Review of Experimental Pharmacological Studies of Plants Used for Asthma Management in Africa

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Abstract

Objectives: The aim was to contribute to the promotion of medicinal plants used in Africa for management of asthma by analyzing their experimental pharmacological evaluation data.

Methods: We carried out a systematic review of the literature based on the following research equations in English and in French: « médecine traditionnelle africaine » ET « asthma » ; « African traditional medicine » AND « asthma » or « Medicine African traditional » AND « asthma » ; « plantes médicinales » ET « asthma » ET « antispasmodique » ; « medicinal plants » AND « asthma » AND « anti-spasmodic » ; « plantes médicinales » ET « asthma » ET « anti-inflammatoire » ; « medicinal plants » AND « asthma » AND « anti-inflammatory ».

Results: The study revealed 184 medicinal plants used in Africa for the treatment of asthma, 34 of which showed pharmacological properties in favor of their use. In animal experiments, 18 of these plants exerted a spasmolytic effect, 22 an anti-inflammatory effect and 6 both effects. The spasmolytic activity study protocols were based primarily on inhibition of smooth airway muscle contraction, including trachea, induced by various spasmogenic agents. As for the methods used to study anti-inflammatory activity, the majority of them consisted of tests for carrageenan-induced edema or for formalin-induced leg irritation.

Conclusion: Our results justify the need for standardization of experimental study protocols for the recovery of medicinal plants.

Keywords: Asthma; Medicinal plants; Spasmolytic; Anti-inflammatory; Africa

Introduction

Asthma is increasing in an African population with high population growth, with air pollution [1,2], while medical infrastructure remains inadequate or inaccessible [3]. Thus, medicinal plants, inexpensive and easily accessible, are sometimes a first resort. Following the recommendations of the World Health Organization for the development of traditional medicines on the basis of evidence of safety, efficacy

and quality control [4], we considered working on the theme of highlighting effectiveness. Thus, in order to contribute to the valorization of anti-asthmatic medicinal plants, the aim of this study was to list the plants which are used as traditional anti-asthmatic remedies in Africa, identify those that have been the subject of pharmacological experimental studies that demonstrate their antispasmodic and/or anti-inflammatory properties, and analyse the experimental methods used in these published works.

Materials and Methods

Our review was structured in three main stages:

1. Literature search based on the following:

- Target population: plants found in Africa, used by African traditional medicine in the management of asthma.
- Research tools: Health Sciences and Biosciences theses, reference books, and Internet research using:
 - Databases: PubMed / Medline, Hinari Health, Scopus
 - Search engines: Google, Google scholar
 - English and French Search equation: « médecine traditionnelle africaine » ET « asthma »
 - « African traditional medicine » AND « asthma » or « Medicine African traditional » AND « asthma »
 - « plantes médicinales » ET « asthma » ET « antispasmodique »
 - « medicinal plants » AND « asthma » AND « anti-spasmodic »
 - « plantes médicinales » ET « asthma » ET « anti-inflammatoire »
 - « medicinal plants » AND « asthma » AND « anti-inflammatory »

2. Selection of articles and works according to the following criteria:

- Languages: French, English

- Media: written (electronic and paper)

- Presentation: understandable and readable texts; simple and clear styles.

- Contents: related to plants used in African traditional medicine in the treatment of asthma and the evaluation of antispasmodic and/or anti-inflammatory activity of these plants mentioned either in the title, introduction, conclusion or summary.

- Scientific quality: journal articles, institutional reports, guidelines, theses, references.

3. Processing of results

The aim was to extract the data for synthesis, through the translation of English-French texts and vice versa on the one hand, and the reading and comparative analysis of articles dealing with the same theme in order to retain only relevant and similar data on the other.

Results

Inventory of traditional anti-asthmatic plants in Africa

Table I shows the plant species published as anti-asthmatic medicinal plants in Africa. We have identified 184 species of traditional use in the management of asthma in Africa.

Table 1: Plants used in the management of asthma in Africa.

