Journal of Medicinal Plants for Economic Development
ISSN: (Online) 2616-4809, (Print) 2519-559X

Botanical characterisation, drug indications and sustainability status of traditional oral powdered herbal formulations in Ogbomoso, Nigeria

Authors:
Jennifer E. Ideh[1]
Adepoju T.J. Ogunkunle[1]
Muhammed A. Jimoh[1]

Affiliations:
[1]Department of Pure and Applied Biology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Corresponding author:
Adepoju Ogunkunle,
tjogunkunle@lautech.edu.ng

Dates:
Received: 05 Oct. 2018
Accepted: 16 Dec. 2018
Published: 30 Apr. 2019

How to cite this article:
Ideh, J.E., Ogunkunle, A.T.J. & Jimoh, M.A., 2019, 'Botanical characterisation, drug indications and sustainability status of traditional oral powdered herbal formulations in Ogbomoso, Nigeria', *Journal of Medicinal Plants for Economic Development* 3(1), a64. https://doi.org/10.4102/jomped.v3i1.64

Background: The foremost requirements in quality control of a herbal drug are its identity and purity. In addition, information is necessary on whether continual exploitation of medicinal herbs for traditional oral powdered herbal formulations (TOPHFs) in Ogbomoso, Nigeria, is sustainable.

Aim: To botanically characterise and ethno-medicinally document the health indications of TOPHFs manufactured in Ogbomoso, as well as to examine the sustainability status of the drugs.

Setting: Ogbomoso, Nigeria.

Methods: Fifteen manufacturers of TOPHFs provided information on the botanical constituents and recipes of their products, the sources of raw material herbs, and types of health conditions treated with the drugs. Sustainability status of the drugs was quantified as relative percentage of the three choices of sources of raw material herbs available to the manufacturers and in terms of conservation status of the plant species as recorded by the International Union for Conservation of Nature.

Results: Fifty-five medicinal plant species from 33 angiosperm families were used by traditional herbal medical practitioners to produce 68 TOPHFs that are indicated for treating 17 different health conditions. The sources of raw material herbs, in relative terms, were purchased from herbal markets (43.8%), collected from the wild (28.1%) and cultivated (28.1%). Most of the herbs can be sustainably harvested and only 3 (i.e. 5.5%) of the 55 plant species (i.e. *Lophira alata* Banks ex Gaertn., *Khaya senegalensis* A. Juss. and *Garcinia kola* Heckel) are under threatened (vulnerable) species.

Conclusion: Production of TOPHFs in Ogbomoso is sustainable with minimal injury on the natural flora.

Keywords: Traditional oral powdered herbal formulations; Sustainable exploitation of medicinal herbs; Ethno-Medicine; Forest conservation; Ethno-Botany.

Introduction

The Medical and Dental Practitioners' (Amendment) Decree number 78 promulgated by the Government of Nigeria on 30 September 1992 placed traditional and alternative medicine side by side with orthodox medicine (ABFR & CO 1996). However, a key obstacle to the acceptance of alternative medicine in certain parts of the world lies in the lack of documentation and stringent quality control (Prasad et al. 2012). African herbal products have particularly been called to question on account of adulteration, substitution, contamination, misidentification of ingredients, lack of standardisation, incorrect preparation and/or dosage, inappropriate labelling and/or advertisement (Lau, Woo & Koh 2003; World Health Organization 2003). For these reasons, herbal products from Africa have not enjoyed worldwide acceptability compared to those from other countries such as India and China (Patwardhan et al. 2005).

The World Health Organization (World Health Organization 2002) refers to quality of herbal drugs on the basis of their reproducible efficacy and safety, while Bauer (Bauer 1998) identifies quality criteria in terms of the scientific definition of the raw materials. Therefore, standardisation and quality control of herbal formulations seem to hinge mainly on their identity and purity. To that extent, correct identification and quality assurance of the starting materials is an essential prerequisite to ensure reproducible quality of herbal medicine, which will contribute to its safety and efficacy

(Kadam et al. 2012). Although many believe that it is difficult to establish comprehensive quality for herbal drugs because of professional secrecy of traditional herbal medical practitioners (THMPs), this challenge has been shown to be surmountable (Obu 2015). The raw medicinal herbs serving as the starting materials for traditional oral powdered herbal formulations (TOPHFs) in Ogbomoso are regarded as 'active ingredients' for these drugs (World Health Organization 2000), and their enumeration formed one of the focal points for this study.

