

A Survey on Indigenous Knowledge Systems Databases for African Traditional Medicines

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ABSTRACT

This study aimed at surveying the constructed Indigenous knowledge systems databases for African Traditional medicine; learning their diversity features, common challenges and develops the missing information when constructing indigenous knowledge system for Tanzanian Traditional Medicine. According to the research presented by different scholars, there are more than 10 databases for African traditional plants medicine. The translation of biodiversity towards the new therapy has been a challenge towards creating the database for traditional medicine in Africa. This has led to most of the available database lack enough information on ethnopharmacological data. The effort towards the introduction of bioinformatics in most of the undergraduate circular gives the best direction towards developments of computational in pharmaceutical fields. By concluding, the development of global data in a single indigenous knowledge system may be impossible in view of the culture and biodiversity differences; efforts have to be given to specific regional areas and African museum should act as a center to link all indigenous knowledge systems. The need of using the collaborative approach for defining a common standard in medicinal plant database for knowledge sharing and scientific advancement is inevitable in developing a unified indigenous knowledge systems Database for African Traditional Medicine.

Keywords

Traditional Medicine; Biodiversity; Indigenous Knowledge Systems; Phytomedicine; Ethno-medicinal;

1. INTRODUCTION

Traditional medicine (TM)—variously called ethnomedicine, complementary and alternative medicine (CAM), folk medicine, or native healing—refers to the oldest form of healthcare system that, for many years, has remained useful to people. Several national programs policies sensitive to practices of traditional medicines, which have significantly increased over the past few years, describe and provide uses of these medicines along the biomedical perspective [1]. National policies form the basis for defining the role of traditional medicines in national healthcare programs, ensuring that the necessary regulatory and legal mechanisms are created for promoting and maintaining good practice; assuring authenticity, security, and effectiveness of traditional therapies; and providing equitable access to healthcare resources and information about those resources [2]. The World Health Organization (WHO) works with countries to develop policies most appropriate for their locations.

In most of the African, Asian, and Latin American countries, traditional medicine makes an important part of healthcare in building successful disease treatment. China and India, for example, have developed sophisticated systems such as acupuncture and ayurvedic medicine [3]. Traditional medicines are widely available and affordable, even in remote areas, and

generally accessible to most people. This appreciation of the traditional medicines signals serious concerns in the allopathic sector regarding safety and quality of the remedies associated with the medicines.

Scholars have put more efforts on the effects demonstrated by medicinal materials. To study the effects, resources that systematically describe the chemical compounds in medicinal materials are necessary. Previous studies have defined Indigenous Knowledge as a cumulative body of strategies, practices, techniques, tools, intellectual resources, explanations, beliefs, and values accumulated over time in a particular locality, without the interference and impositions of external hegemonic forces [4]. Indigenous Knowledge Systems are not limited to the material sphere, but often interconnected with spiritual and non-material realms of existence. The significance of indigenous knowledge systems to local communities and its application to modern life cannot be underestimated. Indigenous Knowledge constitutes much of the world's medicinal knowledge, and indigenous communities rely on this knowledge for their survival, daily life, healing, and nutritional needs. WHO noted that the inappropriate use of traditional medicines or practices can have negative or dangerous effects and that further research is needed to ascertain the efficacy and safety of many traditional medical practices [5]. The World Intellectual Property Organization (WIPO) authorized the permission to substantially reproduce, disseminate, and/or translate publication on Traditional Indigenous Knowledge systems [6] [7]. Documenting these systems helps to preserve knowledge, collect and compile related information, and create an easy-to-access organizational structure.

In recent years, numerous indigenous knowledge systems databases on medicinal materials of traditional medicines and associated constituent compounds have been constructed [8]. This study aims at surveying the constructed TM indigenous knowledge systems databases of traditional medicines, with emphasis being given to those systems that can be accessed and confirmed online.

2. METHODS

2.1 List of databases for African medicinal plants

We extensively searched and extracted articles on African medicinal plants from popular bibliographic repositories: Google Scholar, PubMed, and ResearchGate. The keywords such as “African Medicine Indigenous Knowledge Systems”, “ethnomedicinal African plant”, “ethnobotanical African database”, “botanical African garden database”, “ethnopharmacological African database”, “herbal African database”, “African traditional medicine database”, “ethnomedicinal African plant database”, and “African database” were used independently and in combination. Articles related to

databases were also searched for the printed materials to be used for citation and references. Navigating through different sources of information, we found that the authors in [9] [10] present the indigenous TM knowledge systems databases.

