/kg p.o. body wt). Biochemical estimations in milk-induced total leukocytosis count showed maximum decrease in total leukocyte count (250 mg/kg p.o body wt.

2.1.8 *Mangifera indica* Linn, Anacardiaceae (Mango)

M. indica has great values as food product and its parts have been used in medicine, to ameliorate hemorrhages and bleeding hemorrhoids and to manage asthma, nasal catarrh and cough [26,27].

The stem bark contains tannin (16–20%), protocatechuic acid, catechin etc., terpenoids friedelin, cycloartan-3β-30-diol and its derivatives, mangiferin and the isomer mango coumarin etc. [27].

Mango exhibits anti-inflammatory, antibacterial, antiulcer, neuropathic pain reduction activity, anti-diarrhoeal and anti-asthmatic activities [27]. A case report was carried out on two asthmatic patients treated with Vimang® (an aqueous extract of *M. indica* stem bark) which has been registered as an antioxidant and anti-inflammatory. The extract reduced the total IgE, ECP concentrations and MMP–9 activity in blood serum. The study concluded that Vimang® could be a suitable alternative for the treatment of bronchial asthma [26].

2.1.9 *Anchomanes difformis* (Blume) Engl. Araceae

A. difformis was reported widely used in traditional medicine for the treatment of asthma by herbal practitioners in Delta State, Nigeria [28].

A. difformis contains some quantities of tannins, flavonoids, alkaloids, steroids and phenolic compounds [29].

The anti-asthmatic property of the leaf aqueous extract was investigated in guinea pigs with salbutamol and ovalbumin as reference drugs. The percentage protection from asthma was not significantly different from that of the reference drug, salbutamol (32.5%) and the aqueous leaf extract of *A. difformis* at 400 $mgkg^{-1}$ (32.7%). The study concluded that *A. difformis* leaf extract was safe and possessed anti-asthmatic [29].

2.1.10 *Calotropis procera* Ait R. Br, Asclepiadaceae (Dead Sea apple, sodom apple, swallow wort, milk weed, Roaster tree, French cotton)

C. procera roots are used to treat asthma, bronchitis and cough. The milky juice and flowers are used as a digestive, stomachic, tonic and in the treatment of cough, asthma and loss of appetite [30].

C. procera latex gives cardenolides, terpenes and terpenoids and flavonoids [30].

C. procera aqueous extract (50, 100, 200 µg/ml, p.o) showed a dose-dependent relaxant activity probably exhibited through the direct relaxant action on the smooth muscles. The flower extract was investigated for anti-asthmatic activity using human beings as volunteers; patients had good recovery from symptoms of asthma. *C. procera* extracts – latex and juice from all parts of the plant showed strong anti-inflammatory, spasmolytic, anti-oxidant, anti-microbial, immune responses activity. Calotropin isolated from the latex has been used as a remedy for boils, cold, cough, inflammatory lesions and asthma [31].

2.1.11 *Ageratum conyzoides*Linn., Asteraceae (Billygoat weed, goat weed, craw-craw plant, Devil's dirt, tropic ageratum)

A. conyzoides is used in folk medicine to treat fevers, inflammation, cough, skin diseases etc. It is used for its anti-asthmatic, antispasmodic and haemostatic properties [32].

The leaf contains an essential oil, chromenes and flavonoids many of which are oxygenated flavones.

A. conyzoides was reported to have bronchodilating and uterine relaxant activity, gastro-protective, antibacterial, antifungal, anti-viral and wound-healing properties [33].

2.1.12 *Bidens pilosa* L., Asteraceae (Beggar's stick, Spanish needle, Cobbler's pegs, Farmer's friend)

B. pilosa whole plant decoction or maceration is taken orally to treat asthma, pharyngitis, gastritis, colds and influenza [34].

Aerial parts and roots have furnished polyacetylenes which include I-phenylhepta-1, 3, 5-tryine and cytopiloyne, terpenes and flavonoids [35].

Plant is anti-inflammatory, antimycobacterial, antibacterial, anti-allergic and antifungal [35].

B. pilosa extracts and essential oil were found to be highly antibacterial, showing bacteriostatic and/or bactericidal action. The polyyne (R) – 1,2 – Dihydroxytrideca – 3, 5, 7, 9, 11 – pentatayne from this plant was found to suppress bacterial growth and had a similar MIC_{50} value to antibiotics – ampicillin, tetracycline, norfloxacin and amphotercin B – in most of the bacteria tested. Centaurein and centareidin from *B. pilosa* extract also enhanced bactericidal activity in macrophages and were found to have additive effect with ampicillin. Extracts of *B. pilosa* have demonstrated strong antifungal effects [35].

2.1.13 *Eclipta alba Hassk, Asteraceae*

E. alba is widely used in folk medicine as a rejuvenator, indeed an anti-ageing plant. The plant juice, mixed with honey is used in the treatment of asthma, cough, selinity, bronchitis, skin diseases; the powder is used to manage cough while the whole plant is considered spasmolytic, antibacterial, anti-catarrhal, anti-dysenteric, age-sustaining, tonic and detoxifier, antiseptic and rejuvenating [36].

The aerial parts of *E. alba* contains terpenoids, wedelolactone, desmethylwedelolactone etc. [36,37].

Wedelolactone was found to be a selective 5 – lipogenase inhibitor with an IC_{50} of 2.5 µm and an isolated coumarin compound as an anti-inflammatory and bronchodilator [36]. The anti - anaphylactic activity of an alcoholic extract of *E. alba* was investigated [37], with two different doses – 250 and 500 mg/kg, using different animal models. Results showed a positive anti-anaphylactic activity of *E. alba* alcoholic extract. The authors concluded that this could be due to membrane stabilizing potential, inhibition of antigen-induced histamine release and ability of extract to inhibit the release of various inflammatory mediators in the test animals.

2.1.14 *Balanites aegyptiaca* Delile, Zygophyllaceae (Balanitaceae) (Desert date, Soap berry tree, Thorn tree)

B. aegyptiaca fruit is traditionally used in cough, asthma, fever, whooping cough, dysentery, wounds, internal worm infestation, diarrhea [38,39]. In asthma, about 10gm of seed powder is taken with a glass of water in the morning for 10 days.

Plant contains steroidal saponins, coumarins, 15% of organic acids, balagyptin, Balanitin-3 (spirostanol glycoside), Balanitin-6 and 7 and other diosgenyl saponins and flavonoids [39].

B. aegyptiaca extracts showed pronounced spasmolytic and anti-inflammatory properties [38]. The fruit extract showed bronchodilatory effect and this could be due to the presence of steroidal saponins. The antiasthmatic and antianaphylactic activity of the n-BuOH fraction was evaluated using various experimental models; the study found out that *B. aegyptiaca* extracts had anti-anaphylactic and anti-asthmatic properties, the bronchodilatory effect of n-butanol fraction was comparable to the protection offered by both the reference standard drug chlorpheniramine and atropine sulphate. Plant has smooth muscle relaxation properties [38].

2.1.15 *Garcinia kola* Heckel, Clusiaceae/ Guttiferae (Bitter Kola, African Wonder nut)

Bitter Kola seed is used in folk medicine to treat bronchitis, laryngitis, throat infections, cough and asthma, while the leaf is used in the treatment of tuberculosis and typhoid fever [40,41]. The dried seed is powdered and mixed with honey to make a cough syrup.

Major constituents of the seed are biflavones and biflavanones – GBI, GBII, kolaflavanone, benzophenones, fatty acids-hexadecanoic acid, 9-octadecanoic acid methylester, linoleic acid [42,43].

G. kola is antibacterial, antifungal and anti-inflammatory. Cycloartenol, 24-methylenecycloartenol and garcinianin from the seeds showed strong antibacterial activity. Polyisoprenyl benzophenone, kolanone and hydroxybiflavanoids from seed showed strong antibacterial activities against *Streptococcus mutans*, *Aspergillus flavus*, 30 clinical strains of *Helicobacter pylori* and many oral bacteria (with MIC values of 32-64µg/ml). Kolaviron showed anti-inflammatory properties. Xanthones and flavonoids have demonstrated anti-asthmatic activities by various mechanisms [41,44]. The above data support the traditional use of *G. kola* in asthma, tuberculosis and bacterial infections.

2.1.16 *Anogeissus leiocarpus* Guill and Perr. Combretaceae (Axlerwood tree, African birch)

A. leiocarpus is used in traditional medicine for the treatment of cough, general body pain, asthma and tuberculosis [23].

A. leiocarpus contains 3,3,4'-tri-O-methylflavellagic acid, 3,4,3'-tri-O-methylflavellagic acid-4- β-D-glucoside, gentisic, protocatechuic and gallic acid; tannins (23 %) – chebulagic acid, chebulinic acid and ellagic acid and fatty acids [45,46].

A. leiocarpus root, leaf and stem bark exhibited potent antibacterial activity against *S. aureus*, a clinically known human bacterial pathogen responsible for or associated with dental caries and periodontal disease, respiratory infections and wound infections. The plant extracts also showed good activity against the fungi- *Candida albicans* and *A. niger. A. niger* is a causative agent of respiratory tract infection and superficial fungal infections of the skin. [46].

The ethanolic extract of the stem bark showed relaxant effects indicating an anti-asthmatic action of the extract. Yerima et al., [47] reported the *in vitro* antispasmodic effect of leaf ethanol extract which they claimed had a dose-dependent depolarizing effect on the rabbit ileum.

2.1.17 *Luffa cylindrica* (L.) Roem Cucurbitaceae (Sponge gourd, loofa, vegetable sponge, bath sponge, dish cloth gourd)

Different parts of *Luffa cylindrica* are used in folk medicine to treat respiratory complaints such as chronic bronchitis, asthma, sinusitis, pain, inflammation, pharyngitis and rhinitis [48].