There is ample evidence to show increasing human dependence on herbal drugs for primary healthcare (World Health Organization 1998), but we hardly seek to know where the herbs we use come from. One may wonder why we need to be mindful of the source of medicinal herbs, but the herbs we take as medicine are inextricably connected to the processes that produce them. In fact, we cannot be healthy unless our environment is healthy. Therefore, if we choose to use plants as our medicine, we become accountable for the vegetation or environment that produced the plants. This is the pattern of thinking in sustainable herbal medicine (Medicine Hunter 2012; Pesic 2015).

The strategies for ensuring sustainability of medicinal plants production have been highlighted to include *in situ* and *ex situ* conservation efforts, controlled cultivation and sustainable harvesting, among others (Chen et al. 2016; World Health Organization 2003). For these strategies to succeed in a country, the political will is the first requirement. Presently, there is no government policy in place to ensure the sustainability of traditional medicine and the protection of the environment in Nigeria (Osunderu 2009). However, the literature has it that traditional healers in Ogbomoso prepare and market various herbal preparations used for different types of ill health conditions. Among these are the TOPHFs used by different categories of residents of the city (Ogunkunle & Ashiru 2011). There is no information on whether continual exploitation of medicinal plants for TOPHFs in Ogbomoso is sustainable or not. This gap formed another area of consideration in this study.

Against the aforestated background, the objectives of this study were to botanically characterise and ethno-medicinally document the health indications of TOPHFs in Ogbomoso, as well as to examine the conservation status of the medicinal plants alongside the cultivation efforts being made by the THMPs.

Materials and methods

This study was conducted in 2014 in Ogbomoso, Nigeria, located around 8.1333'N latitude and 4.2567'E longitude. The target population consisted of the THMPs in the study area who produced, sold and provided healing services with TOPHFs. Seventeen THMPs were selected using stratified sampling technique, during which each of the five local government areas (LGAs) was taken as a stratum. Fifteen of the THMPs were eventually found suitable for inclusion, to whom a questionnaire was administered or used as an interview schedule.

Section A of the questionnaire sought the herbal healers' socio-demographic data with 11 questions, while Section B, with 9 questions, was used to gather information on the types of TOPHFs they manufactured and sold, their botanical constituents and sources of the herbs used, the ailments they were meant to treat, and details of preparation of the drugs. In seeking information about the sources of raw herbal materials, the THMPs were supplied with a list of possible sources (i.e. purchase, collection from the wild, cultivation, etc.) and each of them was asked to tick as many of the options as applicable to him or her. Each of these multiple choices was considered as an independent variable across the 15 participants and counted. Thereafter, a summation of the counts for the 3 alternatives selected was obtained and equated to 100%, from which the relative percentage of each choice was computed. The relative percentage value obtained for cultivation of the required herbal materials was taken as sustainability index for TOPHFs in the study area.

Information on the conservation status or population dynamics of each of the plant species used by the TOPHF manufacturers was obtained by cross-checking its name against the red list of threatened plant species compiled by the International Union for Conservation of Nature (IUCN 2017). The proportion of the species in the threatened category, taken alongside conservation efforts by the THMPs, was used to project whether manufacturing of TOPHFs in Ogbomoso was sustainable.

Codes (A, B, C, D, etc.) were assigned to the THMPs for anonymity purpose, while their products were labelled with reference to the indications (i.e. health conditions that they treat) of the drugs they produced. In doing this, each health condition was first given a short code of five alphabets, which was then used as a hyphenated prefix to the anonymity code of its manufacturer, such as MALAR-B (i.e. malaria drug from healer B) , PILES-F (i.e. drug for piles from healer F) and TYPHO-E (i.e. drug for typhoid from healer E) (see Table 1).

Results

Information about the traditional herbal medical practitioners contacted and their activities

Out of the 17 THMPs initially recruited in the study, 13 (i.e. 76.5%) were men and 4 (i.e. 23.5%) were women; 10 of them (about 59%) were over 50 years of age. The majority of the healers (70%) had only primary and/or secondary education, but up to 65% of them had practiced in the profession for more than 30 years. Historically, these people came into the profession by descent (being their family trade), while few others either combined some form of training with this option or depended on their natural gifts or talents to become traditional healers. The THMPs updated their knowledge of medical practice through a wide range of choices, such as by intuition (35.3%), attendance at health talks or meetings (11.0%) and electronic media (5.9%), while 47.8% of them adopted various forms of a combination of these and other choices. Of the 17 THMPs contacted, 15 produced, sold and applied TOPHFs against 17 different types of health conditions,

TABLE 1: Information about the traditional herbal healers who participated in the study.

