TRADITIONAL AND INTEGRATIVE MEDICINE

Trad Integr Med, Volume 6, Issue 1, Winter 2021

Review

Utilization of Plants for Medicinal Purposes and Concerns with Endangered Plant Species from Ghana

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Received: 11 Jan 2021 **Revised:** 8 Feb 2021 **Accepted:** 22 Feb 2021

Abstract

There has always been a strong human dependency on plants for health purposes and such an important relationship should be sustained. Plants remain a repository of drug leads for discovering new pharmaceutical agents for prevention, treatment and improving the quality of health for many people globally. In the effort to improve healthcare services, Ghana put up the Recommended Essential Herbal Medicine List (REHML) consisting of products that are used in the treatment of both Communicable and non-Communicable diseases. To inspire confidence among prescribers and clients of the products it has become necessary to validate the plants and their products. The aim of the study was to identify the medicinal plants' species in the herbal products in Ghana's REHML commonly used for treatment, the conditions being treated with them and finding published research for the plants therapeutic use. Medicinal plants on the REHML with chances of getting extinct were also assessed. The REHML of Ghana and the Ghana Herbal Pharmacopoeia were reviewed for the required information. Electronic databases; PubMed and Scopus, as well as online search engines, Google Scholar and Google were used to obtain information on the identified medicinal plants and their families. A total of 167 medicinal plant species were found to be used in 180 products as compiled in the Ghana REHML and these belonged to 63 botanical families. Most of the medicinal plants are collected from the wild making sustainability and bio-conservation a challenge. Decoctions, creams and ointments are the commonest

Citation: Agyemang AO, Turkson BK, Baidoo MF, Amponsah IK, Kwao Mensah ML, Orman E, Bayor MT. **Utilization of Plants for Medicinal Purposes and Concerns with Endangered Plant Species from Ghana.** Trad Integr Med 2021; 6(1): 24-40.

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dosage forms. The REHML of Ghana caters for 13 disease areas using 180 finished herbal products. These products are made from 167 medicinal plants, 16 of which are in the group of medicinal plants classified as endangered species. There should be a conscious effort to bio-conserve these endangered medicinal plant species so that there can be continuous supply for use in the preparation of herbal products for healthcare purposes.

Keywords: Phytotherapy; Ethnobotany; Bio-conservation; Polyherbal; Biodiversity

Introduction

There has always been a great relationship between human beings and plants for health purposes [1]. It is estimated that two-thirds of the global population use plants and their products as their greatest sources of medicines for the maintenance of health and well-being [2]. Herbal medication still forms part of the means to achieving universal healthcare, since allopathic medical services are either not available or highly inadequate in many communities in developing and underdeveloped countries [3]. Herbal products are regarded to be safe, readily accessible, affordable and efficacious; this makes them a great and acceptable means of preventing diseases and improving the quality of life [4,5]. Among the other reasons accounting for the high usage of phytotherapy for healthcare purposes include; sociocultural acceptability, easy adaptability and compatibility with the body systems as well as few possibilities of adverse effects [6].

Before the modern era, marked by synthetic materials for medicines, about 80% of all therapeutic agents used owed their sources either directly or indirectly to medicinal plants [7]. Currently, up to about 50% of all medicines manufactured globally emanate directly from higher medicinal plants and 25% of prescription−only medicines are from tropical plants [8−12]. Medicinal plants then are very key to global health as directly used therapeutic agents or as precursors for the development of allopathic medications [4].

Medicinal plants are represented as either the whole plant or its part (e.g. seed, fruit, flower, leave, bark, root), that have been recognized and utilized for medicinal purposes [13]. Some of these plants used for health purposes also have non-pharmacological uses; environmental and other economic applications. Most of these plants that are utilized for medical purposes are collected from the wild. Due to the high demand for medicinal plants, legitimate concerns have been raised about the sustainability of such plants and their products for healthcare purposes [14,15].

Studies conducted within the Ghanaian population at the Ministry of Health between the year 1998 and 2009, stated that 60–79% of the population in Ghana uses indigenous Traditional Medicines [16]. There are about 210 local herbal product manufacturers and about 36 foreign−registered herbal medicine importers in Ghana. As of 2017, there were 851 registered medicinal herbal products by the Ghana Food and Drugs

Authority (FDA) on the Ghanaian market [17]. Ghanaians embrace the use of herbal medications for the treatment of diseases. The practice of herbal medicine in the country was given a boost by the commencement of the BSc. degree programme in herbal medicine in the year 2001 at the Kwame Nkrumah University of Science and Technology. This was followed by the integration of herbal medicine practice into the national healthcare delivery system in the year 2011 [5]. To ensure that quality plant medicines are available and utilized in the integrated herbal medicine centres, the Ministry of Health, Ghana developed a Recommended Essential Herbal Medicines List (REHML) in 2008 for primary healthcare services for the treatment of selected diseases [18].

The REHML is a document of selected finished herbal products for use in public health facilities by the experts of herbal medicine (Medical Herbalist). The criteria for the inclusion of products onto the list was based on the ethnobotanical uses of the medicinal plants used in the formulation, availability of clinical data on the plants and products, history of long-term use, laboratory analysis of microbial load and safety, data availability from reference books, cost of product and recommendations from expert committees. This list is to be reviewed periodically to reflect the current state of herbal products on the Ghanaian market based on safety, quality and effectiveness [18].

Access to some medicinal plants in Ghana is dwindling due to deforestation, poor agricultural practices, climate change, illegal mining, environmental pollution, pests and the use of herbicides [19]. In addition, plant diseases are reducing the stock and the quality of plants available for all users. Biodiversity conservation is therefore of paramount importance for sustainable use of plants for healthcare [20]. In the interest of protecting and promoting the conservation of plants, the 2018 General Assembly of the United Nations selected the year 2020 as the International Year of Plant Health (IYPH). This declaration affirms challenges with plants survival and the need to study and advocate for measures to ensure their sustenance [21,22].