The fruit of *L. cylindrica* contains triterpenoid saponins, flavonoids and polypeptides-luffins PI, S, luffacylin, lucyoside N and P [48].

L. cylindrica seed extract showed anti-inflammatory properties. The fraction with the high antifungal activity showed bronchodilator activity [49]. The plant has anti-allergenic property. The water and ethanol extracts showed antiasthmatic, antitussive and expectorant effects. Oral and intraperitoneal administration of EtOH/H_2O extracts suppressed sulphur dioxide- and ammonium aerosol-induced cough in

mice and increased the respiratory tract phenol-red excretion in mice. It was found that intraperitoneal administration of water decoction of *L. cylindrica* extracts inhibited histamine-induced asthma. These scientific facts support its use in the treatment of respiratory disorders such as asthma [48].

2.1.18 *Alchornea cordifolia* (Shumach and Thonn) Müell Arg., Euphorbiaceae

All the parts of *A. cordifolia* are used extensively in traditional medicines for managing respiratory disorders such as coughs, bronchial troubles and urinary disorders. Fruit slurry may also be prepared for managing cough and asthma [50].

Leaves contain flavonoids, phenolic acids and alkaloids [51].

A. cordifolia showed antibacterial, antifungal, antiparasitic and anti-inflammatory properties [51,52]. Isolated flavonoids showed muscle relaxant properties [50]. Root extracts showed anti-asthmatic properties. Bayor et al. [53] investigated the scientific basis for the traditional use of *A. cordifolia* in asthma and coughs using isolated tissue models of smooth muscles and concluded that the extract stimulated smooth muscles through activation of β-adrenoceptors in a manner similar to isoprenaline; this supports its traditional use in anti-asthmatic and cough formulations.

2.1.19 *Euphorbia hirta* Linn, Euphorbiaceae. (Asthma plant, Pills bearing Spurge, Cat's hair, Hairy Spurge, Australian asthma herb, Queensland asthma weed)

E. hirta is used in traditional medicine to manage respiratory diseases – cough, asthma, colic, bronchitis, laryngeal spasms, colds, coryza and hiccough [54].

E. hirta aerial parts also contain terpenoids and flavonoids. The major essential oil components were phytol, hexadecanal, hexadecanoic acid and 3, 7, 11,15 – tetramethyl – 2- hexadecen-l-ol [54,55].

E. hirta has shown antibacterial, antifungal, antioxidant anti-allergic, anti-stress and anti-inflammatory properties [56,58]. It has also shown anti-anaphylactic and anti-asthmatic properties [57,58]. The listed scientific evidences justify its use as an anti-asthmatic plant.

2.1.20 *Phyllanthus amarus* Schum et Thonn, Euphorbiaceae

P. amarus is used in folk medicine in the management of asthma, tuberculosis, kidney problems, inflammation and prostate problems. [59].

P. amarus contains flavonoids and derivatives; phenolic acids, lignans, alkaloids and volatile oil – linalool, phytol [59].

P. amarus has exhibited strong antiviral, antibacterial, antifungal, anti-oxidative, anti-hepatits and anti-inflammatory properties. The lignans phyltetralin, nirtetralin and niranthin are anti-inflammatory compounds, phyllanthin and structurally-related compounds and the phenolics have shown strong anti-bacterial and anti-oxidative properties [60]. *P. amarus* demonstrated strong antiviral values suppressing hepatitis B virus by interrupting interaction between HBV enhancer I and cellular transcription factors and for eradicating hepatitis B in chronic carriers [61].

2.1.21 *Phyllanthus niruri* Linn, Euphorbiaceae

P. niruri is used in traditional medicine to treat bronchitis, tuberculosis, cough, allergic asthma, allergic rhinitis, sinus problems and urinary problems [59].

P. niruri contains alkaloids, tannins, lignans-phyllangin, sesamine and derivatives, phenolic acid and ellagic acid and derivatives and flavonoids-rutin, quercetin, astragalin etc. [59].

P. niruri is strongly antibacterial, anti-inflammatory, antifungal, antiviral, antispasmodic and anti-hepatitis [59]. Corilagin is anti-hyperalgesic, phyllanthoside is antispasmodic, the plant alcoholic extract was reported to be highly antibacterial and antiviral, phyllanthin and the flavonoids showed strong antibacterial and anti-oxidative properties and so the plant could be used in the management of urinary and respiratory disorders caused by various infections. The plant has been described as anti-asthmatic, antispasmodic and bactericidal [62,63].

2.1.22 *Abrus precatorius* Linn., Fabaceae (Precatory bean, Rosary pea, Crab's eye, Jequirity bean)

Plant is used traditionally in the management of respiratory disorders- cold, colic, cough and

fever, bronchitis and *Abrus* seeds are used in tuberculosis [64]. To manage cough for example; two (2) or three (3) teaspoonfuls of fresh leaf juice is taken twice daily for three (3) days.

Leaf contains alkaloids, saponins and flavonoids-precatorins I, II and III, vitexin etc. [64].

The plant is reputed to have antibacterial, antifungal, anti-inflammatory and antispasmodic effects.

Leaf MeOH extract showed bronchodilator activity in guinea pigs and exhibited a maximum degree of protection of 41.62% compared to the reference compound, salbutamol (of 47.52%) [65]. The leaf ethanol extract, 100-150 mg/kg i.p, significantly decreased milk-induced leukocytosis and eosinophilia in mice in a dose-dependent manner when compared with the control group and concluded that the leaf extract could be used in the management of asthma [66]. They also found that the leaves of *A. precatorious* possessed muscle relaxant, mast cell stabilizing and anti-anaphylactic activities.

2.1.23 *Albizia lebbeck* Benth, Fabaceae – Mimosoideae (Indian Walnut, Siris tree)

A. lebbeck stem bark and flower are used in traditional medicine in bronchitis, boils, cough, flu, lung problems, inflamed eyes, allergic conjunctivitis, atopic allergy and other pathologies such as asthma, allergic rhinitis, helminth infections and anti-tubercular disease. [67]. *Albizia coriaria* Welw. ex Oliver and *Albizia zygia* (DC.) J. F. Macbr are used in the same way.

The leaf contains flavonoids, the stem bark contains condensed tannins (7-11%), catechin, and triterpenoids and albiziasaponins A, B and C [68].

A. lebbeck has been described as antiseptic, antibacterial, anti-allergic and anti-dysenteric. Leaf saponins inhibited mast cell degranulation. Bark decoction protects against bronchoconstriction induced by acetylcholine and histamine. Plant was reported to have antitussive action and the ability to prevent bronchoplasm induced by allergens [67]. *A. lebbeck* was also shown to possess anti-asthmatic and anaphylactic activities in many experimental animal models. These were due to smooth muscle relaxant properties, anti-histaminic and antispasmodic activities, cromoglycate action on the mast cells and due to inhibition of the synthesis of antibodies

2.1.24 *Cassia occidentalis* Linn, Fabaceae (Coffee senna, Negro coffee, Rubbish Cassia, stinking weed, Foetid Cassia)

C. occidentalis roots are widely used in folk medicine to treat whooping cough and related diseases. Eight to ten roasted pods are eaten for cough; two table spoonfuls of leaf juice may also be mixed with honey to treat cough [69,70].

C. occidentalis pods contain flavone-glycosides, the seed contains anthraquinones, the leaf-chrysophanol, emodin and their glycosides and the roots, anthraquinones, occidentalol I, occidentalol II and cassia occidentalins A, B and C [69,70].

C. occidentalis was found to possess significant bacterial and antifungal properties, whole plant ethanol extract showed anti-allergic activity while leaf aqueous extract showed muscle-relaxant effects. The anti-asthmatic potential of the leaf aqueous extract was investigated *in vitro* and *in vivo* in animal models [71]; the extract showed antihistamine, mast cell stabilizing and decreasing capillary permeability effect.

2.1.25 *Desmodium adscendens* (Sw.) DC var. *adscendens*, Fabaceae (Amor seco, strong back, hard man, hard stick)

D. adscendens is used in folk medicine as tea or as a decoction in the treatment of asthma and related respiratory disorders. About 2 tablespoonful of powder made from the crushed leaf and stem is taken up in warm water and taken to manage asthma. [72]. Ayensu [73] recorded that the plant was used for bronchial asthma, cough, colic, among other diseases. *Desmodium gangeticum* (L.) DC and *Desmodium triflorum* (Linn) DC, have similar properties.

The plant contains essential oil, alkaloids and flavonoid compounds. [74].

Extracts of the plant showed strong antimicrobial properties [74]. EtOH/H_20 extracts reduced anaphylactic contractions of guinea pig ileum, interfered with histamine-induced contractions and reduced the amount of smooth muscle stimulating substances released from lung tissue of guinea pigs [75].The plant has been described as anti-anaphylactic, anti-asthmatic, anti-histaminic, antispasmodic, anti-inflammatory and

bronchodilator. It was noted that the plant provided protection against acetylcholine and histamine – aerosol-induced bronchospasms [72].

2.1.26 *Dichrostachys cinerea* (L.) Wight et Arn, Fabaceae

The root infusion of *D. cinerea* is used in folk medicine to treat leprosy, syphilis, coughs, asthma and other respiratory disorders [76].

The leaf contains terpenoids and coumarins. The stem bark isolates were friedelin, friedlan-3β-ol, β-sitosterol, ∝-amyrin while the aerial parts gave flavonoid compounds [76].