S. No.	Species	Family	Used Parts
1	<i>Acacia albida</i> Del.	Mimosaceae	Bark, leaves, roots
2	<i>Acacia nilotica</i> (L.) Willd ex Delile	Mimosaceae	Leaves, seeds
3	<i>Acacia senegalensis</i> (L.) Willd ex Del.	Mimosaceae	Latex
4	<i>Adansonia digitata</i> (L.)	Bombaceae	Leaves
5	<i>Aerva lanata</i> (L.) Schult Juss. Ex	Amaranthaceae	Leaves
6	<i>Adhatoda vasica</i> (L.)	Acanthaceae	Nuts
7	<i>Aframomum laurentii</i> Schum.	Zingiberaceae	Seeds, Fruits
8	<i>Aframomum melegueta</i> (Roscoe) K. Schum.	Zingiberaceae	Seeds
9	<i>Agava americana</i> (L.) Subsp.	Agavaceae	Leaves
10	<i>Ageratum conyzoides</i> (L.)	Astéraceae	Whole plan
11	<i>Ajuga iva</i> (L.)	Lamiaceae	Leaves
12	<i>Alchornea cordifolia</i> (Schumach. Thonn.) Mull.Arg.	Euphorbiaceae	Leaves
13	<i>Allium cepa</i> (L.)	Liliaceae	Bulbs
14	<i>Allium sativum</i> (L.)	Liliaceae	Pods
15	<i>Aloe vera</i> (L.) Burm.F.	Liliaceae	Latex

16	<i>Ammi visnaga</i> (L.) Lamark	Apiaceae	Fruits
17	<i>Anacardium occidentale</i> (L.)	Anacardiaceae	Fruits, leaves, bark
18	<i>Ananas communis</i> (L.)	Broméliaceae	Peduncles
19	<i>Anchomanes giganteus</i> (Engl.)	Araceae	Stem
20	<i>Arachis hypogaea</i> (L.)	Fabaceae	Seeds
21	<i>Achras sapota</i> (L.)	Sapotaceae	Leaves
22	<i>Argemone mexicana</i> (L.)	Papaveraceae	Leaves
23	<i>Aristolochia longa</i> (L.)	Aristolochiaceae	Seeds, leaves
24	<i>Asystasia gangetica</i> (L.)	Acanthaceae	Seeds, leaves
25	<i>Azadirachta indica</i> (L.)	Meliaceae	Leaves, bark
26	<i>Baissea multiflora</i> A.D.C.	Apocynaceae	Leaves
27	<i>Balanites aegyptiaca</i> (L.) Del.	Bananitaceae	Bark, Fruits, leaves
28	<i>Baphia nitida</i> Lodd.	Fabaceae	Leaves
29	<i>Bidens pilosa</i> (L.)	Astéraceae	Bark
30	<i>Boerhavia diffusa</i> L. Sp.	Nyctaginaceae	Leaves
31	<i>Brassica juncea</i> (L.) Czern	Brassicaceae	Seeds, leaves
32	<i>Brassica oleracea</i> (L.)	Brassicaceae	Leaves
33	<i>Bridelia micrantha</i> (Hochst.) Baill.	Phyllanthaceae	Roots, bark
34	<i>Bridelia ndellensis</i> Beille.	Phyllanthaceae	Roots
35	<i>Brillantaisia patula</i> T. Anders.	Acanthaceae	Leaves
36	<i>Brugmansia suaveolens</i> (Humb. Et Bonpl. ex Willd.) Bercht. et J. Presl	Solanaceae	Leaves
37	<i>Calotropis procera</i> (Aiton) W.T.	Asclepiadaceae	Roots
38	<i>Cannabis sativa</i> (L.)	Cannabinaceae	Leaves
39	<i>Cannarium schweinfurthii</i> Engl.	Burseraceae	Leaves, Fruits, bark
40	<i>Carapa procera</i> D.C	Meliaceae	Seeds
41	<i>Carica papaya</i> (L.)	Caricaceae	Leaves
42	<i>Cassia italica</i> (Mill.) Spreng.	Cesalpiniaceae	Leaves
43	<i>Cassia occidentalis</i> (L.) Sp.	Cesalpiniaceae	Leaves
44	<i>Casuarina equisetifolia</i> (L.)	Cassuarinaceae	Stem
45	<i>Celtis integrifolia</i> (Lam.)	Ulmaceae	Leaves
46	<i>Citrus aurantifolia</i> L. Sp	Rutaceae	Fruits, bark
47	<i>Chrozophora senegalensis</i> (Lam.)	Euphorbiaceae	Leaves, bark
48	<i>Crataegus monogyna</i> Jacq.	Rosaceae	Buds
49	<i>Cochlospermum tinctorium</i> Perr. ex A. Rich	Cochlospermanaceae	Leaves, roots
50	<i>Cocos nucifera</i> (L.)	Aracaceae	Bark
51	<i>Cola cordifolia</i> (Cav.) R. Br.	Sterculiaceae	Leaves, roots
52	<i>Cola gigantea</i> A. Chev.	Malvaceae	bark
53	<i>Cola nitida</i> (Vent.) Schott et Endl.	Sterculiaceae	Nuts
54	<i>Combretum acculeatum</i> Vent.	Combretaceae	Leaves
55	<i>Combretum glutinosum</i> Perr.ex D.C.	Combretaceae	Leaves, bark
56	<i>Combretum micranthum</i> G. Don.	Combretaceae	Leaves
57	<i>Commelina diffusa</i> Burm. F.	Commelinaceae	Leaves