This study, therefore, sought to find out the composition of the REHML finished herbal products to determine, the types of medicinal plants commonly used by traditional medicine practitioners in Ghana. The study also assessed how the commercial importance, lifespan, access and availability influence the sustainability of these plants so as to promote the herbal medicine industry in Ghana.

Methods

Literature Search and Data Entry

The primary data used for this study was the REHML for Primary Healthcare Services of the Ministry of Health of the Republic of Ghana [18] and the Ghana Herbal Pharmacopoeia (GHP) [23]. Information on the products used for different disease conditions was captured. Each product was captured once to avoid duplication of herbal products with multiple indications. For each product, the dosage form (decoctions, tablets, capsules, powders, creams, ointment, soaps and external solutions), the number of plants used in the formulation and

names of all plant compositions were captured. Disease conditions which had more than 10 herbal products were further analysed for the commonly used plants for their treatment.

Data from the GHP [23], a national reference document with monographs on 50 commonly medicinal plants available and utilized in Ghana for health purposes. The most commonly used plants found in the REHML were checked for their presence or otherwise in the GHP, as well as the availability of scientific and ethnobotanical data were available to support their clinical applications.

Electronic databases, PubMed and Scopus and online academic-related search engines, Google Scholar and Google were used to obtain supporting data and current information on the pharmacological activities and the abundance of the medicinal plants. The names and authority of plant species were confirmed using the Electronic Plant Information Centre [24].

Data Analysis

Data were captured, cleaned and analysed using Microsoft Excel (2016).

Results and Discussion

Overview of Plants included in the REHML

In all 180 finished herbal products were included in the REHML and recommended by the Ministry of Health of Ghana to be prescribed by Medical Herbalists for patients' care at public hospitals. These products contained 167 medicinal plants from 63 different families, which were used 598 times in formulating them into different dosage forms. It was established that 90.80% of finished herbal products were polyherbal and the remaining 9.20% were monoherbal preparations. On average, more than 3 medicinal plants were used in the formulation every product contained in the REHML. Out of the 180 herbal products, 174 had their plant compositions listed but 6 of the products had no stated plant components but had only secondary metabolites listed.

The use of polyherbal preparations is a common practice in traditional medicine all over the world. The philosophy behind herbal medicine practice is that total extract is always better than the isolates or pure compounds in the prevention and treatment of diseases [25]. Maybe the presence of many and varied secondary metabolites in medicinal plants and products might explain their indications for use in multiple body systems [26,27].

Ghana's flora contains several medicinal plants many of which are used as crude drugs and also in the formulation of finished herbal products [28]. These plant products are used in various forms as herbs (e.g. whole plants), herbal materials, herbal preparations (crushed and powdered forms) and finished herbal products (e.g. well-labelled decoctions, dried extracts, infusions, poultices, capsules, tablets and tinctures). Majority of the products (78.88%) were for internal administration that included decoctions, powders, teas, tablets and capsules. The 38 (21.11%) of the products were for external applications comprising of creams, ointments, soaps and external solutions for applications (Table 1). The decoctions formed the majority

(66.11%) of the dosage forms followed by the creams /ointments with tablets being the least (1.11%). There are many challenges with the use of decoctions as concerns are raised because of poor product stability, inadequate preservations and inaccurate dosing by clients [29]. The formulation of various dosage forms is based on the nature of the plant materials involved, the nature of active principles, the duration for keeping the products, route of ad-

Table 1: Dosage forms of herbal products and conditions treated on Ghana Recommended Herbal Medicine List

Dosage form	Frequency	Percent
Preparations for Internal Use		
Decoctions	119	66.11
Powders/Teas	11	6.11
Tablets	2	1.11
Capsules	10	5.56
Preparations for External Use		
Creams/Ointments	30	16.67
Soaps	3	1.67
Liquids	5	2.78
Total	180	100.00
Disease Conditions	Number of Product	Percent
Anaemia	23	12.78
Malaria	22	12.22
Musculoskeletal pain	20	11.11
Haemorrhoids	19	10.56
Hypertension	13	7.22
Skin diseases	13	7.22
Enteric fever	11	6.11
Diabetes mellitus	8	4.44
Cough	7	3.89
Peptic ulcer	5	2.78
Diarrhoea	4	2.22
Helminthics	3	1.67
Mouth wash	3	1.67
Miscellaneous	29	16.11
Total	180	100

ministration, level of technology, equipment and personnel availability [29]. The most stable dosage forms like the tablets and capsules [30] were, however, the least produced while the decoctions with less stability were mostly produced (Table 1). Decoctions are easy to prepare and administer to patients because it involves simple technology, technical skills and less cost [31]. However, there is the need to provide adequate training and capacity building in areas of quality and stable product development as well as technical support from experts, researchers and regulators in the field of herbal medicine practice. This will improve the development of more stable dosage forms. Even though traditional medicine practitioners in private practice treat many disease conditions, those in public facilities (Ministry of Health) are limited to 13 disease areas mentioned above as a pilot for the integration of traditional medicine into the national healthcare system. Diseases allowed to be managed and treated using traditional medicines in public hospitals in Ghana include malaria, hypertension, diabetes mellitus, HIV/AIDS, TB, anaemia, sickle-cell anaemia, enteric fever, infertility, skin infections, skin ulcers, peptic ulcers, inflammatory and degenerative conditions, diarrhoeal diseases [32].

It was upon these disease conditions that the 180 herbal products were settled on by the Technical Committee that developed the REHML products, for 13 diseases including others which no specific disease conditions were mentioned (miscellaneous) were captured in the REHML. Anaemia, malaria and musculoskeletal pain were the conditions with the highest number of products in that order respectively whilst mouthwashes and anthelmintics had the least number of products. Products with no specific indications and adaptogens were classified as miscellaneous (Table 1).