D. cinerea extract had anti-ulcer and anti-inflammatory activity and compounds with myricetin nucleus were found to exhibit the highest scavenging activity. *D. cinerea* ethanol and water extracts had tracheal relaxant effects [77] and cumulative concentrations of the extracts induced moderate to strong relaxation and this result support the traditional use of this plant in asthma treatment.

2.1.27 *Mimosa pudica* Linn, Fabaceae (Lollipop Mimosa, Shame plant, Urban's Mimosa)

Shame plant has been used in traditional medicine to treat diarrhoea, amoebic dysentery, bleeding piles, convulsions and asthma [78,79].

Plant contains amino-acid derivatives, fatty acid derivatives, and flavonoid glycosides [79].

Studies on anti-asthmatic properties of *M. pudica* aqueous extracts were on *in vivo* and *in vitro* animal models [78]. The extract showed excellent protection in guinea pigs against the histamine-induced bronchospasm. The study concluded that the anti-asthmatic activity of *M. pudica* aqueous extract could be due to bronchodilating, antihistaminic (H-antagonist), mast cell stabilizing, suggestive of the extract's potential in prophylaxis and management of asthma.

2.1.28 *Sida acuta* (Burm.f.) Malvaceae

Root decoction is used in rheumatism, breathing problems and cough [80]. Other species such as *S. cordifolia, S. rhombifolia, S. alnifolia, S. spinosa* etc. have been found useful in folk medicine.

S. acuta contains alkaloids, phenethyl bases, phytosterols, fatty acids, hydrocarbons and others-syringin, heraclenol, xylan etc. [81].

Sida acuta contains cryptolepine (5-methylindolo [2,3b]-quinoline). Cryptolepine has been proven to be an anti-asthmatic agent hence the rationale for the use of *S. acuta* in asthma. The plant also contains scopoletin, a potential regulator of inflammatory reactions mediated by mast cells and an inhibitor of leukemia cell proliferation [82]. *S. acuta* contains polyphenols and alkaloids which were found responsible for the antibacterial properties of the plant.

2.1.29 *Waltheria indica* L, Malvaceae (Sleepy morning, Monkey bush, Velvet leaf, Marsh-mallow Boater bush)

W. indica is used in traditional medicine in cough and asthma and generally as an anti-inflammatory drug in Africa. Plants parts are chewed or taken as a decoction in the treatment of sore throat, cough, asthma and lung infections [83].

Leaves and roots contain cyclopeptid alkaloids, flavonoids and triterpene derivatives- betulinic acid and oleanolic acid derivatives [83].

Root, stem and leaf extracts have shown antibacterial, antifungal, anti-inflammatory and anti-oxidant effects [83]. *W. indica* gave three flavonoid compounds- epicatechin, quercetin and tiliroside [84] which significantly and dose-dependently inhibited the production of the inflammatory mediator nitric oxide (NO), and the cytokines (tumor necrosis factor (TNF)-α and interleukin (IL)-12) in activated macrophages.

2.1.30 *Moringa oleifera* Lam, Moringaceae (Drum stick, Horse radish tree, Benzoline tree, Moringa)

Root, bark, pods and leaves are used for medicinal purposes apart from its food values. Moringa has traditional uses against the common cold, bronchitis, fever and asthma [85].

Phytochemicals from *Moringa* include benzyl isothiocyanates, benzylglucosinolates, niazirin, niazimirin and β-sitosterol-3-0-β-D-glucopyranoside [86].

A clinical study of the anti-asthmatic activity of Moringa extract was undertaken [87]. Treatment

with the drug produced improvement in (i), forced vital capacity (ii), forced expiratory volume in one second and (iii), peak expiratory flow rate values by 32.97 ± 6.03%, 30.05 ± 8.12% and 32.09 ± 11.75% resp. in asthmatic subjects. Improvement was observed in % predicted values and none of the patients showed any adverse effects with the seed. The study concluded that the results suggested the potential of the seed kernel in the treatment of bronchial asthma.

2.1.31 *Eucalyptus torelliana* F. Muell, Myrtaceae

E. torelliana extracts and essential oil have been used traditionally to treat lung diseases, sore throat, pharyngitis, sinusitis and respiratory diseases such as bronchitis [88]. *Eucalptus globulus* Labili share the same values.

The leaf essential oil of a sample examined in Nigeria had 1,8-Cineole (33.8 %), ∝-pinene (21.7 %), p-cymene (10.7 %), β-pinene (10.3 %) [88].

The leaf and stem extracts showed antibacterial and gastroprotective properties; inhibited the growth of *Helicobacter pylori*; useful in the treatment of (i) cough associated with pulmonary diseases (ii) infections caused by non-tuberculosis Mycobacteria (iii) bacterial infections of the urinary tracts and respiratory tracts (iv), inflammations of the mucus membranes and (v) sore throat. The leaf oil was reported to have a direct effect on the coxsakievirus B3 and against four non-tuberculosis Mycobacteria species [88].

2.1.32 *Psidium guajava* Linn, Myrtaceae (Guava, Goyave or Goyavier in French; Guave)

P. guajava leaves and roots are used in traditional medicine to treat respiratory disorders such as coughs, bronchitis, asthma attacks, pulmonary diseases as well as gastro-intestinal disorders [89].

Guava contains antioxidants including ascorbic acid in the fruit; leaf contains essential oil. Mature leaf has myricetin (208.44 mg kg^{-1}), quercetin (2883.08 $mgkg^{-1}$), luteolin (51.22 $mgkg^{-1}$), kaempferol (97.25 $mgkg^{-1}$) [90].

The water extract of guava leaf (2 and 5 g/kg p.o) decreased the frequency of cough induced by capsaicin aerosol by 35 and 54% resp. as compared to the control within 10 minutes after injection of the extract ($p<0.01$). Infusion on isolated rat tracheal muscle demonstrated its spasmolytic action. This demonstrates the antitussive effects of guava leaves [91]. Quercetin has shown many important biological properties which include anti-diarrhoea effect, antioxidant and spasmolytic effects, inhibition on skeletal muscles contraction, vasodilator effects, antimicrobial, anti-inflammatory and induced reduction of presynaptic molecular activity [89-91].

2.1.33 *Biophytum sensitivum* (L.) DC, Oxalidaceae (Life plant)

Decoction of the leaves, which are astringent, bitter and antiseptic are used in asthma [92].

Aerial parts of *B. sensitivum* contain the biflavones- cupressuflavone and amentoflavone, flavonoids and quinic acids. The essential oil contains benzene derivatives and monoterpenes. [92].

Leaf extracts showed antibacterial activity and inhibited the growth of fungal pathogens. Plant had significant antioxidant and anti-inflammatory activities due to the presence of amentoflavone and other phenolic compounds in it.

The anti-asthmatic activity of the leaf ethanol extract was investigated in guinea pigs using the leaf ethanol extract, (100 $mgkg^{-1}$ and 200 $mgkg^{-1}$p.o). Leaf ethanol extracts showed dose-dependent effect in prolonging the preconvulsion time (PCT) in guinea pigs induced by histamine (0,2% w/v.). The ethanol extract (200 $mgkg^{-1}$ p.o.) extended the latent period of convulsions followed by exposure to histamine aerosol at a time of 4 hours and showed the maximum percentage protection of 67.53% compared to chlorpheniramine maleate (1 $mgkg^{-1}$,p.o.), the standard drug, which showed 76.66% protection at the same time interval. The study concluded that the extract possessed highly significant anti-asthmatic activity by inhibiting histamine-induced bronchoconstruction in guinea pigs [93].

2.1.34 *Crytolepis sanguinolenta* (Lindl.) Schlt, Periplocaceae

C. sanguinolenta is used in folk medicine by traditional healers to treat malaria, wounds, urinary and upper respiratory tract infections and hepatitis [94].

Plant contains quindoline, cryptolepine, crypspirolepine, hydroxycryptolepine, cryptoheptine, cryptoquindoline, isocryptolepine, biscryptolepine and neocryptolepine [95].

Isolates from *C. sanguinolenta* have shown hypotensive, antipyretic, anti-inflammatory, *in vitro* antibacterial and antimalarial effects. Cryptolepine was found to have bronchodilatory and anti-inflammatory effects [96]. Airway inflammation and allergic inflammatory responses were studied. Results revealed that cryptolepine (10-100 $mgkg^{-1}$) significantly and dose-dependently inhibited inflammatory cells in the periphery. Significant reductions were observed in the oedema at various doses of the compound compared to the control. Cryptolepine showed dose-dependenbt protection in histamine-induced bronchospasm. The study concluded that oral administration of cryptolepine in a guinea-pig asthma model significantly inhibited the increase in the total inflammatory cell count induced by ovalbumin; cryptolepine had the ability to delay the progression of airway inflammation and is capable of stabilizing mast cells.

2.1.35 *Cymbopogon citratus* DC, Stapf, Gramineae/ Poaceae (Lemon grass, Citronelle (F), Citronella grass oil, Grass tea)

Traditionally, a decoction of *C. citratus* and *O. gratissimum* is taken as 'herbal tea' to treat coughs, catarrh and blocked nostrils [97].

Plant contains essential oil and flavonoids [97,98].

Pure lemon grass oil showed strong antimicrobial, antifungal, antioxidative, antispasmodic and stimulant effects. It was found to have chemoprotective activity, being active on *Mycobacterium smegmatis*. Hexane extract inhibited iNOS (inducible nitric oxide synthase) expression, nitric oxide (NO) production and various lipopolysaccharide (LPS) – induced pathways demonstrating its anti-inflammatory prowess [97,98]. Lemon grass essential oil has been formulated and used as a vaporizer. It was found that the oil works as an effective panacea against bacteria, flu and colds; this justifies its use in the management of respiratory disorders.