Variable	Number of participants		
	Male	Female	Total (N = 17)
Age (years)			
31–40	4	0	4
41–50	2	1	3
➢50	7	3	10
Formal education			
None	0	2	2
Primary	7	1	8
Secondary	3	1	4
OND or NCE	1	1	2
HND or Degree	1	0	1
Experience (years)			
< 10	2	0	2
10–20	1	1	2
21–30	1	1	2
➢30	9	2	11
Professional history			
By descent	11	4	15
By training	0	0	0
Both by descent and training	1	0	1
Others†	1	0	1
Manufacturer of powdered herbs			
Yes††	11	4	15
No	2	0	2
Update of knowledge in medical practice			
By intuition (A)	5	1	6
Attendance of meetings or health talks (B)	2	0	2
Electronic media (C)	1	0	1
Internet (D)	0	0	0
A and B	2	3	5
A, B and C	1	0	1
A, B, C and D	2	0	2

OND, Ordinary National Diploma; NCE, Nigeria Certificate in Education; HND, Higher National Diploma.

†, Talent from God.

††, Of the 17 herbal healers, 15 produced powdered herbal formulations for oral use and their residential homes doubled as factories, with none of them having evidence of registration of their products with National Food and Drug Administration and Control.

including maintenance of general body homeostasis and the management of some dreaded diseases, such as high blood pressure and diabetes. All of the 15 THMPs (100%) produced oral powdered drugs for malaria therapy, and also sizable proportions of them (6.7% in each case) produced powdered drugs for female infertility, onchocerciasis, diabetes, stomach ulcers and yellow fever (Table 2).

Medicinal plants used by traditional herbal medical practitioners in Ogbomoso to produce traditional oral powdered herbal formulations

A total of 55 medicinal plant species from 33 angiosperm families were listed by the THMPs as constituents of TOPHFs in Ogbomoso, Nigeria. Plants of the families Fabaceae, Cucurbitaceeae and Euphorbiaceae were most widely used, followed by those of Amaryllidaceae, Annonaceae, Apocynaceae, Combretaceae, Rutacecae, Solanaceae and Zingiberaceae. Members of the other 23 families were seldom used by the THMPs (Tables 3–13). The plant parts used as herbs include fruits, seeds, leaves, stem barks, flowers, roots

TABLE 2: List of health conditions indicated for traditional oral powdered herbal formulations manufactured and marketed in Ogbomoso, Nigeria.

Number	Health condition or type of powdered herb	Number of manufacturers (N = 15)
1	Arthritis and rheumatism	2
2	Back and waist pain	2
3	Bareness or female infertility	1
4	Blood enricher or enhancer	4
5	Blood purifier or thinner	6
6	Body itch or onchocerciasis	1
7	Convulsion	2
8	Diabetes	1
9	Male erectile dysfunction	2
10	Gonorrhoea	2
11	High blood pressure	8
12	Jaundice or anaemia	6
13	Malaria	15
14	Piles	14
15	Typhoid	11
16	Ulcer (stomach, duodenum, peptic)	1
17	Yellow fever	1

TABLE 3: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of arthritis or rheumatism in Ogbomoso, Nigeria.

Number	Plant species	Family name	Part(s) used
1	*Elais guinensis* Jacq.	Arecaceae	Dry kernel shell
2	*Allium sativum* L.	Amaryllidaceae	Leaf base or fruit
3	*Xylopia aethiopica* (Dunel) A. Rich.	Annonaceae	Fruit with seeds
4	*Aframomum melegueta* K. Schum.	Zingiberaceae	Fruit
5	*Garcinia kola* Heckel	Clusiaceae	Seeds
6	*Allium cepa* L.	Amaryllidaceae	Leaves

Herbal recipes for two powdered drugs: ARRHE-D (1, 2, 3, 4 + cow bone) and ARRHE-K (5,6); suffix alphabets indicate the manufacturers' anonymity codes.

ARRHE, arthritis or rheumatism.

TABLE 4: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of back and waist pain in Ogbomoso, Nigeria

Number	Plant species	Family name	Part(s) used
1	*Piper guinense* Schumach.	Piperaceae	Fruits
2	*Allium cepa* L.	Amaryllidaceae	Leaves
3	*Xylopia aethiopica* (Dunel) A. Rich.	Annonaceae	Fruit pods
4	*Capsicum frutescens* L.	Solanaceae	Fruits
5	*Anthocleista djalonensis* A. Chev.	Gentianaceae	Stem bark
6	*Morinda lucida* Benth.	Rubiaceae	Stem bark
7	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	Fruits

Herbal recipes for two powdered drugs: BAWAP-C (1, 3 + potash) and BAWAP-O (3, 4, 5, 6, 7); suffix alphabets indicate the manufacturers' anonymity codes.