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58	<i>Convolvulus arvensis</i> (L.)	Convolvulaceae	Leaves
59	<i>Crescentia cujetes</i> (L.)	Bignonaceae	Leaves
60	<i>Curcuma longa</i> (L.)	Cucurbitaceae	Rhizomes, leaves
61	<i>Cymbopogon giganteus</i> Chiov	Poaceae	Leaves
62	<i>Cymbopogon septratus</i> DC.	Poaceae	Leaves
63	<i>Cyphostemma adenocaula</i> Desc.	Vitaceae	Leaves
64	<i>Dacryodes edipis</i> (G. Don) H.J. Lam	Burseraceae	Bark
65	<i>Datarium microcarpum</i> Guill et Perr.	Cesalpiniaceae	Roots
66	<i>Datura stramonium</i> (L.)	Solanaceae	Leaves, Flowers
67	<i>Desmodium adscendens</i> (Sw.) DC.	Fabaceae	Leaves
68	<i>Desmodium tortuosum</i> DC.	Fabaceae	Leaves
69	<i>Dichrostachys cinerea</i> (L.) Wight et Arn	Fabaceae	Roots, leaves
70	<i>Diospyros mespiliformis</i> Hochst.ex A. Rich.	Ebenaceae	Leaves
71	<i>Elaeis guineensis</i> Jacq.	Anecaceae	Seeds
72	<i>Eucalyptus camaldulensis</i> Dehnh.	Myrtaceae	Leaves
73	<i>Eucalyptus globulus</i>	Myrtaceae	Leaves
74	<i>Eugenia caryophyllata</i>	Myrtaceae	Cloves
75	<i>Euphorbia balsamifera</i> Ait.	Euphorbiaceae	Roots
76	<i>Euphorbia hirta</i> (L.)	Euphorbiaceae	Whole plant
77	<i>Euphorbia milii</i> Des. Moul.	Euphorbiaceae	Leaves
78	<i>Ficus benghalensis</i> (L.)	Moraceae	Leaves, bark
79	<i>Ficus exasperata</i> Vahl.	Moraceae	Leaves, roots, bark
80	<i>Ficus iteophylla</i> Miq.	Moraceae	Leaves
81	<i>Ficus sycomorus</i> (L.)	Moraceae	Leaves
82	<i>Ficus vallis-choudae</i> Del.	Moraceae	Fruits, bark
83	<i>Foeniculum vulgare</i> P. (Mill.)	Apiaceae	Seeds
84	<i>Glycyrrhiza glabra</i> (L.)	Fabaceae	Roots
85	<i>Gossypium barbadense</i> (L.)	Malvaceae	Leaves
86	<i>Guiera senegalensis</i> J.F. Gmel.	Combretaceae	Leaves
87	<i>Helianthus annuus</i> (L.)	Asteraceae	Seeds
88	<i>Hymenocardia acida</i> Tul.	Euphorbiaceae	Leaves
89	<i>Hypericum perforatum</i> (L.)	Hypericineae	Flowering heads
90	<i>Icacina senegalensis</i> A. Juss.	Icacinaceae	Leaves, roots
91	<i>Illicium verum</i> Hook.F.	Schisandraceae	Fruits
92	<i>Jatropha curcus</i> (L.)	Euphorbiaceae	Leaves
93	<i>Juniperus phoenicea</i> (L.)	Cupressaceae	Flowering heads
94	<i>Kigelia africana</i> (Lam.) Benth.	Bignoniaceae	Leaves
95	<i>Lannea acida</i> A. Rich.	Anacardiaceae	Bark
96	<i>Lantana camara</i> L.	Verbenaceae	Leaves
97	<i>Lavandula angustifolia</i> Mill	Lamiaceae	Flowering heads
98	<i>Lavandula multifida</i> L.	Lamiaceae	Flowering heads
99	<i>Lavandula stoechas</i> L.	Lamiaceae	Flowering heads
100	<i>Lawsonia inermis</i> L.	Lythraceae	Leaves
101	<i>Lepidium sativum</i> L.	Brassicaceae	Leaves, Fleurs