2.1.36 *Cynodon dactylon* (L.) Pers, Poaceae (Burmuda grass, Dog's teeth grass, Creeping panic grass, Couch grass, Bahama grass, Dun grass)

C. dactylon is traditionally used to treat diabetes but has also been found useful to manage diarrhea, sore throat, wounds, cough, asthma, bronchitis and piles [99,100].

Whole plant contains alkaloids, flavones and an essential oil [100].

Plant was investigated for its anti-anaphylactic action. This was evaluated by using compound 48/80 induced anaphylaxis and mast cell stabilization was studied using peritoneal mast cells of rats [99]. It was found that the plant constituent isolated and used in the test was more potent than disodium chromoglycate (used in the experiment) in producing anti-anaphylactic activity through mast cell stabilization and inhibition of nitric oxide synthesis. This result confirms the ability of the plant to control asthma and its related problems, justifying the use of the plant in folk medicine [99].

2.1.37 *Securidaca longipedunculata* Fresen Polygalaceae (Violet tree, Fibre tree, Rhodesian violet)

Roots are used in traditional medicine for coughs, flu, fever, pneumonia, toothache, tuberculosis, infections including skin infections [101]. Plant extract was formulated as part of *Gakani*, a herbal anti-asthmatic drug [102].

S. longipedunculata root contains volatile oil with methylsalicylate (methyl-2-hydroxybenzoate), saponins, flavonoids and alkaloids [101].

Various extracts revealed potent antibacterial activity, exhibited antiMycobacterial properties, [103]. Root extracts also showed strong antifungal activity, antiparasitic, anti-oxidant and anti-inflammatory properties. The 50% aqueous MeOH extract showed anti-inflammatory activity in a dose dependent manner by exhibiting reduction of NO production in macrophages stimulated with LPS/IFN-γ yielding 51.3% inhibition at a concentration of 150 µl [104]. The above evidences justify the use of the plant in respiratory disorders.

2.1.38 *Physalis angulata* Linn, Solanaceae (Wild tomato, winter cherry, cut leaf ground cherry)

P. angulata is widely used in traditional medicine to treat asthma, inflammatory diseases and malaria [105,106].

The leaf contains quercetin, quercetin 3-O-methylether, iso – quercetin, myricetin 3 – O-neohesperidoside, physaline B, D, F, G, E, H and I, Withangulation A and Withaferin A [105,107].

Plant showed anti-Mycobacterial activity against *Mycobacterium tuberculosis, M. avium, M. kanasii, M. malmonense* and *M. intracellulase* [108]. The anti-asthmatic activity of the *P. angulata* alcohol root extract was studied in albino mice. Asthma was induced with ovalbumin. Results showed that the extract inhibited ovalbumin-induced asthma by decreasing the release of inflammatory mediators. The study concluded that anti-asthmatic activity was due to the reduction in inflammatory mediator release [109], thus giving support to its ethnomedicinal use.

2.1.39 *Lantana camara* Linn, Verbenaceae

Fevers, colds, rheumatism, asthma and high blood pressure are treated in traditional medicine with preparations from *L. camara* [110]. An infusion of the whole plant is used for bronchitis; the leaves are used to treat rheumatism and pulmonary diseases [111].

The leaves and aerial parts contain various enzymes, tannin, sugars, flavonoids and an essential oil. [111].

The plant was reported to be antibacterial, carminative, antioxidant, antimicrobial, antifungal, antiviral, antispasmodic and anti-asthmatic. Lantic acid showed strong antibacterial activity against *E. coli and Bacillus cereus* with 0.08 and 0.1 µg the minimum inhibition doses, resp. compared to 0.05 and 0.005 µg resp. for chloramphenicol. This means a strong antibacterial potential against multi -resistant bacteria strains. Anti-inflammatory actions of oleanolic acid and ursolic acid have significant activity as inhibitors of human leucocyte elastase. This enzyme participates in the destruction of elastin and plays a role in chronic disorders such as pulmonary emphysema, hepatitis, rheumatic arthritis [111,112].

The leaf aqueous extract, when examined induced contractions in isolated guinea pig ileum and the effect was always greater with the aqueous extract [113]. Effects were concentration dependent. This supports the use of this drug as a remedy for cough and chest conditions.

3. RESULTS

This is a review of 56 medicinal plants used traditionally in the management of asthma (Table 1). Apart from their use and proven potentials as anti-asthmatic plants, some of the very common plants are mentioned only in Table 1 and have not been discussed fully for lack of space. They have also been identified as antitussives and as antiMycobacterium tuberculosis medicinal plants; these include *Allium* species*, Aloe vera, Crinum species, Xylopia aethiopica, some Eucalyptus* species*, Eugenia caryophyllata, Piper species, Datura species, Curcuma longa and Zingiber officinale.*

All the plants have accumulated myriads of bio-active compounds in their organs and with a good concentration of these chemical compounds, these plants have found use in many areas of disease control. Even within the group identified as anti-asthmatics, some plants have been identified with three or four mechanisms of action and these depend on the various bio-active compounds accumulated in the plants. It is also noted that different plant organs have accumulated different types of bio-molecules making one organ more useful in one area of disease control than the other. Some plants have accumulated essential oils, for example, in all the organs making the various organs of the plant available for use in the control of a particular disease.

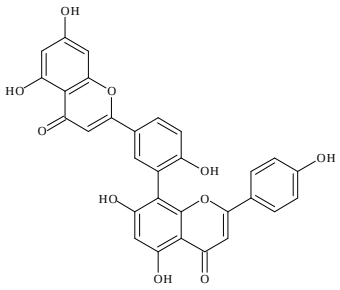
4. DISCUSSION

Asthma and allergy are known to be lifestyle diseases/disorders and this *review* has shown that medicinal plants are helpful in their management. Fifty-six plants have been found to contribute to the health of man, alleviating the problems of asthma. Many of these plants have shown antioxidant, anti-inflammatory, antispasmodic, anti-allergic, antibacterial, demulcent and antitussive properties and have been found to contain extracts and chemical compounds that can act as bronchodilators, anti-anaphylactics, mast cell stabilizers, lipoxygenase inhibitors etc. While some act to maintain and nourish the lungs (or the airways), others support the nerve functions.

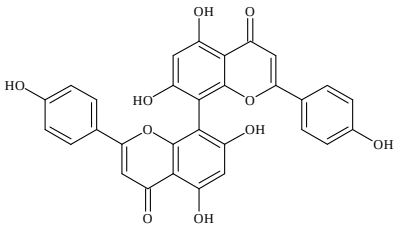
Table 1. Medicinal plants as anti-asthmatic agents

S/NO.	Plant name	Plant parts used	Mechanism of action
1	*Acanthus ilicifolius*	Root	Anti-spasmodic, anti-anaphylactic, anti-inflammatory
2	*Asystasia gangetica*	Leaf	Anti-inflammatory, bronchodilator, spasmolytic
3	*Allium cepa*	Bulb	Anti-allergenic, anti-inflammatory, anti-asthmatic, mast cell stabilizer, suppression of lipoxygenase
4	*Allium sativum*	Bulb	Anti-inflammatory
5	*Aloe vera*	Leaf	Anti-allergic
6	*Achyranthes aspera*	Whole plant	Mast cell stabilizer, anti-allergic, bronchodilator
7	*Aerva lanata*	Aerial plant	Anti-inflammatory, mast cell stabilizer
8	*Amaranthus spinosus*	Stem bark	Anti-inflammatory, bronchodilator
9	*Crinum jagus*	Root and bulb	Anti-asthmatic
10	*Crinum glaucum*	Root and bulb	Anti-allergic, mast cell stabilizer, anti-anaphylactic
11	*Anacardium occidentale*	Stem bark	Anti-inflammatory, Anti-asthmatic
12	*Mangifera indica*	Stem bark	Immunomodulatory, anti-asthmatic, anti-inflammatory
13	*Xylopia aethiopica*	Fruit	Anti-anaphylactic, anti-inflammatory, mast cell stabilizer
14	*Anchomanes difformis*	Leaf	Anti-asthmatic
15	*Calotropis procera*	Flower, Latex	Anti-inflammatory, spasmolytic, mast cell stabilizer
16	*Ageratum conyzoides*	Whole plant	Bronchodilator
17	*Bidens pilosa*	Whole plant	Mast cell stabilizer, anti-allergic, anti-inflammatory
18	*Eclipta alba*		Bronchodilator, anti-inflammatory, anti-anaphylactic, mast cell stabilizer
19	*Balanites aegyptiaca*	Fruit	Anti-inflammatory, bronchodilator, anti-anaphylactic
20	*Garcinia kola*	Seed	Anti-asthmatic, anti-inflammatory
21	*Anogeissus leiocarpus*	Leaf, stem	Anti-spasmodic, anti-asthmatic
22	*Luffa cylindrical*	Seed, stem	Anti-allergic, bronchodilator, anti-anaphylactic
23	*Alchornea cordifolia*	Root	Anti-asthmatic, anti-inflammatory
24	*Euphorbia hirta*	Whole plant	Anti-inflammatory, anti-allergic, anti-anaphylactic
25	*Phyllanthus amarus*	Whole plant	Anti-asthmatic, anti-inflammatory
26	*Phyllanthus niruri*	Whole plant	Anti-asthmatic, anti-inflammatory, anti-spasmodic, anti-allergic
27	*Abrus precatorius*	Leaf	Anti-inflammatory, bronchodilator, mast cell stabilizer, anti-anaphylactic
28	*Albizia coriaria*	Stem bark	Anti-inflammatory, bronchodilator
29	*Albizia lebbeck*	Stem bark	Anti-allergic, anti-anaphylactic, mast cell stabilizer
30	*Albizia zygia*	Stem bark	Anti-allergic
31	*Cassia occidentalis*	Leaf, root	Mast cell stabilizer, anti-allergic, anti-inflammatory
32	*Desmodium adscendens*	Leaf	Anti-histaminic, anti-anaphylactic, bronchodilator, anti-inflammatory
33	*Desmodium gangeticum*	Root, leaf	Anti-inflammatory, bronchodilator
34	*Desmodium triflorum*	Aerial parts	Bronchodilator, anti-histaminic
35	*Dichrostachys cinerea*	Root, leaf	Anti-inflammatory, bronchodilator
36	*Mimosa pudica*	Aerial parts	Mast cell stabilizer, anti-histaminic, bronchodilator
37	*Sida acuta*	Whole plant	Anti-asthmatic, anti-inflammatory, mast cell stabilizer
38	*Waltheria indica*	Stem, leaf	Anti-asthmatic, anti-inflammatory
39	*Azacdirachta indica*	Root, leaf	Anti-inflammatory, anti-anti-anaphylactic, anti-histaminic, mast cell stabilizer
40	*Moringa oleifera*	Leaf, seed, root	Anti-asthmatic, bronchodilator
41	*Eucalyptus globulus*	Leaf oil	Anti-inflammatory, cytokine inhibitor, anti-allergic
42	*Eucalyptus torelliana*	Leaf	Anti-inflammatory, cytokine inhibitor,
43	*Eugenia caryophyllata*	Leaf	Anti-anaphylactic, anti-inflammatory, anti-spasmodic
44	*Psidum guajava*	Leaf	Anti-inflammatory, spasmolytic
45	*Biophytum sensitivum*	Leaf	Anti-asthmatic, anti-inflammatory, anti-histaminic
46	*Cryptolepis sanguinolenta*	Root	Anti-inflammatory, bronchodilator, anti-histaminic, anti-allergic
47	*Piper guineense*	Fruit	Anti-histaminic, anti-allergic, anti-anaphylactic
	Piper longum	Fruit	Anti-histaminic, Anti-asthmatic