BAWAP, back and waist pain.

TABLE 5: Names of plants and their parts for the formulation of traditional oral powdered herbal formulations used as blood enricher or enhancer in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Sorghum bicolor*	Poaceae	Leaf sheath
2	*Maranthes polyandra* Benth.	Chrysobalanaceae	Stem bark
3	*Alstonia boonei* De Wild.	Apocynaceae	Stem bark
4	*Senna alata* (L.) Roxb.	Fabaceae	Flowers
5	*S. alata* (L.) Roxb.	Fabaceae	Root
6	*Calyptrochilum christyanum* (Rchb. f.) Summerh	Orchidaceae	Leaves

Herbal recipes for four powdered drugs: BLENH-C (6 only), BLENH-F (1, 2 + potash), BLENH-K (3 + table salt + potash) and BLENH-M (4, 5); suffix alphabets indicate the manufacturers' anonymity codes.

BLENH, blood enricher or enhancer.

TABLE 6: Names of plants and their parts for the formulation of traditional oral powdered herbal formulations used as blood purifying or thinning drug in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Alcohorneae laxiflora* (Benth.) Pax & K. Hoffm.	Euphorbiaceae	Leaves
2	*Tetrapleura tetraptera* (Schumm. & Thonn.)Taub.	Fabaceae	Fruits
3	*Allium cepa* L.	Amaryllidaceae	Leaves
4	*Harungana madagascariensis* Lam ex Poiret	Hypericaceae	Stem bark
5	*Capsicum frutescens* L.	Solanaceae	Fruits
6	*Lophira alata* Banks ex Gaertn.	Onchnaceae	Stem bark
7	*Khaya senegalensis* A. Juss.	Meliaceae	Stem bark
8	*Allium sativum* L.	Amaryllidaceae	Fruit or leaf base
9	*Zingiber officinale* Roscoe	Zingiberaceae	Rhizome
10	*Xylopia aethiopica* (Dunel) A. Rich.	Annonaceae	Fruit

Herbal recipes for six powdered drugs: BLPUR-B (1, 2, 3), BLPUR-C (4, 5), BLPUR-E (3, 6, 7, 8, 9), BLPUR-H (3, 5, + potash), BLPUR-I (5, 7, 10 + potash) and BLPUR-M (7, 10 + potash); suffix alphabets indicate the manufacturers' anonymity codes.

BLPUR, blood purifying or thinning drug.

TABLE 7: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of convulsion in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Nicotiana tabacum* L.	Solanaceae	Leaves
2	*Khaya senegalensis* A. Juss.	Meliaceae	Stem bark
3	*Parkia biglobosa* (Jacq.) R.Br ex G Don	Fabaceae	Fermented seeds
4	*Capsicum anuum* L.	Solanaceae	Fruits

Herbal recipes for two powdered drugs: CONVU-B (1 + table salt) and CONVU-C (2, 3, 4 + table salt); suffix alphabets indicate the manufacturers' anonymity codes.

CONVU, convulsion.

TABLE 8: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of male erectile dysfunction in Ogbomoso, Nigeria.

No.	Plant species name	Family	Part(s) used
1	*Sesamum indicum*	Pedaliaceae	Leaves
2	*Abelmoscus esculentus* (L.) Moench.	Malvaceae	Dried fruits
3	*Manihot esculenta* Crantz	Euphorbiaceae	Root tuber
4	*Musa parasidiaca* L.	Musaceae	Fruit
5	*Garcinia kola* Heckel	Clusiaceae	Seed

MERDY, male erectile dysfunction.

Herbal recipes for two powdered drugs: MERDY-A (1, 2) and MERDY-D (1, 3, 4, 5); suffix alphabets indicate the manufacturers' anonymity codes.

TABLE 9: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of gonorrhoea in Ogbomoso, Nigeria.