102	<i>Leptadenia hastata</i> Decne	Asclepiadaceae	Leaves
103	<i>Linum usitatissimum</i> L.	Linaceae	Seeds
104	<i>Lippia chevalieri</i> L.	Verbenaceae	Leaves
105	<i>Lobelia inflata</i> L.	Campanulaceae	Leaves
106	<i>Lobelia siphilitica</i> L.	Campanulaceae	Roots
107	<i>Mammiphytum fulvum</i> Mull	Euphorbiaceae	Leaves
108	<i>Mandragora autumnalis</i> Bert	Solanaceae	Leaves
109	<i>Mangifera indica</i> L.	Anacardiaceae	Leaves
110	<i>Marrubium vulgare</i> L.	Lamiaceae	Leaves
111	<i>Melaleuca viridiflora</i> Gaertner	Myrtaceae	Leaves
112	<i>Melissa officinalis</i> L.	Lamiaceae	Aerial parts
113	<i>Mentha piperata</i> L.	Lamiaceae	Aerial parts
114	<i>Mentha pulegium</i> L.	Lamiaceae	Aerial parts
115	<i>Mentha spicata</i> L.	Lamiaceae	Leaves
116	<i>Microglossa pyrifolia</i> Lam	Asteraceae	Fruits
117	<i>Morinda lucida</i> Benth	Rubiaceae	Leaves
118	<i>Morinda morindoides</i> Milue	Rubiaceae	Leaves
119	<i>Moringa oleifera</i> Lam	Moringaceae	Leaves, seeds, roots
120	<i>Musa acuminata</i> Cola	Musaceae	Leaves
121	<i>Musanga cecropioides</i> R. Br.	Moraceae	Leaves
122	<i>Myrianthus arboreus</i> P	Moraceae	Root bark
123	<i>Myrtus communis</i> L.	Myrtaceae	Seeds, Fruits, leaves
124	<i>Nerium oleander</i> L.	Apocynaceae	Leaves
125	<i>Nicotiana rustica</i> L.	Solanaceae	Leaves
126	<i>Nigella sativa</i> L.	Ranunculaceae	Seeds
127	<i>Ocimum basilicum</i> L.	Lamiaceae	Leaves, whole plant
128	<i>Oxythenanthera abyssinica</i> Munro	Poaceae	Leaves
129	<i>Parinari macrophylla</i> Sabine	Rosaceae	Leaves, Fruits, roots
130	<i>Pakia biglobosa</i> Jacq.	Mimosaceae	Leaves
131	<i>Palisota ambigua</i> L.	Commelinaceae	Whole plant
132	<i>Pennisetum panicum</i> L.	Poaceae	Leaves
133	<i>Pennisetum thyphoides</i> Stapf et Hubb	Gramineae	Seeds
134	<i>Persea americana</i> L.	Lauraceae	Leaves
135	<i>Petroselinum sativum</i> L.	Ombelifereae	Leaves
136	<i>Phyllanthus acidus</i> L.	Euphorbiaceae	Leaves, Fruits
137	<i>Piliostigma reticulatum</i> DC	Cesalpiniaceae	Leaves, bark
138	<i>Piper betle</i> L.	Piperaceae	Leaves
139	<i>Piper guineensis</i> Schum. &Thonn.	Piperaceae	Leaves
140	<i>Piper longum</i> L.	Piperaceae	Fruits
141	<i>Pistacia lentiscus</i> L.	Anacardiaceae	Stem resins
142	<i>Platynerium stermarie</i> DC	Polypodiaceae	Bark
143	<i>Plumbago zeypanica</i> L.	Plumbaginaceae	Leaves