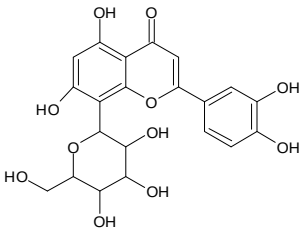
S/NO.	Plant name	Plant parts used	Mechanism of action
48	*Cymbopogon citratus*	Leaf	Anti-inflammatory, anti-spasmodic
49	*Cyndon dactylon*	Leaf	Anti-anaphylactic, mast cell stabilizer
50	*Securidaca longipedunculata*	Root	Anti-asthmatic, anti-inflammatory
51	*Datura metel*	Leaf	Anti-asthmatic, anti-inflammatory, anti-spasmodic
52	*Datura stramonium*	Aerial parts	Anti-asthmatic, anti-inflammatory
53	*Physalis angulate*	Root	Anti-asthmatic, anti-inflammatory
54	*Lantan camara*	Leaf	Anti-asthmatic, anti-inflammatory, anti-spasmodic
55	*Curcuma longa*	Rhizome	Anti-asthmatic, anti-inflammatory, anti-allergic, mast cell stabilizer
56	*Zingiber officinale*	Rhizome	Anti-inflammatory, anti-spasmodic



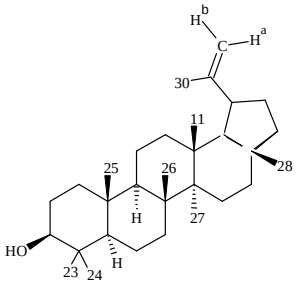
Amentoflavone



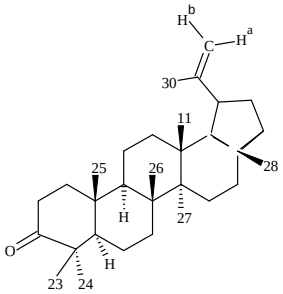
Cupressuflavone



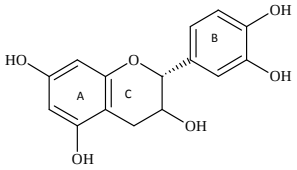
Orientin



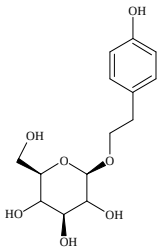
Lupeol



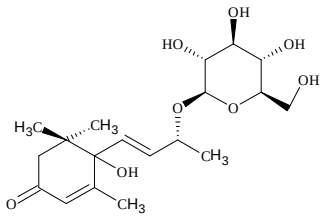
Lupeonone



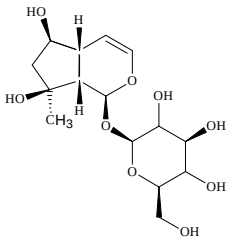
(+)-Catechin



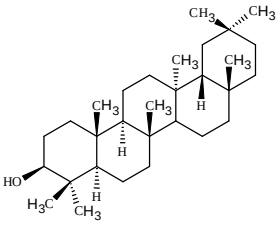
Salidroside



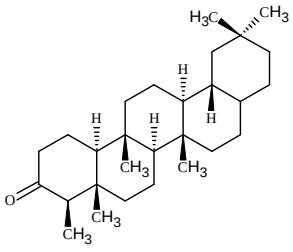
Roseoside



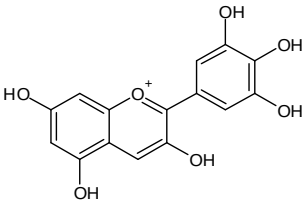
Ajugol



Taraxerol



Friedelin



Delphinidin

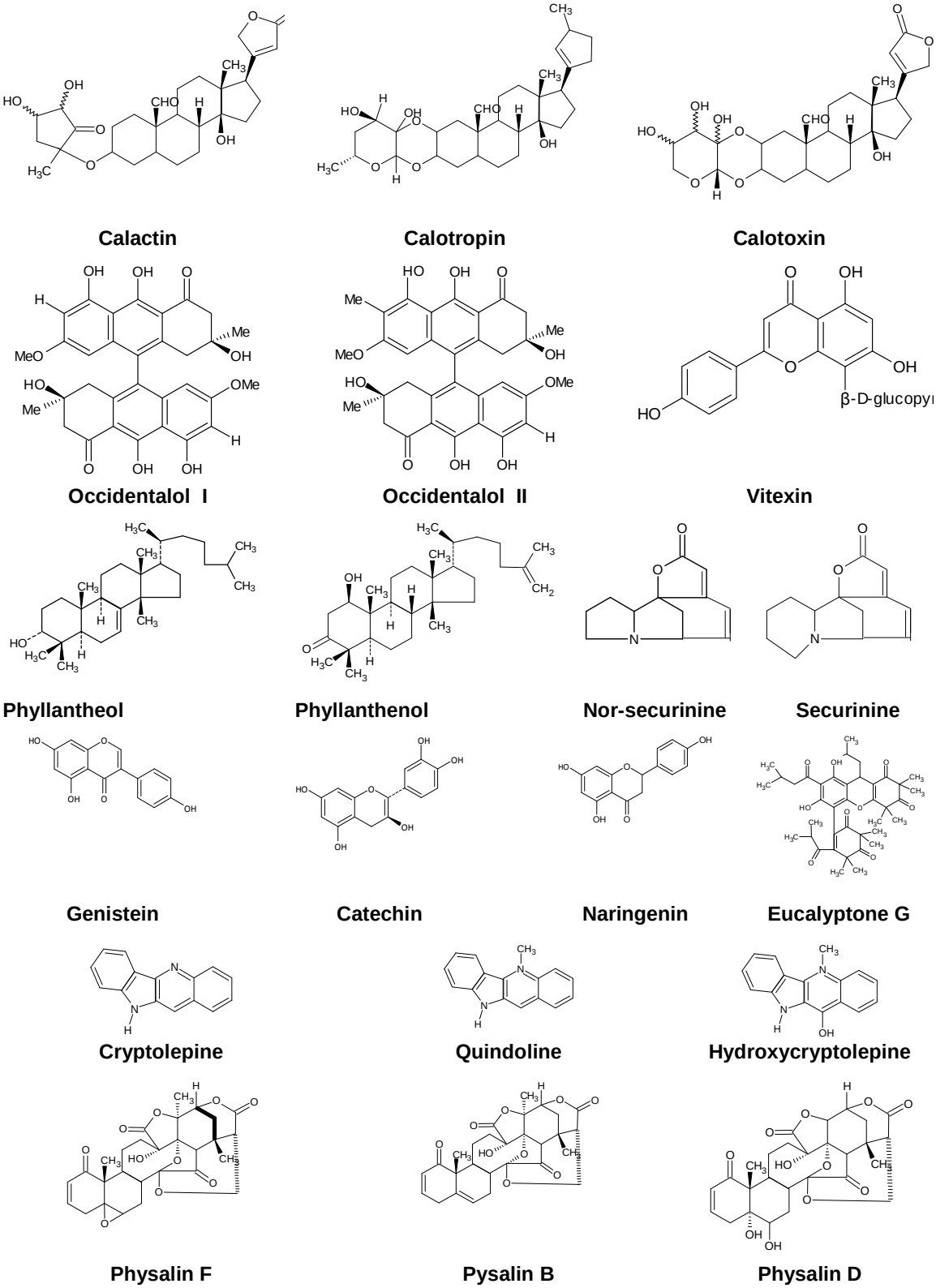


Fig. 1. Structures of compounds cited in the text

Indigenous remedies are usually presented as polyherbal formulations- concoctions, decoctions, powdered ash residue etc. [23] suggesting the administration of remedies containing dilators, expectorants, hydrating agents, xanthines etc. Thus an antiasthmatic remedy that contains extracts of *Crinum jagus* and *Eugenia aromatic*a, for example, may contain *Crinum* alkaloids with their strong antibacterial, cholinesterase inhibitory and mast cell stabilizing properties and Clove extract, with its age-long reputed antibacterial, antifungal, anti-oxidative, anti-inflammatory and antispasmodic properties. One expects a highly potent and effective remedy that may be beneficial against colds, bronchitis, sinus conditions, cough and asthma without much toxic effect. Care must however, be taken not to include a plant with a toxic potential.