Among the top ten most common plants used in the herbal products (Table 2), 73.68% were listed in the GHP whiles 23.32% were not list-

Table 2: Ten most commonly used plants in the REHML of Ghana

Plant	Frequency	%	Family	GHP
Khaya senegalensis (Desr.) A.Juss	32	5.35	Meliaceae	Yes
Rauvolfia vomitoria Afzel.	22	3.68	Apocynaceae	Yes
Alstonia boonei De Wild.	21	3.51	Apocynaceae	Yes
Xylopia aethiopica (Dunal) A.Rich.	18	3.01	Annonaceae	Yes
Cryptolepis sanguinolenta (Lindl.) Schltr.	18	3.01	Apocynaceae	Yes
Anthocleista nobilis G.Don	16	2.68	Gentianaceae	No
Paullinia pinnata L.	16	2.68	Sapindaceae	Yes
Azadirachta indica A.Juss.	15	2.51	Meliaceae	Yes
Zingiber officinale Roscoe	14	2.34	Zingiberaceae	Yes
Allium sativum L.	14	2.34	Alliaceae	Yes
Morinda lucida Benth.	13	2.17	Rubiaceae	No
Nauclea latifolia Sm.	13	2.17	Rubiaceae	Yes

Pycnanthus angolensis (Welw.) Warb.	10	1.67	Myristicaceae	No
Cassia alata L.	10	1.67	Fabaceae	Yes
Carica papaya L.	10	1.67	Caricaceae	Yes
Vernonia amygdalina Delile	10	1.67	Asteraceae	Yes
Piper guineense Schumach. & Thonn.	10	1.67	Piperaceae	Yes
Monodora myristica (Gaertn.) Dunal	9	1.51	Annonaceae	No
Aloe ferox Mill.	9	1.51	Asphodelaceae	No

Key: Yes = Plant is listed in the Ghana Herbal Pharmacopoeia
No = Plant is not listed in Ghana Herbal Pharmacopoeia

ed. This data supports the inclusion of medicinal plants with available GHP standards into the REHML. The GHP contains information on the plant's identity, purity, chemical composition, quality assessment, methods of preparation, storage conditions, traditional uses, pharmacological applications, adverse effects and scientific research available on the plants. Thirty-nine (39) plants representing 23.35% of the total listed plants were found in the GHP while the rest were not captured. This calls for more medicinal plants in Ghana to be investigated and included in the GHP to provide for the needed standards to guide their use.

Commonest medicinal plants for the management of disease conditions

Plants for Musculoskeletal Pain

From the REHML, 22 finished herbal products made from 47 medicinal plants, belonging to 32 families are indicated for the treatment of various types of musculoskeletal pains. An average of 2 plants were used to formulate each herbal analgesic product. The commonest species and families employed for analgesic purposes have been presented in Table 4.

Plants for Enteric fever

In all, 11 products were indicated for the treatment of enteric fever produced from 41 medicinal plant species distributed over 20 botanical families. The most frequently used plants for the treatment of enteric fever from the Ghana REHML are listed in Table 3. There was an average of 3.73 medicinal plants per product for the treatment of enteric fever in Ghana. Table

Table 3: Disease conditions, plants and their families used plants for treatment

Musculoskeletal pain	Frequency	%	Family	Reference authenticating biological activity
Rauvolfia vomitoria Afzel	6	7.14	Apocynaceae	[33]
Piper guineense Schumach. & Thonn.	5	5.95	Piperaceae	[34]
Khaya senegalensis (Desv.) A.Juss.	4	4.76	Meliaceae	[35]
Aframomum melegueta K.Schum.	4	4.76	Zingiberaceae	[36]
Xylopia aethiopica (Dunal) A.Rich.	4	4.76	Annonaceae	[37]
Anthocleista nobilis G.Don	4	4.76	Gentianaceae	[38]
Zingiber officinale Roscoe	4	4.76	Zingiberaceae	[39]

Enteric fever				
Nauclea latifolia Sm.	4	9.76	Rubiaceae	[40]
Morinda lucida Benth.	3	7.32	Rubiaceae	[41]
Psidium guajava L.	3	7.32	Myrtaceae	[42]
Hoslundia opposita Vahl	3	7.32	Labiatae	[43]
Citrus aurantiifolia (Christm.) Swingle	2	4.88	Rutaceae	[44]
Vernonia amygdalina Delile	2	4.88	Asteraceae	[45]
Azadirachta indica A.Juss.	2	4.88	Meliaceae	[46]
Jatropha curcas L.	2	4.88	Euphorbiaceae	[47]
Spondias mombin L.	2	4.88	Anacardiaceae	[48]
Momordica charantia L.	2	4.88	Cucurbitaceae	[49]
Skin diseases				
Cassia alata L.	5	12.5	Fabaceae	[50]
Xylopia aethiopica (Dunal) A.Rich.	3	7.5	Annonaceae	[51]
Carica papaya L.	2	5	Caricaceae	[52]
Alstonia boonei De Wild.	2	5	Apocynaceae	[53]
Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg.	2	5	Euphorbiaceae	[54]
Elaeis guineensis Jacq.	2	5	Palmae	[55]
Cymbopogon citratus (DC.) Stapf	2	5	Poaceae	[56]
Haemorrhoids				
Aloe ferox Milli.	7	10.45	Asphodelaceae	[57]
Khaya senegalensis (Desv.) A.Juss.	6	8.96	Meliaceae	[58]
Paullinia pinnata L.	5	7.46	Sapindaceae	[59]
Anaemia				
Khaya senegalensis (Desv.) A.Juss.	14	15.22	Meliaceae	[60]
Pycnanthus angolensis (Welw.) Warb.	4	4.35	Myristicaceae	[61]
Terminalia glaucescens Planch. ex Benth.	4	4.35	Combretaceae	[62]
Xylopia aethiopica (Dunal) A.Rich.	4	4.35	Annonaceae	[63]
Khaya ivorensis A.Chev.	3	3.26	Meliaceae	[64]
Monodora myristica (Gaertn.) Dunal	3	3.26	Annonaceae	[65]
Anthocleista nobilis G.Don	3	3.26	Gentianaceae	[66]
Zingiber officinale Roscoe	3	3.26	Zingiberaceae	[67]
Kigelia Africana (Lam.) Benth.	3	3.26	Bignoniaceae	[68]
Hypertension				
Rauvolfia vomitoria Afzel.	5	11.90	Apocynaceae	[69]
Cassia occidentalis L.	3	7.14	Caesalpinaceae	[70]
Persea americana Mill.	3	7.14	Lauraceae	[71]
Anthocleista nobilis G.Don	2	4.76	Gentianaceae	[72]
Allium sativum L.	2	4.76	Alliaceae	[73]
Lippia multiflora Moldenke	2	4.76	Verbenaceae	[74]
Taraxacum officinale G. Weber ex F.H.Wigg.	2	4.76	Asteraceae	[75]
Phyllanthus niruri L.	2	4.76	Euphorbiaceae	[76]