144	<i>Prosopis africana</i> Taub	Cesalpiniaceae	Roots, leaves
145	<i>Prunus cerasus</i> L.	Rosaceae	Fruits
146	<i>Pseudo mussaenda stenocarpa</i> (Hiern.) Petit	Rubiaceae	Leaves
147	<i>Psidium guajava</i> L.	Myrtaceae	Leaves
148	<i>Punica granatum</i> L.	Pinicaceae	Leaves
149	<i>Pupalia lappacea</i> L.	Amaranthaceae	Fruits
150	<i>Ricinus communis</i> L.	Euphorbiaceae	Leaves
151	<i>Rosmarinus officinalis</i> L.	Lamiaceae	Whole plant
152	<i>Saba senegalensis</i> Pichon	Apocynaceae	Leaves
153	<i>Salvadora persica</i> L.	Salvadoraceae	Leaves, roots
154	<i>Salvia officinalis</i> L.	Lamiaceae	Leaves
155	<i>Sanguisorba minor</i> Scop	Rosaceae	Leaves
156	<i>Scelerocacya birrea</i> A.	Anacardiaceae	Bark, Fruits, Fleurs
157	<i>Scyphocephalum ochocoa</i> Warb	Myristicaceae	Bark, leaves
158	<i>Sesamum indicum</i> L.	Pedeliaceae	Leaves
159	<i>Smilax aspera</i> L.	Smilacaceae	Roots, Fruits
160	<i>Solanum melongena</i> L.	Solanaceae	Fruits
161	<i>Sterculia stegera</i> Del.	Sterculiaceae	Bark
162	<i>Sterculia tragacantha</i> Lind P	Sterculiaceae	Bark, leaves, Fruits
163	<i>Tamarindus indica</i> L.	Caesalpiniaceae	Fruits, roots, leaves
164	<i>Tapinanthus bangwensis</i> Engl.	Loranthaceae	Leaves
165	<i>Tectrorchidium didymostemon</i> Baill	Euphorbiaceae	Stem bark
166	<i>Terminalia avicennoides</i> G et Perr	Combretaceae	Leaves
167	<i>Terminalia catappa</i> L.	Combretaceae	Leaves
168	<i>Terminalia chebula</i> RTZ	Combretaceae	Fruits, roots
169	<i>Terminalia macroptera</i> Gill et P	Combretaceae	Leaves
170	<i>Thormandersia hensii</i> DE Will	Acanthaceae	Leaves
171	<i>Thuya orientalis</i> L.	Cupressaceae	Leaves
172	<i>Thymus vulgaris</i> L.	Lamiaceae	Leaves
173	<i>Trigonella foenum graecum</i> L.	Apiaceae	Seeds
174	<i>Tylophora sylvation</i> Decno	Apocynaceae	Root bark
175	<i>Vernonia caferia</i> Benth	Asteraceae	Stem bark
176	<i>Vernonia colorata</i> (Willd) Drake	Asteraceae	Leaves
177	<i>Viscum album</i> L.	Santalaceae	Leaves
178	<i>Vitex doniana</i> Sweet	Verbenaceae	Leaves
179	<i>Waltheria indica</i> L.	Malvaceae	Whole plant
180	<i>Ximenia americana</i> L.	Olaaceae	Leaves
181	<i>Xylopia aethiopica</i> A. Rich	Annonaceae	Seed
182	<i>Zea mays</i> L.	Poaceae	Stigmata
183	<i>Zingiber officinal</i> Roscoe	Zingiberaceae	Rhizomes
184	<i>Ziphyphus mauritiana</i> Lam	Rhamnaceae	Leaves

Pharmacological properties demonstrated in animal experiments

In preclinical experiments, 34 plants showed properties against bronchospasm and/or inflammation, including 18 for antispasmodic property, 22 for anti-inflammatory property and 6 for both pharmacological properties (Figure 1).

Experimental protocols for the demonstration of pharmacological properties

In vivo, *ex vivo* and *in vitro* tests were used in the protocols for the study of anti-asthmatic activity. The bronchospasm-related aspect of asthma was explored through 14 tests, including 4 whole animal tests [5-8] and 10 isolated organs, including the trachea and to a lesser extent the intestine [9-18] as shown in Table 2.