Flavonoids and other polyphenolic compounds such as tannins were found to occur naturally in many of the plants reviewed. Flavonoids influence biological cells in many ways- they are significant medicinally [114] as they are known to inhibit or kill many bacterial strains, inhibit many viral enzymes and even destroy some pathogenic protozoans. Found as components of vegetables, honey, fruits, it is believed that man can consume 1-2g daily. Flavonoids are useful medicinally as free radical scavengers, as they simulate some hormones and neurotransmitters and as they exhibit various physiological properties. Flavonoids have shown anti-inflammatory, anti-allergenic and anti-asthmatic properties. For instance, quercetin, 20mgKg^{-1} was reported [115] to cause significant bronchodilation *in vivo* and *in vitro*. Quercetin proved in laboratory conditions its ability to reduce hyperreactivity of airways as one of the main attribute of allergic asthma. Catechin was also reported [116] to exhibit antibacterial, antifungal, antiviral, anti-oxidative, antispasmodic, bronchodilator and vasodilator activities. Studies on polyphenols and their components in experimental allergic asthma showed that polyphenols are more effective in the anti-inflammatory effects in the airways than their separate components [117]. Quercetin and resveratrol, single components of two polyphenols, 'Provinol' and 'Flavin-7' did not show anti-inflammatory effects of the parent polyphenols.

5. CONCLUSION

This is a review of fifty six medicinal plants with proven anti-asthmatic properties. Medicinal plants remain the main ingredients of indigenous medicines; this review justifies the need for polyherbal formulations for use in the management of respiratory disorders.

In our discussion, we highlighted the values of of tannins and flavonoids. Other chemical groups of compounds found as active principles in the plants reviewed include alkaloids, polyacetylenes, cardenolides, sulphur-containing compounds-thiocyanates and sulphinates, coumarins, lignans, terpenoids, essential oil components etc. which have been found to act as bronchodilators, mast cell stabilizers, expectorants etc. It is to be noted that herbs with soothing, antioxidant, antibacterial, anti-inflammatory, antispasmodic, demulcent, expectorant and pulmonary tonic properties have generally been found beneficial in asthma management.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENT

The authors acknowledge the contributions of all scientists whose work(s) were cited in this manuscript

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ingle N, Ojha N, Kumar A. Critical analysis of Charakokta mahakashaya in the management of Respiratory Allergic Disorders (RAD). J Humeop Ayurv Med. 2013;2(3):1-4.
2. Chaudhari SP, Talele P, Asthma management: A review. World J. Pharm. Res. 2014;3(8):275–326.
3. National Institute of Health, Expert panel report 2. Guidelines for the diagnosis and Management of asthma. NIH Publication. 1997;97-4051.
4. Taur DJ, Patil RY. Some medicinal plants with anti-asthmatic potential. A current

status. Asian Pac. J Tropical Biomed. 2011;1(5):413-418.

5. Singh SK, Patel JR, Debey PK, Thakur S. A review on anti-asthmatic activity of traditional medicinal plant. International J Pharm. Sci. and Res. 2014;5(10):4109–4116.
6. Fireman P. Understanding asthma Pathophysiology. Allergy Asthma Proc. 2003;24:79-83.
7. Mali RG, Dhake AS. A review on herbal anti-asthmatics. Orient Pharm Exp. Med. 2011;11:77–90.
8. Greenberger PA. Therapy in management of rhinitis asthma complex. Allergy Asthma Proc. 2003;24:403-407.
9. Saranya A, Ramanathan T, Kesavanarayanan KS, Adam A. Traditional medicinal uses, chemical constituents and biological activities of a mangrove plant, *Acanthus illicifolius* Linn: A brief review. American – Eurasian J. Agric. and Environ. Sci. 2015;15(2):243–250.
10. Ahmed K, Roy BK, Saha BK. Pharmacological evaluation of *Acanthus illicifolius* L. root extract for asthmatic condition. Bangladesh J. Sci. Ind. Res. 2005;40:195–202.
11. Akah PA, Ezike AC, Nwafor SV, Okoli CO, Enwerem NM. Evaluation of the anti-asthmatic property of *Asystasia gangetica* leaf extracts. J. Ethnopharmacol. 2003: 89(1):25-36.
12. Kanchanapoom T, Ruchirawat S. Megastigmane glucoside from *Asystasia gangetica* (L.) T. Anderson. J. Nat. Prod. 2007;61(4):430–433.
13. Ezike AC, Akah PA, Okoli CO. Bronchospasmolytic activity of the extract and fractions of *Asystasia gangetica* leaves. Int. J. App. Res. Nat. Prod. 2008; 1(3):8-12.
14. Sharrif Moghaddasi M, Verma SK. *Aloe vera*, their chemical composition and applications; A review. Int. J. Biol. Med. Res. 2011;2(1):466-471.
15. Gupta R, Thakur B, Singh P, Singh HB, Sharma VD, Katoch VM, Chauhan SVS. Anti-tuberculosis activity of selected medicinal plants against multi-drug resistant Mycobacterium tuberculosis isolates. Indian J. Med. Res. 2010;131: 809-813.
16. Srivastav S, Singh P, Mishra G, Jha KK, Khosa RL. *Achyranthes aspera* – An important medicinal plant: A review. J. Nat Prod. Plant Resour. 2011; 1(1):1–14.
17. Datir SB, Ganjare AB, Nirmal SA, Bhawar SB, Bharati DK, Patil MJ. Evaluation of anti-allergic activity of the various extracts of the aerial part of *Achyranthes aspera* var*. porphyristachya.* Pharmacologyonline. 2009;921–925.
18. Goyal BR, Mahajan SG, Mali RG, Goyal RK, Mehta AA. Beneficial effect of *Achyranthes aspera* Linn in toluene-Di-Isocyanate induced occupational asthma in rats. Global J. Pharmacology. 2007;1(1): 6–12.
19. Kumar D, Prasad DN, Parkash J, Bhatnagar SP, Kumar D. Antiasthmatic activity of ethanolic extract of *Aerva lanata* Linn. Pharmacologyonline. 2009;2:1075–1081.
20. Sabahi M, Mansouri SH, Ramezanian M. Antimicrobial activity of Amaranthaceous plants, Int. J. Crude Drug Res. 1987: 25: 72.
21. Kumar RP, Shammy J, Nitin G, Rinu R. An inside review of *Amaranthus spinosus* Linn: A potential medicinal plant of India. Int. J. Res. Pharm. Chem (IJRPC). 2014; 4(3):643–653.
22. Chaudhary MA, Imran I, Bashir S, Mehmood MH, Rehman N, Gilani AHI. Evaluation of gut modulatory and bronchodilator activities of *Amaranthus spinosus* Linn. BMC Comp and Alter Med. 2012;12:166-178.
23. Sonibare MA, Gbile ZO. Ethnobotanical survey of anti-asthmatic plants in Southwestern Nigeria. Afr. J. Trad. CAM. 2008;5(4):340-345.
24. Mahajan SK Chaudhariry. Evaluation of anti-asthmatic activity of *Anacardium occidentale* L. leaves. Pharmacology Online. 2011;3:449-455.
25. Fadeyi EO. Olatunji GA, Ogundele VA. Isolation and characterization of the chemical constituents *of Anacardium occidentale* cracked bark, Nat. Prod. Chem. Res. 2015;3(5):1-8.
26. Alvarez A, Sanchez C, Garcia D, Rodriguez J, Lemus Y, Jane A, Rodriguez J, Izquierdo M, Morales CI, Garrido G. Treatment of bronchial asthma with an aqueous extract of *Mangifera indica* L. (Vimang$^{R)}$): Two case reports, Boletin Latinamericano y del Caribe de Plantas

Medicinales y Aromaticas. 2009;8(2):63-66.