Malaria				
Cryptolepis sanguinolenta (Lindl.) Schltr.	12	15.79	Apocynaceae	[77]
Azadirachta indica A.Juss.	9	11.84	Meliaceae	[78]
Alstonia boonei De Wild.	7	9.21	Apocynaceae	[79]

4 shows the commonest botanical families to which the 41 plants belong.

Plants for Skin diseases

For the treatment of skin diseases, 13 products comprising 40 medicinal plant species which belong to 23 botanical families were used. Thus three (3) medicinal plants on average were used in each product indicated for dermatological disorders. The most frequently used plants for the treatment of skin diseases from the Ghana REHML are shown in Table 3. The most used botanical families of the plants for treating dermatological disorders are stated in Table 4.

Plants for Haemorrhoids

A total of 19 products formulated from 67 plants species belonging to 24 families are used in the treatment of haemorrhoids in herbal units of Ghana's public hospitals. Each product on average consists of 3.53 medicinal plants. The most commonly used in managing haemorrhoids are shown in Table 3. The commonest families from which the plants utilized for treating haemorrhoids are listed in Table 4.

Plants for Anaemia

In the treatment of all forms of anaemia, the Ghana REHML lists 23 products that are com-

Table 4: Commonest families of plants for treatment

Musculoskeletal Pain	**Frequency**	**Percent**
Annonaceae	3	6.38
Apocynaceae	3	6.38
Fabaceae	3	6.38
Meliaceae	3	6.38
Caesalpiniaceae	2	4.26
Euphorbiaceae	2	4.26
Liliaceae	2	4.26
Myrtaceae	2	4.26
Rutaceae	2	4.26
Zingiberaceae	2	4.26
Enteric fever		
Anacardiaceae	2	7.69
Asteraceae	2	7.69
Euphorbiaceae	2	7.69
Fabaceae	2	7.69

Meliaceae	2	7.69
Rubiaceae	2	7.69
Skin Diseases		
Annonaceae	2	6.90
Caesalpiniaceae	2	6.90
Euphorbiaceae	2	6.90
Liliaceae	2	6.90
Rubiaceae	2	6.90
Zingiberaceae	2	6.90
Malaria		
Meliaceae	4	11.43
Apocynaceae	3	8.57
Rubiaceae	3	8.57
Annonaceae	2	5.71
Asteraceae	2	5.71
Bignoniaceae	2	5.71
Euphorbiaceae	2	5.71
Lamiaceae	2	5.71
Haemorrhoids		
Apocynaceae	5	14.29
Annonaceae	3	8.57
Asteraceae	3	8.57
Fabaceae	3	8.57
Meliaceae	2	5.71
Anaemia		
Meliaceae	4	7.69
Apocynaceae	3	5.77
Bignoniaceae	3	5.77
Fabaceae	3	5.77
Moraceae	3	5.77
Annonaceae	2	3.85
Combretaceae	2	3.85
Euphorbiaceae	2	3.85
Lamiaceae	2	3.85
Musaceae	2	3.85
Poaceae	2	3.85
Rubiaceae	2	3.85
Rutaceae	2	3.85
Solanaceae	2	3.85

Zingiberaceae	2	3.85
Hypertension		
Apocynaceae	4	13.79
Fabaceae	3	10.34
Asteraceae	2	6.90
Euphorbiaceae	2	6.90
Liliaceae	2	6.90
Meliaceae	2	6.90
Rubiaceae	2	6.90

posed of 92 medicinal plants distributed over 31 families. An average of 4 medicinal plants are used in a product are utilized for anaemia treatment. The commonly used plants, as well as their families, are listed in Tables 3 and 4 respectively.

Plants for Hypertension

In the management of hypertension, 13 products made from 42 medicinal plants belonging to 19 families are utilized; an average of 3 plants are used in formulating an antihypertensive product. The most frequently used plants for hypertension management are listed in Table 3. The 3 most used botanical families for producing the antihypertensives are shown in Table 4.

Plants for Malaria

Twenty-two (22) products are used in the treatment of malaria from the REHML. These products are made from 76 medicinal plants that belong to 23 families. On average, 3.45 plants are used to formulate an antimalarial product. The most frequently used plants for the treatment of malaria are listed in Table 3. The 3 highest botanical families for producing the antimalarials are shown in Table 4.

Sustainability and Bio-conservation

There is a high demand for plants for both medicinal and non-medicinal purposes. This may ultimately lead to over exploitations of such plants. Some of the factors promoting the high demand for medicinal plants include increase global population, cultural acceptability, affordability, availability and health benefits [80]. The over exploitation of medicinal plants is worse in developing and underdeveloped countries because such plants are used extensively locally and also exported to developed countries. This inability to meet the high demand for medicinal plants from the wild is of high concern since many people in the developing and underdeveloped countries utilized these plants as sources of medicines for their primary healthcare needs. A lot of plants in the world are in danger of getting extinct and prudent measures are therefore needed to be instituted to curtail it [81,82]. More attention should be given to plants with their roots as the preferred choice for medicinal purposes (Table 5). Using the roots of medicinal plants collected from the wild poses the greatest challenges as some of such plants are already classified as engendered with a higher probability of getting extinct.

In order to meet the increased demand and commercialization of the medicinal plants, the following prudent measures must be in place; capital injection to facilitate sufficient research on high yielding breeds of medicinal plant species, with short gestational periods, best cultivation methods and technologies, apply scientific harvesting procedures, employ other good agricultural practices as well as improve coordination among researchers into medicinal plants cultivation [83,84].