No.	Plant species name	Family	Part(s) used
1	*Senna alata* (L.) Roxb.	Fabaceae	Leaves
2	*Jatropha curcas* L.	Euphorbiaceae	Fruits
3	*Xylopia aethiopica* (Dunel) A. Rich.	Annonaceae	Fruits
4	*Adenopus breviflorus* Benth.	Cucurbitaceae	Fruits
5	*Euphorbia lateriflora* Sch. & Thonn.	Euphorbiaceae	Leaves or stem
6	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	Whole fruit

Herbal recipes for two powdered drugs: GONOR-B (1, 2+ sulphur) and GONOR-C (3, 4, 5, 6 + potash); suffix alphabets indicate the manufacturers' anonymity codes.

GONOR, gonorrhoea.

and rhizomes. Additional information obtained from the THMPs indicated the sources of raw material herbs available to them in relative terms as purchased from herbal markets or suppliers (43.8%), collection from wild vegetation (28.1%) and cultivation of some of the herbs for use (28.1%).

TABLE 10: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of high blood pressure in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Citrus sinensis* (L.) Osbeck	Rutaceae	Fruit rind or bark
2	*Citrus aurantifolia* (Christ.) Swingle	Rutaceae	Whole fruits
3	*Aframomum melegueta* K.Schum.	Zingiberaceae	Whole fruit
4	*Persea americana* Miller	Lauraceae	Leaves
5	*Parkia biglobosa* (Jacq.) R.Br ex G.Don	Fabaceae	Dried fermented seeds
6	*Xylopia aethopica* (Dunel) A. Rich.	Annonaceae	Fruits
7	*Allium cepa* L.	Amaryllidaceae	Leaves
8	*Capsicum anuum* L.	Solanaceae	Fruits
9	*Parkia biglobosa* (Jacq.) R.Br ex G.Don	Fabaceae	Flowers
10	*Allium sativum* L.	Amaryllidaceae	Fruits or leaf base
11	*Zingiber officinale* Roscoe	Zingiberaceae	Rhizome
12	*Enantia chlorantha* Oliv.	Annonaceae	Stem bark
13	*Calyptrochilum christyanum* (Rchb. f.) Summerh	Orchidaceae	Leaves
14	*Combretum mucronatum* Thonn.	Combretaceae	Root
15	*Curculigo pilosa* (Schum & Thonn.) Engl.	Hypoxidaceae	Rhizome

Herbal recipes for eight powdered drugs: HIGBP-A (1, 2, 3), HIGBP-B(4, 5), HIGBP-C (6,7, 8 + table salt), HIGBP-D (1, 7, 9, 14), HIGBP-F (5, 10), HIGBP-I (15 only), HIGBP-M (11 + potash) and HIGBP-N (7, 10, 12); suffix alphabets indicate the manufacturers' anonymity codes.

HIGBP, high blood pressure.

TABLE 11: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of malaria fever in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Senna accidentalis* L.	Fabaceae	Leaves
2	*Senna tora* (L.) Roxb.	Fabaceae	Leaves
3	*Aframomum melegueta* K. Schum.	Zingiberaceae	Whole fruit
4	*Morinda lucida* Benth.	Rubiaceae	Leaves
5	*Capsicum frutescens* L.	Solanaceae	Fruits
6	*Alstonia boonei* De Wild.	Apocynaceae	Leaves
7	*Alstonia boonei* De Wild.	Apocynaceae	Stem bark
8	*Allium cepa* L.	Amaryllidaceae	Leaves
9	*Piper guinense* Schumach.	Piperaceae	Fruits and leaves
10	*Carica papaya* L.	Caricaceae	Dried or fallen leaves
11	*Anthocleista djalonensis* A. Chev.	Gentianaceae	Dried or fallen leaves
12	*Khaya senegalensis* A. Juss.	Meliaceae	Stem bark
13	*Anogeissus leiocarpus* (DC) Guill & Perr.	Combretaceae	Stem bark
14	*Xylopia aethiopica* (Dunel) A. Rich.	Annonaceae	Fruit pods
15	*Olax subscorpioidea* Oliv.	Olacaceae	Root bark
16	*Securidaca longipedunculata* Fresen.	Polygalaceae	Root bark
17	*Senna podocarpa* (Guill. & Perr.) Lock	Fabaceae	Leaves
18	*Terminalia glauscecens* Planch. ex Benth.	Combretaceae	Root bark
19	*Senna podocarpa* (Guill. & Perr.) Lock	Fabaceae	Root bark
20	*Eugenia aromaticum* (L.) Merr. & L.M. Perry	Myrtaceae	Fruits or flowers

Herbal recipes for 15 powdered drugs: MALAR-A (1,2,3), MALAR-B (4, 5, 6, + table salt), MALAR-C (5, 7, 8), MALAR-D (7, 9, 10 + potash), MALAR-E (5, 12, 13, 14, 15), MALAR-F (7, 9, 16, 20), MALAR-G (5, 7, 8), MALAR-H (5, 6, 7 + table salt), MALAR-I (7, 18), MALAR-J (7 + potash), MALAR-K (7, 14 + potash), MALAR-L (17 only), MALAR-M(13, 14 +potash), MALAR-N (5,8,12, 18, 19) and MALAR-O (5, 12, 13, 15); suffix alphabets indicate the manufacturers' anonymity codes.