27. Ghuniyal J. Ethnomedical, chemical, pharmacological, toxicological properties of *Mangifera indica- A* review. Intern J Pharma Res & Rev. 2015;4(10):51-64.
28. Idu M, Akinibosun H, Omonihinmin CA. Ethnomedicinal field study in the wetlands of Udu and Ughievwen clans of Delta State, Nigeria. Proc Glob Submit Med. Plants. 2003;1:98-106.
29. Oghale O, Idu M. Phytochemistry, anti-asthmatic and antioxidant activities of *Anchomanes difformis* (Blume) Engl leaf extract. Asian Pac. J. Trop. Biomed. 2016; 6(3):225-231.
30. Meena AK, Yadav AK, Niranjan US, Singh B, Nagariya AK, Sharma K, Gaurav A, Sharma S, Rao MM. A review on *Calotropis procera* Linn and its ethnobotany, phytochemical, pharmacological profile. Drug Invention Today. 2010:2(2):185-190.
31. Pusapati MR Eswara RG Krishnapriya M, Nagalakshmi V, Silpa P, Anjali M. An overview of phytochemical and pharmacological activities of *Calotropis procera.* FS J. Pharm. Res. 2012;1(2):18-25.
32. Kokwaro JO. Medicinal plants of East Africa, Nairobi. East African Literature Bureau. 1976;58.
33. Chaha KF, Eze CA, Emuelosi Esimone CE. Antibacterial and wound healing properties of methanolic extracts of some Nigerian Medicinal Plants. J. Ethnopharmacol. 2006;104:164–167.
34. Namukebe JK, Asenene JM, Kiremire BT, et al. Traditional plants used for medicinal purposes by local communities around the Northern sector of Kibale National Park, Uganda. J. Ethnopharmacology. 2011;136(1):236-245.
35. Bartolome A, Villasenor IM, Yang WC. *Bidens pilosa* L. (Asteraceae): Botanical properties, traditional uses, Phytochemistry and Pharmacology, Evidence-based. Complementary and Alternative Medicine. 2013; 1-51:Article ID 340215.
36. Jadhav VM, Thorat RM, Kadam VJ, Salaskar KP. Chemical composition, pharmacological activities of *Eclipta alba.* J Pharm Res. 2009;2(8):1229–1231.
37. Patel MB, Panchal SJ, Patel JA. Anti-anaphylactic activity of alcoholic extract of *Eclipta alba.* J Young Pharm. 2009;1(3): 244- 250.
38. Patil SD, Ahale SV, Surana SJ. Evaluation of anti-asthmatic and anti-anaphylactic activity of *Balanites aegyptiaca* Delile, Balanitaceae, Asian J. Pharm. Cli. Res. 2011;4(1):52-55.
39. Chothani DL, Vaghasiya HU. A review on *Balanites aegyptiaca* Del (Desert date): Phytochemical constituents, traditional uses and pharmacological activity, Pharmacognosy Rev. 2011;5(9):55-62.
40. Adesina SK, Gbile ZO, Odukoya OA, Akinwusi DD, Illoh HC, Jayeola AA. Survey of indigenous useful plants of West Africa, The United Nations Programme on Natural Resources, Africa, Second Edition. 1995; 84–85.
41. Ebomoyi MI, Okojie AK. Physiological mechanism underlying the use of *Garcinia kola* Heckel in the treatment of asthma. African J of Respiratory Medicine. 2012;8: 5-8.
42. Eleyinmi AF, Bressler DC, Amoo IA, Sporms P, Oshodi AA. Chemical composition of Bitter kola (*Garcinia kola*) Seed and hulls. Polish J Food and Nutr Sci. 2006;15/56(4):395-400.
43. Seanego CT, Ndip RN. Identification and antibacterial evaluation of bioactive compounds from *Garcinia kola* Heckel seeds, Molecules. 2012;17:6569–6584.
44. Buba CI, Okhale SE, Muazzam I. *Garcinia kola*, the phytochemistry, pharmacology and therapeutic applications. Intern J Pharmacognosy (IJP). 2016;3(2):67–81.
45. Chaabi M, Benayache S, Benayache F, N'Gom S, Kone M, Anton R, Weniger B, Lobstein A. Triterpenes and Polyphenols from *Anogeissus leiocarpus,* Combretaceae, Biochem. Syst. & Ecol. 2008;36:59-62.
46. Ibrahim MB, Owonubi MO, Onaolapo JA. Antibacterial effect of the leaf, stem and root back of *Anogeissus leiocarpus* on *S. aureus*, *S. pyrogens, E. coli, P. vulgaris.* J. Pharmac Res Dev. 1997;2:20-26.
47. Yerima TS, Mashi FI, Helga BI, Galadima IH, Midala TAS. Phytochemical screening, antibacterial evaluation and *in vitro* spasmodic effect of the aqueous and ethanol leaf and bark extracts of *Anogeissus leiocarpus* (DC) Guill and Perr.

Asian J. Pharm Sci & Tech. 2015:5(4): 302-308.

48. Partap S, Kumar A, Sharma NK, Jha KK. *Luffa cylindrica:* An important medicinal plant. J Nat Prod Plant Resource. 2012; 2(1):127-134.
49. Muthumani P, Meera R, Subin M, Jeenamathew DP, Kameswari B, Eswara PB. Phytochemical screening and anti- inflammatory, bronchodilator and antimicrobial activities of the seeds of *Luffa cylindrical.* Res J Pharm Biol & Chem Sci. 2010;1(4):11-22.
50. Ogungbamila FO, Samuelsson G. Smooth muscle relaxing flavonoids from *Alchornea cordifolia.* Acta Pharm Nord. 1990;2(6): 421-2.
51. Essien EE, Newby JS, Walker TM, Setzer WN, Ekundayo O. Characterization and antimicrobial activity of volatile constituents from fresh fruits of *Alchornea cordifolia* and *Canthium subcordatum*. Medicines. 2016; 3:1-10.
52. Okeke IN, Ogundaini AO, Ogungbamila FO, Lamikanra A. Antimicrobial spectrum of *Alchornea cordifolia* leaf extract Phytother. Res. 1999;13:67-69.
53. Bayor MT, Ansah C, Duwiejua M, Abaite AK. *Alchornea cordofolia* (Euphorbiaceae), the major constituent of antiasthmatic herbal formulations in Ghana, stimulates β-adrenoceptors. J. the Ghana Sci. Assoc. 2008;10(2):1-11.
54. Kumar S, Malhotra R, Kumar D. *Euphorbia hirta*: Its chemistry, traditional and medicinal uses and pharmacological activities. Pharmacogn. Rev. 2010;4(7): 58–61.
55. Huang L, Chen S, Yang M. *Euphorbia hirta* (Feiyangcao): A review on its ethnopharmacology, phytochemistry and pharmacology. J Med Plants Res. 2012; 6(39):5176–5185.
56. Tiwari N, Mishra A, Bhatt G, Chaudhary A. Anti-stress activity of a bioflavonoid: Quercetin from *Euphorbia hirta.* British J. Pharm Research. 2015;6(2):68–75.
57. Youssouf MS, Kaiser P, Tahir M, Singh GD, Sharma VK, Satti NK, Haque SE, Johri RK. Anti-anaphylactic effect of *Euphorbia hirta* Fitoterapia. 2007;78:535–539.
58. Ekpo OE, Pretorius E. Asthma, *Euphorbia hirta* and its anti-inflammatory properties. South African J. Sci. 2007;103:201–203.
59. Mao X, Wu LF, Guo HL, Chen WJ, Cui YP, Qi Q, Li S, Liang, WY, Yang GH, Shao YY, Zhu D, She GM, You Y, Zhang LZ. The genus *Phyllanthus*: An ethnopharmacological, phytochemical and pharmacological review. Evidence-based Compl & Altern Med. 2016;36:Article ID: 7584952.
60. Mazumder A, Mahato A, Mazumder R. Antimicrobial potentiality of *Phyllanthus amarus* against drug resistant pathogens. Natural Prod Res. 2006;20(4):323-326.
61. Kiemer AK, Hartung T, Huber C, Vollmar AM. *Phyllanthus amarus* has anti-inflammatory potential by inhibition of iNOS, COX-2 and cytokines via the NF-KappaB pathway. J Hepatol. 2003;38(3): 289-297.
62. Narendra K, Swathi J, Sowjanya K, Satya A. *Phyllanthus niruri:* A review on its ethnobotanical, phytochemical and pharmacological profile. J Pharm Res, 2012;5(9):4681-4692.
63. Bedi O, Gauttam V, Kumar P. Ethnomedical and pharmacological role of *Phyllanthus niruri*: A review. Innovations in Pharmaceuticals and Pharma co therapy (IPP). 2015;3(3):650-658.
64. Garaniya N, Bapadra A. Ethnobotanical and phytopharmacological potential of *Abrus precatorious* L., a review. Asian Pac. J Trop Med. 2014;4(1):S27-S34.
65. Mensah AY, Bonsu AS, Fleischer TC, Investigation of the bronchodilator activity of *Abrus precatorius.* Int. J. Pharm. Sci Rev. Res. (IJPSRR). 2011;6(2):09–13.
66. Taur DJ, Patil RY. Effect of *Abrus precatorious* leaves on milk-induced leukocytosis and eosinophilia in the management of asthma, Asian Pac. J. Trop. Biomedicine. 2012;S40-S42.
67. Kokila K, Priyadharshini SD, Sujatha V. Phyto-pharmacological properties of *Albizia* species: A review. Int. J. Pharm. Pharmaceut Sci. 2013;5(3):70-73.
68. Barbosa A De P. Pharmacologically active saponins from the genus *Albizia* (Fabaceae). Int. J. Pharm Pharmaceut. Sci. 2014;6(11):32-36.
69. Yadav JP, Arya V, Yadav S, Panghal M, Kumar S, Dhankhar S. *Cassia occidentalis* L., A review of its ethnobotany, phytochemical and pharmacological profile. Fitoterapia. 2010;81:223-230.