Apart from medicinal purposes, plants like *Alstonia boonei, Anthocleista nobilis, Pycnanthus angolensis* and *K. senegalensis* are used as cattle fodder, fuelwood, furniture, industry, building construction and for building fishing boats [85]. Some of the medicinal plants (e.g., *K. senegalensis*) are high-demanding agroforestry timber species for export [86,87]. All these social and environmental applications of the medicinal plants make them highly susceptible to extinction.

Table 5: Biodiversity status and plant parts used in the Ghana REHML

Plant	Status	Reference
Albizia ferruginea (Guill. & Perr.) Benth.	Endangered	[90]
Alstonia boonei De Wild.	Endangered	[90]
Baphia nitida Lodd.	Rare	[90]
Entandrophragma angolense (Welw.) C.D.C	Endangered	[88]
Garcinia kola Heckel	Endangered	[88]
Khaya ivorensis A.Chev.	Rare	[90]
Khaya senegalensis (Desv.) A.Juss.	Endangered	[88]
Monodora myristica (Gaertn.) Dunal	Endangered	[90]
Morinda lucida Benth.	Endangered	[90]
Nauclea latifolia Sm.	Endangered	[90]
Newbouldia laevis (P.Beauv.) Seem.	Endangered	[90]
Parinari robusta Oliv.	Endangered	[90]
Pycnanthus angolensis (Welw.) Warb.	Endangered	[90]
Rauvolfia vomitoria Afzel.	Endangered	[90]
Ricinodendron heudelotii (Baill.) Heckel	Endangered	[90]
Terminalia ivorensis A.Chev.	Endangered	[90,91]
Plant	**Part commonly used**	**Other parts of interest**
Khaya senegalensis (Desv.) A.Juss.	Stem bark	Leaves; roots; seeds
Rauvolfia vomitoria Afzel.	Roots and rhizome	Leaves
Alstonia boonei De Wild.	Stem bark	Leaves
Xylopia aethiopica (Dunal) A.Rich.	Stem	Stem bark, root bark
Cryptolepis sanguinolenta (Lindl.) Schltr.	Roots	Leaves, stem
Anthocleista nobilis G.Don	Bark	Leaves and roots
Paullinia pinnata L.	Leaves	Roots
Azadirachta indica A.Juss.	Leaves	Stem bark, seeds
Zingiber officinale Roscoe	Rhizome	

Allium sativum L.	Bulb	
Morinda lucida Benth.	Bark	Leaves
Nauclea latifolia Sm.	Root	Fruit; Leaf; Stem bark
Pycnanthus angolensis (Welw.) Warb.	Bark (stem, root)	Leaves fruits
Cassia alata L.	Young leaflets	Flower; root; seed; bark
Carica papaya L.	Seeds	Root; leaf, fruit
*Vernonia amygdalin*a Delile	Leaves	Root
Piper guineense Schumach. & Thonn.	Fruits	Root; seed; stem bark; leaf
Monodora myristica (Gaertn.) Dunal	Fruits	Seed
Aloe ferox Mill.	Whole leaf	

K. senegalensis which happens to be the most commonly used plant in the REHML is among the 119 plants that have been classified as endangered species in Ghana and other African countries [88]. *K. senegalensis* takes at least 10 years to start viable seed production for its propagation [89]. This clearly poses a challenge to manufacturers who source for *K. senegalensis* from the wild. Manufacturers who use such endangered plants will have challenges in getting raw material supplies for sustainable production. There is an urgent need for the state to properly put measures in place to protect such endangered plant species for conservation purposes.

Terminalia ivorensis and *K. ivorensis* are also used in the production of herbal products found on the REHML but not part of the top 10 most commonly used plants (Table 2). These two plants are also classified as engendered in Ghana adding up to the issues of continuous availability of such plants. Establishment of medicinal farm plantations is long overdue in Ghana because of the high dependency of plants from

Figure 1: Plants harvested from the wild (A) *K. senegalensis stem bark* (B) Roots of *Cryptolepis sanguinolenta*

the wild for medicinal purposes. There is a huge potential for cultivation of medicinal plants with the many commercial producers of herbal medications and the setting up of myriads of herbal clinics with huge patronage.

Ghana is estimated to have about 5,429 species of plants with 119 of them being classified as threatened by the International Union for Conservation of Nature (IUCN) [92]. Among the threatened plant species, 96 are vulnerable, 20 endangered and 3 are critically endangered [93]. Among the plants used in REHML recommended products, 16 plants are among those classified as threatened species (Table 5). The classification of some these medicinal plants as rare, endangered and threatened poses a great challenge to the production of herbal products in the country. Endangered plant species are plants with a very high risk (≥ 20%) of getting extinct within the next 5 years in the wild [94]. Possible shortages of such threatened plants may lead to cessation of some of the herbal products which may be critical life-saving products for clients who need it for survival and for improving their quality of life.

Substitution and adulteration may be the consequences from the unavailability of critical medicinal plants that are usually in high demand for the preparation of herbal medications since manufacturers may still want to be in business even in the face of plant shortages [95]. Effective post−marketing surveillance and pharmacovigilance can be means of curtailing such nefarious activities of some herbal medicine producers.

Conclusion

From the REHML, polyherbal formulations are mostly employed in the treatment of diseases rather than single plant products in Ghana. The REHML of Ghana deals with over 13 disease areas with 180 finished herbal products made from 167 medicinal plants. Sixteen medicinal plants from the list are classified as endangered and rare species raising concerns on the sustainability of using plants for health. Meanwhile, almost all the medicinal plants are collected from the wild. There is, therefore, a strong need to consider alternative means of getting quality and continuous supply of plant materials for the sustenance of the seemingly booming herbal medicine industry in Ghana and globally. Conservation of medicinal plants outside their natural environment (ex-situ) like medicinal and botanical gardens should be considered to safeguard the plants. In-situ conservations systems like natural reserves where no harvesting is allowed can be used to protect endangered medicinal plant species. Future studies will be conducted to establish why specific families of plants are used for certain disease conditions.