MALAR, malaria fever.

A further scrutiny of the plant lists against the IUCN red list of threatened plants revealed that only 8 of the 55 plant species have been evaluated for their conservation status and population dynamics (IUCN, 2017). From these eight,

TABLE 12: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of piles in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Lonchocarpus cyanescens* Perkin	Fabaceae	Leaves
2	*Aframomom melegueta* K.Schum.	Zingiberaceae	Whole fruit
3	*Senna alata* (L.) Roxb.	Fabaceae	Leaves
4	*Hunteria umbellata* (K. Schum) Hallier	Fabaceae	Seeds
5	*Senna alata* (L.) Roxb.	Fabaceae	Flowers
6	*Piper guinense* Schumach	Piperaceae	Fruits and leaves
7	*Xylopia aethiopica* (Dumel) A. Rich.	Annonaceae	Fruits
8	*Capsicum frutescens* L.	Solanacecae	Fruits
9	*Alstonia boonei* De Wild.	Apocynaceae	Stem bark
10	*Khaya senegalensis* A. Juss.	Meliaceae	Stem bark
11	*Allium sativum* L.	Amaryllidaceae	Leaf base
12	*Eugenia aromaticum* (L.) Merr. & L.M. Perry	Myrtaceae	Flower buds
13	*Petiveria alliacea* L.	Phytolacaceae	Stem bark

Herbal recipes for 14 powdered drugs: PILES-A (1, 2), PILES-B (3 + potash), PILES-C (4 only), PILES-D (5, 7 + potash + sulphur), PILES-E (5, 7, 12, + kafura + potash), PILES-F (3, 13 + sugar + potash), PILES-G (4, 7, 9); PILES-I (5 only), PILES-J (5 only), PILES-K (3, 8), PILES-L (3, 10), PILES-M (5 + potash), PILES-N (4, 11) and PILES-O (5, 7, + kafura); suffix alphabets indicate the manufacturers' anonymity codes.

PILES, piles disease.

TABLE 13: Names of plants and their parts used for the formulation of traditional oral powdered herbal formulations for the treatment of typhoid fever in Ogbomoso, Nigeria.

Number	Plant species name	Family	Part(s) used
1	*Carica papaya* L.	Caricaceae	Unripe fruit
2	*Piper guinense* Schumach.	Piperaceae	Fruits and leaves
3	*Alstonia bronei* De Wild.	Apocynaceae	Stem bark
4	*Allium cepa* L.	Amaryllidaceae	Leaves
5	*Capsicum frutescens* L.	Solanaceae	Fruits
6	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	Fruits
7	*Anthocleista djalonensis* A. Chev.	Gentianaceae	Stem bark
8	*Morinda lucida* Benth.	Rubiaceae	Stem bark
9	*Huntaria umbellate* K. Schum.	Apocynaceae	Fruit
10	*Zingiber officinale* Roscoe	Zingiberaceae	Rhizome
11	*Mangifera indica* L.	Anacardiaceae	Stem bark
12	*Zanthoxylum zanthoxyloides* (Lam.) Zepern.	Rutaceae	Stem bark
13	*Olax subscorpioidea* Oliv.	Olacaceae	Root bark
14	*Securidaca longipedunculata* Fresen.	Polygalaceae	Root
15	*Citrillus colocynthis* (L .) Schrad.	Cucurbitaceae	Fruit
16	*Thonningia sanguine* Val.	Balanophoraceae	Bulbs

Herbal recipes for 11 powdered drugs: TYPHO-B (1, 2 + palm kernel oil), TYPHO-C (3, 4, 5 + table salt), TYPHO-E (5,6,7,8,15), TYPHO-F (9 + alum), TYPHO-G (3,4,5), TYPHO-I (16 only), TYPHO-J (3 + potash), TYPHO-K (10 + potash), TYPHO-L (11 only), TYPHO-M (10 + potash) and TYPHO-N (3,12,13,14); suffix alphabets indicate the manufacturers' anonymity codes.