The inflammatory component was evaluated using 17 tests including 11 *in vivo* [19-28;5] and 6 *in vitro* [17,29,20,30-32] according to the data in Table 3. The frequency of implementation of testing on biological materials is shown in Figure 2.

Table 2: Experimental protocols for highlighting antispasmodic activity.

Methods	Plants	Results	References
<i>In vivo</i>			
Oral administration of plant extract in pre-treatment, then exposure to the mast cell allergen.	<i>Adhatoda vasica</i>	Inhibition of mast cell degranulation.	[5]
Oral administration of plant extract	<i>Euphorbia hirta</i>	Slowing of respiratory movements, Reduction of gastrointestinal motility	[6, 7]
Administration of plant extract, then acetic acid	<i>Brugmansia suaveolens</i>	Inhibition of abdominal cramps	[8]
<i>Ex vivo</i>			
Tracheal precontraction induced by carbachol or acetylcholine then application of increasing doses of plant extract.	<i>Dichrostachys cinerea</i>	Smooth muscle relaxation	[9]
	<i>Baphia nitida</i>		
	<i>Cassia occidentalis</i>		
	<i>Desmodium adscendens</i>		
	<i>Boerhavia diffusa</i>		
Preliminary impregnation of isolated trachea with the plant extract, then stimulation by histamine or acetylcholine.	<i>Datura stramonium</i>		
	<i>Mentha pulegium</i>		[10]
	<i>Gossypium barbadense</i>		[11]
	<i>Guiera senegalensis</i>		[12]
Precontraction of the trachea with acetylcholine or histamine, then application of increasing doses of plant extract.	<i>Foeniculum vulgare</i>		
	<i>Ammi visnaga</i>		[13]
	<i>Rosmarinus officinalis</i>		[14]
Precontraction of the trachea with acetylcholine, potassium chloride or histamine, then application of increasing doses of plant extract.	<i>Glycyrrhiza glabra</i>		[15,16]

Precontraction of the trachea induced by acetylcholine, then application of increasing doses of plant extract.	<i>Waltheria indica</i>	[17]
Contraction of guinea pig intestinal smooth muscle induced by acetylcholine or barium chloride, then application of plant extract.	<i>Tamarindus indica</i>	[18]

Table 3: Experimental protocols for highlighting anti-inflammatory activity.

Methods	Plants	Results	References
<i>In vivo</i>			
Administration of plant lectin in murine air pouch model	<i>Viscum album</i>	Inhibition of cell recruitment	[19]
Administration of plant extract in carrageenan-induced rat paw edema model		IC50: 0.617 ± 0.017 $\mu\text{g/mL}$	[20]
Administration of plant extract in pre-treatment in formaldehyde 1%-induced guinea pig paw edema model	<i>Aframomum melegueta</i>	Edema inhibition: $90.42 \pm 0.22\%$.	[21]
	<i>Citrus aurantifolia</i>	Edema inhibition: $98 \pm 0.57\%$.	
	<i>Sterculia setigera</i>	Edema inhibition: $80.83 \pm 0.38\%$.	
	<i>Eucalyptus camaldulensis</i>	Edema inhibition $\approx$ lysine acetylsalicylate	
Administration of plant extract in carrageenan-induced rat paw edema model.	<i>Crataegus monogyna</i>	Edema inhibition: 72.4%	[22]
Administration of plant extract in carrageenan-induced guinea pig paw edema model.	<i>Melissa officinalis</i>	Edema inhibition: 65.38%.	[23]
Croton oil-induced ear edema and carrageenan-induced paw edema in guinea pig, then administration of plant extract.	<i>Parkia biglobosa</i>	Edema Reduction	[24]
Administration of plant extract in pre-treatment in formaldehyde 1%-induced guinea pig paw edema model	<i>Lavandula angustifolia</i>	Edema inhibition	[25]
	<i>Ocimum basilicum</i>		
Administration of plant extract in pre-treatment in carrageenan or histamine-induced guinea pig paw edema model	<i>Sterculia tragacantha</i>	Edema inhibition	[26]
Carrageenan or formaldehyde-induced paw edema, then administration of plant extract.	<i>Euphorbia hirta</i>	Dose-dependent reduction of edema	[27]
	<i>Zingiber officinale</i>		[28]
Carrageenan or formaldehyde-induced paw edema in guinea pig, then administration of plant extract.	<i>Adhatoda vasica</i>	Edema inhibition: 59.51%.	[5]
<i>In vitro</i>			
Oxidative stress model and measurement of the trapping effect of the plant extract on hydrogen peroxide and hypochlorous acid	<i>Alchornea cordifolia</i>	IC50: 6.5 mg/mL for H_2O_2	[29]
	<i>Baphia nitida</i>	IC50: 1.7 mg/mL for HOCl	