Conflict of interest

None.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgments

None.

References

[1] Addo-Fordjour P, Anning AK, Akanwariwiak WG, Belford EJD, Firempong CK. Medicinal plants of Ghana. Genetic resources, chromosome engineering, and crop improvement: Medicinal Plants 2012;6:221-246.

[2] Adeyemi AA, Ibe AE, Okedimma FC. Tree structural and species diversities in Okwangwo Forest, Cross River State, Nigeria. Journal of Research in Forestry, Wildlife and Environment. 2015;7(2):36-53.

[3] Adeyi AO et al. In vivo and in vitro antibacterial activities of Momordica charantia on Salmonella typhi and its effect on liver function in typhoid-infected rats. J Pharmacogn Phytother. 2013;5:183-188.

[4] Agyemang AO et al. Clinical Evaluation of the Safety and Effectiveness of Heptonica: A Ghanaian Hepatorestorative Polyherbal Product. Evid Based Complementary Altern Med 2020;2020.

[5] Ajayi TO, Moody JO, Anthony CS. Ethnobotanical survey of plants used in the management of hypertension in Ibadan North Local Government Area of Oyo State, Nigeria. Nigerian Journal of Pharmaceutical Research 2019;15:61-73.

[6] Akinwunmi KF, Oyedapo OO. In vitro anti-inflammatory evaluation of African nutmeg (Monodora myristica) seeds. Eur J Med Plants 2015;167-174.

[7] Akpuaka A, Ekwenchi MM, Dashak DA, Dildar A. Biological activities of characterized isolates of n-hexane extract of Azadirachta indica A. Juss (Neem) leaves. Nature and Science. 2013;11:141-147.

[8] Alo MN, Anyim C, Igwe JC, Elom M, Uchenna DS. Antibacterial activity of water, ethanol and methanol extracts of Ocimum gratissimum, Vernonia amygdalina and Aframomum melegueta. Adv Appl Sci Res 2012;3:844-848.

[9] Alzohairy MA. Therapeutics role of Azadirachta indica (Neem) and their active constituents in diseases prevention and treatment. Evid Based Complementary Altern Med 2016;2016.

[10] Aremu OO et al. Acute and sub-chronic antihypertensive properties of Taraxacum officinale leaf (TOL) and root (TOR). Trans R Soc S Afr 2019;74:132-138.

[11] Aromolaran O, Badejo OK. Efficacy of fresh leaf extracts of Spondias mombin against some clinical bacterial isolates from typhoid patients. Asian Pac J Trop Dis 2014;4:442-446.

[12] Asase A, Asafo-Agyei T. Plants used for treatment of malaria in communities around the Bobiri forest reserve in Ghana. Journal of Herbs, Spices & Medicinal Plants 2011;17:85-106.

[13] Ayodele PO et al. Effect of Anthocleista nobilis root extract on the haematological indices of poultry chicken challenged with newcastle disease virus (NDV). Science and Nature. 2013;2:65-73.

[14] Baradaran A, Nasri H, Rafieian-Kopaei M. Oxidative stress and hypertension: Possibility of hypertension therapy with antioxidants. Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences 2014;19:358.

[15] Barg C, Robertson C. Khaya senegalensis:'Discover khaya, the period pain reliever'. JATMS 2019;25:146.

[16] Bello I et al. Blood pressure lowering effect and vascular activity of Phyllanthus niruri extract: The role of NO/cGMP signaling pathway and β-adrenoceptor mediated relaxation of isolated aortic rings. J Ethnopharmacol 2020;250:112461.

[17] Bello OA, Akinyele AO. In vitro seed germination of Pycnanthus angolensis (Welw.). AJATE 2016;5:40-50.

[18] Bhat P, Hegde GR, Hegde G, Mulgund GS. Ethnomedicinal plants to cure skin diseases-an account of the traditional knowledge in the coastal parts of Central Western Ghats, Karnataka, India. J Ethnopharmacol 2014;151:493-502.

[19] Boadu AA, Asase A. Documentation of herbal medicines used for the treatment and management of human diseases by some communities in southern Ghana. Evid Based Complementary Altern Med 2017;2017.

[20] Bonferoni MC et al. A novel ionic amphiphilic chitosan derivative as a stabilizer of nanoemulsions: Improvement of antimicrobial activity of Cymbopogon citratus essential oil. Colloids Surf B Biointerfaces 2017;152:385-392.

[21] Bristow M, Skelton D. Preliminary weed risk assessment for Khaya senegalensis in plantations in northern Australia. Workshop Proceedings, 'Prospects for high value hardwood timber plantations in the'dry'tropics of northern Australia'. Mareeba, 19th–21st October 2004.

[22] Bugyei KA, Boye GL, Addy ME. Clinical efficacy of a teabag formulation of Cryptolepis sanguinolenta root in the treatment of acute uncomplicated falciparum malaria. Ghana Med J 2010;44:6-9.

[23] Busia K. Ghana Herbal Pharmacopoeia. Science and Technology Policy Research Institute, Council for Scientific and Industrial Research 2007.

[24] Calixto JB. The role of natural products in modern drug discovery. Acad Bras Cienc 2019;91.

[25] Chen SL et al. Conservation and sustainable use of medicinal plants: problems, progress, and prospects. Chin Med 2016;11:1-10.

[26] Christine EA, Albert YK, Séraphin KC. Determination of the Minerals of the Herbal Tea and Tea Green from Lippia multiflora. Am J Plant Sci 2017;8:2608.

[27] Cletus AU et al. Anti-hemorrhoid evaluation of selected medicinal plants used in bali north-east nigeria for the treatment of hemorrhoids (pile). J Pharm Res Int 2017;1-6.

[28] Cock IE. The medicinal properties and phytochemistry of plants of the genus Terminalia (Combretaceae). Inflammopharmacology 2015;23:203-229.

[29] Dehdari S, Hajimehdipoor H, Esmaeili S, Choopani R, Mortazavi SA. Traditional and modern aspects of hemorrhoid treatment in Iran: a review. J Integr Med 2018;16:90-98.