TYPHO, typhoid fever.

three species, namely *Garcinia kola*, *Khaya senegalensis* and *Lophira alata,* are categorised as threatened or 'Vulnerable' (VU) species. The status of the other five species is 'Least Concern' (*Capsicum frutescens*, *Persea ameicana*, *Sorghum bicolor*) and 'Data Deficient' (*Carica papaya* and *Mangifera indica*) categories.

In formulating the powdered drugs, the THMPs collected or purchased the appropriate herbs fresh, partly dried or dried, and if necessary, they properly dried and mechanically milled it into separate powders. Appropriate proportions of each powder for a drug was determined and used by individual manufacturers to compose the drugs. Lastly, the drug was sieved and stored in containers, ready for sale.

Discussion

Indications for TOPHFs produced in Ogbomoso, which have been highlighted in this study (Table 2), are a reflection of the prevalence of malaria, piles, typhoid and high blood pressure among the residents of Ogbomoso. On the other hand, ill health conditions such as onchocerciasis, yellow fever, diabetes and internal ulcers appear to be relatively uncommon, or else, the sufferers of these ailments did not seek healing or management from THMPs. There is ample evidence to show that malaria is a major public health problem in Nigeria, accounting for more cases and deaths than any other country in the world (United States Embassy in Nigeria 2011; World Health Organization 2013). The preponderance of antimalarial powdered drugs among the traditional healers in the study area is a confirmation that the disease is prevalent in the southwestern parts of the country (Okunade 2001).

The number of plant species being exploited by the THMPs in Ogbomoso is on the higher side, and this calls for the necessity to examine whether production of these drugs in the area is sustainable, and if the local vegetation will not be put in jeopardy soon. About 44% of the TOPHF manufacturers sourced their raw material herbs by buying it from the vendors. Truly, a few of the purchased herbs are collections from outside Ogbomoso land; however, a scrutiny of the lists in Tables 3–13 revealed that a good number of them were obtainable in the savanna woodland to which Ogbomoso belongs (Keay 1989). Therefore, there is the probability that most of these plants were readily available in the past for free collection in the neighbourhoods, but now have to be purchased by the users because of urbanisation and other related factors that have rendered them less accessible (Hsueh 2009; Liu et al. 2015). The natural flora of the study area has been largely impacted to the extent that only 28% of the healers now source their raw materials through collection in the wild.

Information about the quantities of the herbs extracted annually by the TOPHFs manufacturers in Ogbomoso is not available to make categorical statements. However, if it is assumed that 47 of the plant species used for TOHPFs not yet evaluated by the IUCN are not threatened, it is logical to infer from available data from this study and information in the red list of IUCN that production of TOPHFs in the study area is sustainable. In addition, the activities of these traditional drug manufacturers do not, at the moment, appear to pose any threat to the population of these plant species, inasmuch as the herbs from the plants (i.e. stem barks and seeds) can be extracted sustainably. Efforts made by certain THMPs (28.1%) in cultivating some of the plant species they use are also commendable, but there is room for improvement.

Conclusion and recommendation

Sixty-eight TOPHFs manufactured in Ogbomoso are indicated for the treatment of 17 different kinds of health conditions, including malaria, piles and typhoid, and in the management

of such dreaded diseases as high blood pressure, yellow fever and diabetes. Herbs from members of 33 angiosperm families are exploited to produce these drugs, but this practice is considered sustainable with minimal injury to the neighbouring flora as long as sustainable harvesting can be encouraged or enforced along with medicinal plants cultivation.

Acknowledgements

The authors are thankful to the THMPs in Ogbomoso who wilfully divulged vital information about the powdered herbal formulations reported.

Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors' contributions

J.E.I. was responsible for data collection and preparation of the draft manuscript. A.T.J.O. was responsible for conceptualisation of research and manuscript preparation. M.A.J. performed data collection and collation.

References

ABFR & CO, 1996, *Chronology of Nigerian decrees*, ABFR & Co Law Office, Onikan, Lagos, viewed 01 August 2018, from http://www.abfr&co.com/1992n.htm.

Bauer, R., 1998, 'Quality criteria and standardization of phytopharmaceuticals: Can acceptable drug standards be achieved?', *Drug Information Journal* 32, 101–110. https://doi.org/10.1177/009286159803200114

Chen, S., Yu, H., Luo, H., Wu, Q., Li, C. & Steinmetz, A., 2016, 'Conservation and sustainable use of medicinal plants: Problems, progress and prospects', *Chinese Medicine* 11, 37. https://doi.org/10.1186/s13020-016-0108-7

Hsueh, D., 2009, 'New York City's metropolitan dome: Past and present CO_2 concentration patterns from an urban to rural gradient', Unpublished M.A. thesis, Department of Ecology Evolution and Environmental Biology (E3B), Columbia University.