	<i>Cassia occidentalis</i>	IC50: 1.8 mg/mL for HOCl	
	<i>Boerhavia diffusa</i>	IC50: 6.8 mg/mL for H ₂ O ₂	
Murine macrophages activated by lipopolysaccharide	<i>Viscum album</i>	IC50: 70.20 ± 1.094 µg/mL	[20]
Incubation with gastric and intestinal physiological fluids	<i>Mentha spicata</i>	Inhibition of lipopolysaccharide-induced PGE2	[30]
Involving plant extract and serum albumin solution	<i>Salvia officinalis</i>	Inhibition of albumin denaturation: 99.18%.	[31]
	<i>Thymus vulgaris</i>	Inhibition of albumin denaturation: 66.12 ± 12.5%.	[32]
Addition of the plant extract to a pro-inflammatory enzyme solution (Phospholipase A2 and 5-Lipoxygenase)	<i>Waltheria indica</i>	Inhibition of enzyme activity: 60-80%.	[17]

Figure 2: Implementation of pharmacological tests.

Discussion

The aim of this study was to analyse pharmacological evaluation data for traditional anti-asthmatic plants in Africa. The literature review identified 184 plant species used in the treatment of asthma in African traditional medicine. This great diversity of species used for the treatment of asthma in Africa is an indication of the importance of medicinal plants but also of the fact that asthma is an important health problem in Africa [33,34].

Only 34 plant species, the majority of which are aromatic plants from the Mediterranean region of North Africa, have undergone preclinical pharmacological studies. These works consisted mainly in the identification of antispasmodic or spasmolytic and/or anti-inflammatory properties. Indeed, the pathophysiology of asthma is mainly characterized by bronchospasm and airway inflammation [35]. Consequently, the pharmacological management of asthma disease is carried out in conventional medicine by bronchodilator agents associated with anti-inflammatory molecules, in particular corticosteroids [36]. Thus, it seems appropriate that the scientific valuation of anti-asthmatic medicinal plants provides evidence of antispasmodic or spasmolytic activity in favor of bronchospasm blockage on the one hand, and/or anti-inflammatory activity on the other.

The protocols for the identification of the activities of these plants against bronchospasm were based mainly on the inhibition of airways smooth muscles contraction previously induced. This corresponds to a curative treatment of the bronchoconstriction of asthma attack. Indeed, short-acting bronchodilators, without anti-inflammatory effect, are recommended to release bronchial smooth muscle [37] because the usual forms, aerosols and dry powders or solutions for nebulization, by inhalation, increase mucociliary clearance and rapidly reach the smooth muscle of trachea and bronchi [38].

Experiments for highlighting anti-inflammatory property of anti-asthmatic plants mainly pre-treated

laboratory animals with plant extracts, then induced edema by a phlogogenic agent. This approach corresponds to a preventive treatment of inflammation, in accordance with the basic treatment of asthma by inhaled glucocorticoids [37]. Indeed, asthma attacks most often result from the activation of cells of inflammation, and the production of various pro-inflammatory mediators [39].

Conclusion

The review of preclinical studies of medicinal plants used in the management of asthma in Africa showed that the African plant flora is rich and diverse. Very little evidence in animal experiments has been provided to enhance the properties claimed by traditional medicines. However, most of the experiments carried out were based on the physiopathology of asthma, on the one hand, by the demonstration of spasmolytic and/or anti-inflammatory effects, and on the other hand in accordance with curative bronchodilator treatment and anti-inflammatory preventive one. The results of this work justify the standardisation of experimental study protocols on the one hand, and the collaboration between scientists and practitioners of African traditional medicine on the other hand for the improvement of medicinal plants valorisation.

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