[30] Musa DA, Sunday GO, Musa A, Nwodo OF. Evaluation of in vitro anti-salmonelal effect of combined crude aqueous extracts of Ficus capensis and Nauclea latifolia used for the

treatment of typhoid fever. Biokemistri 2017;29:19-23.
[31] Ekong MB, Nwakanma AA. Rauwolfia vomitoria and Gongronema latifolium extracts influences cerebellar cortex. Alzheimer's, Dement Cogn Neurol 2017;1:1-6.
[32] Ewudzie EE. Inventory and ethnobotanical studies of medicinal plants in the Asantemanso sacred grove, Ashanti Region, Ghana (Doctoral dissertation).
[33] Fagodia SK, Singh HP, Batish DR, Kohli RK. Phytotoxicity and cytotoxicity of Citrus aurantiifolia essential oil and its major constituents: Limonene and citral. Ind Crops Prod 2017;108:708-715.
[34] Fleischer TC et al. Antimicrobial activity of essential oils of Xylopia aethiopica. African J Trad Complement Altern Med 2008;5:391-393.
[35] Ghana's Sixth National Draft report to the United Nations on Convention on Biological Diversity (CBD). Ministry of Environment, Science, Technology and Innovation (MESTI). 2018.
[36] Ghosh D. Quality issues of herbal medicines: internal and external factors. IJCAM 2018;11.
[37] Gotep JG et al. Therapeutic and safety evaluation of combined aqueous extracts of Azadirachta indica and Khaya senegalensis in chickens experimentally infected with Eimeria oocysts. J Parasitol Res 2016;2016.
[38] Hackman KO. The state of biodiversity in Ghana: Knowledge gaps and prioritization. Int J Biodivers Conserv 2014;6:681-701.
[39] Haq I. Safety of medicinal plants. Pak J Med Res 2004;43:203-210.
[40] Harris JB et al. Conserving imperiled species: a comparison of the IUCN Red List and US Endangered Species Act. Conserv Lett 2012;5:64-72.
[41] http://earthsendangered.com/search-regions3.asp?search=1&sgroup=allgroups&ID=483 accessed on 6/7/2020
[42] http://epic.kew.org/index.htm accessed on 6/7/2020
[43] http://www.fao.org/plant-health-2020/about/en/ retrieved on 2/7/2020
[44]https://www.bfarm.de/SharedDocs/Downloads/DE/Service/Termine-und-Veranstaltungen/dialogveranstaltungen/dialog_2017/170914/19_Kwarteng.pdf?__blob=publicationFile&v=3 accessed on 1/6/2020
[45] Ilic NM et al. Anti-inflammatory activity of grains of paradise (Aframomum melegueta Schum) extract. J Agric Food Chem 2014;62:10452-10457.
[46] Irawati NAV. Antihypertensive effects of avocado leaf extract (Persea Americana Mill). Journal Majority 2015;4:23-25.
[47] Jackson PW, Kennedy K. The global strategy for plant conservation: a challenge and opportunity for the international community. Trends Plant Sci 2009;14:578-580.
[48] Kabiru AY, Ibikunle GF, Innalegwu DA, Bola BM, Madaki FM. In vivo antiplasmodial and analgesic effect of crude ethanol extract of Piper guineense leaf extract in Albino mice. Scientifica 2016;2016.
[49] Kala CP. Medicinal plants conservation and enterprise development. Med Plants 2009;1:79-95.
[50] Karan M et al. Rapid microsatellite marker development for African mahogany (Khaya senegalensis, Meliaceae) using next□generation sequencing and assessment of its intra□specific genetic diversity. Mol Ecol Resour 2012;12:344-353.
[51] Kingston DG. Modern natural products drug discovery and its relevance to biodiversity conservation. J Nat Prod 2011;74:496-511.
[52] Kong JM, Goh NK, Chia LS, Chia TF. Recent advances in traditional plant drugs and orchids. Acta Pharmacol Sin 2003;24:7-21.
[53] Kravchenko I, Eberle L, Nesterkina M, Kobernik A. Anti-inflammatory and analgesic activity of ointment based on dense ginger extract (Zingiber officinale). J Herbmed Pharmacol 2019;8:126-132.
[54] Kulkarni R, Deshpande A, Saxena K, Varma M, Sinha AR. Ginger supplementary therapy for iron absorption in iron deficiency anemia. IJTK 2012;11:78-80.
[55] Kumadoh DO, Ofori-Kwakye KW. Dosage forms of herbal medicinal products and their stability considerations-an overview. J Crit Rev 2017;4:1-8.
[56] Lata H, Chandra S, Khan IA, ElSohly MA. Propagation through alginate encapsulation of axillary buds of Cannabis sativa L.—an important medicinal plant. Physiol Mol Biol Plants 2009;15:79-86.
[57] Lobay D. Rauwolfia in the treatment of hypertension. IMCJ 2015;14:40.
[58] Lobo R, Ballal M. Screening for antidiarrheal activity of Psidium guajava: A possible alternative in the treatment against diarrhea causing enteric pathogens. J Chem 2011;3:961-967.
[59] McChesney JD, Venkataraman SK, Henri JT. Plant natural products: back to the future or into extinction?. Phytochem 2007;68:2015-2022.
[60] Mills-Robertson FC. Characterization of Wild-Type Salmonella and Their Susceptibility to "Mist Enterica" An Anti-Typhoid Herbal Preparation (Doctoral dissertation, University of Ghana).
[61] Ministry of Health (MOH). Recommended List of Herbal Medicines Essential for Primary Healthcare Services 2008.
[62] Ministry of Health (MOH). Strategy for Formal Initialization of Plant Medicine Services, Medical Herbalism and Complementary Medicine in Ghana 2009.
[63] Musa AD. Biochemical and pharmacological studies on Morinda lucida and Eucalyptus camaldulensis (Doctoral dissertation, University of Nigeria Enugu Campus) 2011.
[64] Nabatanzi A, Nkadimeng SM, Lall N, Kabasa JD, McGaw LJ. Ethnobotany, Phytochemistry and Pharmacological Activity of Kigelia africana (Lam.) Benth (Bignoniaceae) Plants 2020;9:753.
[65] Nagalingam A. Drug delivery aspects of herbal medicines. Jpn Kampo Med Treat Common Dis Focus Inflammation 2017;17:143.