IUCN, 2017, *The IUCN red list of threatened species*, International Union for Conservation of Nature, viewed 01 August 2018, from www.iucnredlist.org.

Kadam, P.V., Yadav, K.N., Patel, A.N., Navsare, V.S., Bhilwade, S.K. & Patil, M.J., 2012, 'Phytopharmacopoeial specifications of *Garcinia indica* fruit rinds', *Pharmacognosy Journal* 4(31), 23–28. https://doi.org/10.5530/pj.2012.31.5

Keay, R.W.J., 1989, *Trees of Nigeria*, Oxford Science Publication, New York, p. 476. ISBN: 0-19-854560-6.

Lau, A.H., Woo, S. & Koh, H., 2003, 'Analysis of adulterants in a traditional herbal medicinal product using liquid chromatography-mass spectroscopy', *Journal of Pharmaceutical and Biomedical Analysis* 31, 401–406. https://doi.org/10.1016/S0731-7085(02)00637-4

Liu, Y. Wang, Y., Peng, J., Du, Y., Liu, X., Li, S. et al., 2015, 'Correlations between urbanization and vegetation degradation across the world's metropolises using DMSP/OLS Nighttime Light Data', *Remote Sensing* 7, 2067–2088. https://doi.org/10.3390/rs70202067

Medicine Hunter, 2012, *On sustainability and medicinal plants*, viewed 01 August 2018, from www.medicinehunter.com/sustainability.

Obu, R.N., 2015, *Challenges facing traditional medicine in Ghana*, Feature Article, Modern Ghana, viewed from www.modernghana.com/news/648038/1/challenges-facing-traditional-medicine-inin-ghana.htm.

Ogunkunle, A.T.J. & Ashiru, S.B., 2011, 'Experience and perceptions of the residents of Ogbomoso land Nigeria on the safety and efficacy of herbal medicines', *Journal of Herbal Practice and Technology* 1, 22–28.

Okunade, A.O., 2001, *The underdevelopment of health care system in Nigeria*, Faculty of Clinical Sciences and Dentistry, University of Ibadan, Vantage Publishers Limited, Ibadan, Nigeria.

Osunderu, O.A., 2009, 'Sustainable production of traditional medicines in Africa', in E.K. Yanful (ed.), *Appropriate technologies for environmental protection in the developing world*, pp. 43-51, Springer, Dordrecht

Patwardhan, B., Warude, D., Pushpangadan, P. & Bhatt, N., 2005, 'Ayurveda and traditional Chinese medicine: A comparative overview', *Evidence-Based Complementary and Alternative Medicine* 4, 465–473. https://doi.org/10.1093/ecam/neh140

Pesic, M., 2015, *Development of natural product drugs in a sustainable manner*, Brief for GSDR 2015, viewed 03 August 2018, from https://sustainabledevelopment.un.org/.

Prasad, V., Rameshi, S.D., Rakesh, S.S., Karita, N.Y. & Manohar, J.P., 2012, 'Pharmacognostic, phytochemicl and physicochemical studies of *Mimmusops elengi Linn* Stem Bark (Sapotaceae)', *Der Pharmacia Lettre* 4(2), 607–613, viewed from www.scholarsresearchlibrary.com.

United States Embassy in Nigeria, 2011, *Nigeria Malaria Fact Sheet*, U.S. Embassy in Nigeria, FCT, Abuja, viewed 30 July 2018, from http://nigeria.embassy.gov; http://photos.state.gov/libraries/231771/public/December-MalariaFactSheet2.pdf.

World Health Organization, 1998, *Quality control methods for medicinal plant materials*, World Health Organization, Geneva.

World Health Organization, 2000, *General guidelines for methodologies on research and evaluation of traditional medicine*, World Health Organization, Geneva.

World Health Organization, 2002, *General guidelines for methodologies on research and evaluation of traditional medicine*, World Health Organization, Geneva.

World Health Organization, 2003, *WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants*, WHO, Geneva.

World Health Organization, 2013, *Malaria Fact sheets*, World Health Organization, viewed 30 July 2018, from http://www.who.int/mediacentre/factsheets/fs094/en/.