70. Manikandaselvi S, Vadivel V, Brindha P. Review on Nutriceutical Potential of *Cassia occidentalis* L. An Indian Traditional Medicinal and Food Plant, Int. J. Pharm. Sci. Rev. Res. 2016;37(2):141-146.
71. Vadnere G, Samani R, Singhai AK, Antiasthmatic potential of aqueous extract of *Cassia occidentalis.* Planta Medica 2006;72:297.
72. Trout K. 1997 Trout's notes on the genus *Desmodium*. Second Printing. 2002;7:9-12 and 20-21.
73. Ayensu ES, Medicinal plants of West Africa. Reference Publications. 1978;149.
74. Muanda FN, Soulimani R, Dicko A. Study on biological activities and chemical composition of extracts from *Desmodium adscendens* leaves. J Nat Prod. 2011;4: 100-107.
75. Addy ME, Awumey EM. Effects of the extracts of *Desmodium adscendens* on anaphylaxis. J Ethnopharmacol. 1984: 11(3):283–293.
76. Zeid AHA, Hifnawy MS, Mohammed RS. Phenolic compounds and biological activities of *Dichrostachys cinerea* L. Medicinal and Aromatic Plant Science and Biotechnology. 2009;3(1):42-49.
77. Irie-N'guessan AG, Dade J, Champy P, Siransy-Kouakon NG, Leblais V. Isolation and spasmolytic evaluation of New alkaloids from *Dichrostachys cinerea* (L.) Wight et Arn. (Fabaceae). J Pharmacology & Pharmacy. 2013;4(9):684.
78. Mali Prabha R, Patil CD, Rahila S, Karigar A. Studies on anti-asthmatic activity of aqueous extract of roots of *Mimosa pudica* Linn. Intern R J Pharm. 2011;2(1):104-110.
79. Sanaye MM, Joglekar CS, Pagare NP. *Mimosa*-A brief overview. J Pharmacognosy Phytochem. 2015;4(2): 182-187.
80. Kayode J. Conservation of indigenous medicinal botanicals in Ekiti State, Nigeria. J Zhejiang University Sci. 2006;B7:713–718.
81. Ajithabai MD, Sunitha RSP, Jayakumar G. Review on the species *Sida* used for the preparation of Nayapayam Kashayam. Inten J Res & Rev in Pharm and Applied Sci. 2012;2(2):173–195.
82. Karou SD, Nadembega WM, IIboudo DP, Ouermi D, Gbeassor M, Souza C De, Simpore J. *Sida acuta* Burm F: A medicinal plant with numerous potencies. Afr J Biotech. 2007;6(25):2953–2959.
83. Zongo F, Ribuot C, Boumendjel A, Guissou Botany I. traditional uses, phytochemistry and pharmacology of *Waltheria indica* L (syn. *Waltheria americana*): A review. J Ethnopharmacol. 2013;148:14–26.
84. Rao YK, Fang SH, Tzeng YM. Inhibitory effects of the flavonoids isolated from *Waltheria indica* on the production of NO, TNF-α and IL- 12 in Activated Macrophages. Biol Pharm Bull. 2005;28(5): 912–915.
85. Fahey JW. *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic and prophylactic properties: Part 1, Trees for Life J. 2005;1:5.
    Available: www.TFL Journal.org
86. Toma A, Deyno S. Phytochemistry and pharmacological activities of *Moringa oleifera.* Intern J Pharmacognosy (IJP). 2014;1(4):222-231.
87. Babita Agrawal, Anita Mehta. Antiasthmatic activity of *Moringa oleifera* Lam: A clinical study. Indian J Pharmacol. 2008;40(1):28-31.
88. Elaissi A, Rouis Z, Salem NAB, Mabrouk S, Salem YB, Salah KBH, Aouni M, Marhat F, Chemli R, Harzallah-Shniri F, Khouja ML. Chemical composition of eight *Eucalyptus* species essential oils and the evaluation of their antibacterial, antifungal and antiviral activities. BMC Compl and Alter Med. 2012;12:81.
89. Gutierrez RM, Mitchell S, Solis RV. *Psidium guajava*: A review of its traditional uses, phytochemistry and pharmacology. J Ethnopharmacol. 2008;117(1):1–27.
90. Zhu Y, Liu Y, Zhan Y, Liu L, Xu L, Xu T, Liu T. Preparative isolation and purification of five flavonoid glycosides and one benzophenone gallolyglycoside from *Psidium guajava* by high speed counter-current Chromatography HSCCC. Molecules. 2013;18:15648–15661.
91. Pranee J, Paranee K, Yuwadee W, Pencham P, Potjanee S, Saraya MLS, Orawan R. Anticough and antimicrobial activities of *Psidium guajava* Linn leaf extract. J Ethnopharmacol. 1999;67:203–212.
92. Pawar AT, Vyawahare, Phytochemical and pharmacological profile of *Biophytum*

sensitivum (L) DC. Int. J. Pharmaceutical Sci. 2014;6(11):18-22.

93. George M, Joseph L, Kumar U. Antiasthmatic study of ethanolic leaves extract of *Biophytum sensitivum* L. in asthma-induced guinea pigs. World J. Pharmaceutical Res. 2016;5(8):670-676.
94. Boye GI, Ampofo O. In proceedings of the First. International Seminar on Cryptolepine" Ed, by Boakye Yiadom K and Bamgbose SOA, University of Kumasi, Ghana, 1983;37.
95. Barku VYA, Opoku-Boahen Y, Dzotsi EY. Isolation and pharmacological activities of alkaloids from *Cryptolepis sanguinolenta* (Lindl) Schlt. Int. Res. J. Biochem. Bioinformatics. 2012;2(3):58-61.
96. Mensah-Kane P. Potential anti-asthmatic, anti-histaminic and antidiarrhoeal effects of cryptolepine, the major alkaloid of *Cryptolepis sanguinolenta* (Lindl.) Schltr. (Periplocaceae) in experimental animals; M. Phil. Thesis, Faculty of Pharmacy, Kwame Nkrumah University of Sci.& Tech., Kumasi, August; 2015.
97. Avoseh O, Oyedeji O, Rungqu P, Nkeh-Chungay B, Oyedeji A. *Cymbopogon* species: Ethnopharmacology, phyto-chemistry and pharmacological importance –Review. Molecules. 2015;20:7438-7453.
98. Shah G, Shri R, Panchal V, Sharma N Singh B, Mann AS. Scientific basis for the therapeutic use of *Cymbopogon citratus* Stapf (Lemongrass). J Adv Pharm Technol. 2011;2(1):3-8.
99. Savali A, Biradar P, Jirankali MC. Antianaphylactic and mast cell stabilization activity of *Cynodon dactylon.* Int J Pharm Pharmaceutical Sci. 2010;2(2): 69-73.
100. Asthana A, Kumar A, Gangwar S, Iyotsna D. Pharmacological perspectives of *Cynodon dactylon*. Res. J. Pharm Biol Chem Sci. 2012;3(2):1135–1147.
101. Mongalo NI, McGaw LJ, Finnie JF, Staden J van. *Securidaca longipedunculata* Fresen, Polygalaceae: A review of its ethnomedicinal uses, phytochemistry, pharmacological properties and toxicology. J. Ethnopharmacol. 2015;215-226.
102. Akah AA, Gamaliel KS, Samson A, Wambebe CO. Evaluation of Nigerian traditional medicine effects of Gakani, a herbal anti-asthmatic drug. J. Ethnopharmacol. 1997;55:87-92.
103. Luo X, Pires D, Ainsa JA, Gracia B, Mulhovo S, Duarte A, Anes E, Ferreira MU. Antimycobacterial evaluation and preliminary phytochemical investigation of selected medicinal plants traditionally used in Mozambique. J. Ethnopharmacol. 2011; 137:114-120.
104. Muanda FN, Dicko A, Soulimani R. Assessment of polyphenolic compounds, *in vitro* antioxidant and anti-inflammation properties of *Securidaca longipedunculata* root barks. C. R. Biologies. 2010;333:663-669.
105. Ahmadu AA, Omonigho U. Flavonoids from the leaves of *Physalis angulata* Linn. Afr J Pharmaceut Res & Dev. 2013;5(1): 40-43.
106. Mahalakshmi AM, Ramesh BN. *Physalis angulata* L; An ethnopharmacological review. Indo American J Pharm Res. 2014; 4(3):1479-1486.
107. Soares MBP, Brustolim D, Santos LA, Bellintani MC, Paiva FP, Ribeiro YM, Tomassini TCB, Ribeiro dos Santos R, Physalins BFG. Seco-steroids purified from *Physalis angulata* L inhibit lymphocyte function and allogeneic transplant rejection. Intern. Immunopharmacologic. 2006;6:408-414.
108. Januario AH, Filho ER, Pietro RC, Kashima S, Sato DN, Franca SC, Anti*Mycobacterium* physalins from *Physalis angulata* L (Solanaceae), Phytother Res. 2002;16(5):445-448.
109. Jyothibasu T, Ramana K, Thalla S. Antiasthmatic activity of alcohol extract of *Physalis angulata* induced by ovalbumin. Am J Pharm Tech Res. 2012;2(6):1832-1834.
110. Irvine FR. Woody plants of Ghana, London, Oxford Univ. Press; 1961.
111. Hussain H, Hussain J, Al-Harrasi A, Shinwari ZK. Chemistry of some species genus *Lantana*, Pak. J Bot. 2011;43:51-62.
112. Saleh M, Kamel A, Li X, Swaray J. Antibacterial triterpenoids isolated from *Lantana camara.* Pharm Biol. 1999;37:63-65.
113. Occhiuto F, Circosta C. Pasquale Costa De. Studies on some medicinal plants of Senegal; Effects on isolated guinea pig ileum. J Ethnopharmacol. 1989;26:205-210.
114. Havsteen BH. The biochemistry and medicinal significance of the flavonoids, Pharmacol. Ther. 2002;96(2-3):67-202.

115. Joskova M, Franova S, Sadlonova V. Acute bronchodilator effect of quercetin in experimental allergic asthma. Bratisl Lek Listy. 2011;112(1):9-12.
116. Ghayur MN, Khan H, Gilani AH. Antispasmodic, bronchodilator and vasodilator activities of (+)-catechin, a naturally-occuring flavonoid. Archives of Pharmacol Res. 2009;30:970-975.
117. Joskova M, Sadlonova V, Nosalowa G, Novakova E, Franova S. Polyphenols and their components in experimental allergic asthma. Adv. Exp Med Biol. 2013;756:91-98.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/18911