[66] Ngwoke KG et al. Antioxidant, anti-inflammatory, analgesic properties, and phytochemical characterization of stem bark extract and fractions of Anthocleista nobilis. Pharmacogn Res 2018;10:81.
[67] Noorhosseini SA, Fallahi E, Damalas CA, Allahyari MS. RETRACTED: Factors affecting the demand for medicinal plants: Implications for rural development in Rasht, Iran 2017.
[68] Noundou XS, Krause RW, Van Vuuren SF, Ndinteh DT, Olivier DK. Antibacterial effects of Alchornea cordifolia (Schumach. and Thonn.) Müll. Arg extracts and compounds on gastrointestinal, skin, respiratory and urinary tract pathogens. J Ethnopharmacol 2016;179:76-82.
[69] Oladeji OS, Adelowo FE, Oluyori AP, Bankole DT. Ethnobotanical description and biological activities of Senna alata. Evid Based Complement Altern Med 2020.
[70] Omoregie ES, Oriakhi K, Oikeh EI, Okugbo OT, Akpobire D. Comparative study of phenolic content and antioxidant activity of leaf extracts of Alstonia boonei and Eupatorium odoratum. Nigerian Journal of Basic and Applied Sciences 2014;22:91-97.
[71] Oso BJ, Oyewo EB, Oladiji AT. Influence of ethanolic extracts of dried fruit of Xylopia aethiopica (Dunal) A. Rich on haematological and biochemical parameters in healthy Wistar rats. Clin Phytoscience 2019;5:1-10.
[72] Ouattara LH, Kabran GR, Konan KM. Biological activities and phytochem of Paullinia pinnata LI. J Cur Res 2019;11:10.
[73] Owoyele BV, Owolabi GO. Traditional oil palm (Elaeis guineensis Jacq.) and its medicinal uses: A review. CELLMED 2014;4:16.
[74] Perera PK, Amarasekera HS, Weerawardena ND. Effect of growth rate on wood specific gravity of three alternative timber species in Sri Lanka: Swietenia macrophylla, Khaya senegalensis and Paulownia fortune. JTFE 2012;2:26-35.
[75] Petrovska BB. Historical review of medicinal plants' usage. Pharmacogn Rev 2012;6:1.
[76] Rabadeaux C, Vallette L, Sirdaarta J, Davis C, Cock IE. An examination of the antimicrobial and anticancer properties of Khaya senegalensis (Desr.) A. Juss. bark extracts. Pharmacogn J 2017;9.
[77] Ramawat KG, Merillon JM, editors. Bulbous plants: biotechnology. CRC Press 2013.
[78] Rasoanaivo P, Wright CW, Willcox ML, Gilbert B. Whole plant extracts versus single compounds for the treatment of malaria: synergy and positive interactions. Malaria Journal 2011;10:1-2.
[79] Rates SM. Plants as source of drugs. Toxicon 2001;39:603-613.
[80] Ried K, Fakler P. Potential of garlic (Allium sativum) in lowering high blood pressure: mechanisms of action and clinical relevance. Integr Blood Press Control 2014;7:71.
[81] Roy A, Jauhari N, Bharadvaja N. Medicinal plants as a potential source of chemopreventive agents. Inanticancer plants: Natural products and biotechnological implements. Springer. Singapore. 2018; pp 109-139.
[82] Sofowora A, Ogunbodede E, Onayade A. The role and place of medicinal plants in the strategies for disease prevention. Afr J Trad Complement Altern Med 2013;10:210-229.
[83] Srirama R et al. Species adulteration in the herbal trade: causes, consequences and mitigation. Drug safety 2017;40:651-661.
[84] Sun S, Wang Y, Wu A, Ding Z, Liu X. Influence factors of the pharmacokinetics of herbal resourced compounds in clinical practice. Evid Based Complement Altern Medi 2019;2019.
[85] Sunderland TC et al. Vegetation assessment of Takamanda forest reserve, Cameroon. Takamanda: the Biodiversity of an African Rainforest. SIMAB Series 2003;8:19-53.
[86] Tepongning RN et al. Potential of a Khaya ivorensis–Alstonia boonei extract combination as antimalarial prophylactic remedy. J Ethnopharmacol 2011;137:743-751.
[87] Thirumalai T, Beverly CD, Sathiyaraj K, Senthilkumar B, David E. Ethnobotanical Study of Anti-diabetic medicinal plants used by the local people in Javadhu hills Tamilnadu, India. Asian Pac J Trop Biomed 2012;2:S910-S913.
[88] Tilburt JC, Kaptchuk TJ. Herbal medicine research and global health: an ethical analysis. Bulletin of the World Health Organization 2008;86:594-599.
[89] Tripathi N. International Year of Plant Health. 2020.
[90] World Health Organization. WHO global report on traditional and complementary medicine. World Health Organization; 2019.
[91] Woo CS, Lau JS, El-Nezami H. Herbal medicine: toxicity and recent trends in assessing their potential toxic effects. Adv Bot Res 2012;62:365-384.
[92] Woode E et al. Effects of an ethanol extract and the diterpene, xylopic acid, of Xylopia aethiopica fruits in murine models of musculoskeletal pain. Pharm Biol 2016;54:2978-2986.
[93] Xiao J, Zhang H, Niu L, Wang X. Efficient screening of a novel antimicrobial peptide from Jatropha curcas by cell membrane affinity chromatography. J Agric Food Chem 2011;59:1145-1151.
[94] Yuan H, Ma Q, Ye L, Piao G. The traditional medicine and modern medicine from natural products. Molecules 2016;21:559.
[95] Zaigham H, Tauheed A, Ali A. Recent trend in traditional medicine dosage form and present status of Unani and Ayurvedic Medicine. Int J Pharm Sci Res 2019;10:1640-1649.