2.1.1 Bilingual Indigenous Knowledge Systems Databases

2.1.1.1 Botanica Ethiopia

This database, also called a Living Pharmacy, defines a Home Herbal Garden (HHG) community development project in Fiche, Ethiopia. The project focuses on supporting and promoting practices of traditional herbal medicines in Ethiopia by establishing a sustainable indigenous herbal medicine garden within the Fiche community [11]. The project involves local workshops to share and document traditional medicine knowledges and practices more likely to disappear; it has also involved capacity building in areas of permaculture design, small business development, and modern beekeeping. The documentation, presented in English, received a full support from Blackmores (although users can search plant names in local, scientific, and English languages). Rasoanaivo shows that the Ethiopian database includes 25,000 records of African medicinal plants [5], documented in African M.Sc. and PhD theses and also in regional conference proceedings.

2.1.1.2 Ghanaian Indigenous Knowledge of Medicinal Plants

This online database, established in 2015 and funded by the Elsevier Foundation (Amsterdam, Netherlands), was developed by the Forestry Research Institute of Ghana (FORIG), an institute of the Council for Scientific and Industrial Research (CSIR) [12]. In the past, CSIR had been directly involved in the development of the Ghana Herbal Pharmacopoeia, first published in 1992 and significantly revised and republished in 2007.

The Ghanaian Indigenous Knowledge database, enables searching by scientific Latin name (of the medicinal plant) or by local common names, and allows sorting by category, whether forest food, medicinal plant, or both. The search results provide a page with a photograph of the medicinal plant, nomenclature (Latin binomial, family name, and local names), plant category, plant parts, and their uses according to the literature, traditional uses in Ghana, and listing of diseases treated. The database was published in 2017 by the IFLA journal [12].

2.1.1.3 PRELUDE Database

This is a traditional veterinary and human medicine plants in sub-Saharan Africa. The goal of PRELUDE data bank is to summarize, from about 1000 scientific publications, the use of traditional medicinal plant devoted to traditional human medicine and traditional veterinary medicine. The database contains information on thousands of plants used for treating animals and humans in rural areas in different regions of Africa. The information stored in the database was derived from scientific articles, books, conference reports, and reports specifically

addressed to the PRELUDE sub-network Health, animal production, and environment. Each listing includes, among other aspects, the plant's botanical name, the African countries where the plant can be used for veterinary purposes, and the animal diseases that the medicine may treat. PRELUDE has registered 6528 medicine plants searchable according to plant name, country, or symptom code. The database was published 2012 by Belgian Biodiversity Platform, and has constantly been expanded.

2.1.1.4 Francophone Database:

This database, also called PHARMEL incorporates a database on African Traditional Medicine and Pharmacopoeia. The information in PHARMEL is presented in French and English languages, and hence the database may be more suitable for French-speaking countries. The 18 African countries and Madagascan Council for Higher Education launched this database of recognized qualifications in francophone Africa.

2.1.2 English Indigenous Knowledge Systems Databases

2.1.2.1 National Databases from institution initiatives

According to [10], there exist approximately 10 National Databases from different institutions affiliated with universities. These databases include CESRIKI (Center for Scientific Research, Indigenous Knowledge, and Innovation) affiliated with the University of Botswana. CESRIKI aims at bringing researchers from various disciplines to carry out research on Indigenous Knowledge; IMRA (Institut Malgache de Recherches Appliquées in Madagascar; Makerere University in Uganda; the University of Nairobi in Kenya; Muhimbili University Institute of Traditional Medicine in Tanzania; University of Witwatersrand in South Africa; Natl Institute of Communicable Disease in South Africa; and University of KwaZulu in South Africa and the University of Cape Town in South Africa.

2.1.2.2 PlantZAfrica

This database was established by the South African National Biodiversity Institute (SANBI), which is responsible in exploring, revealing, celebrating, and championing biodiversity for the benefit and enjoyment of all South Africans. PlantZAfrica was started in 2000 and now it contains over 1850 articles of plants information. The database receives updates of two new plants, called "Plants of the Week", weekly, and thus making the Information Library to have hundreds of articles on southern Africa plants and related topics.. Furthermore, the authors in [13] give another South African natural compound database with all information on natural products and drug discovery process. The detailed information on the plant's related drugs mentioned on PlantZAfrica is published 2015 by the journal of Cheminformatics.

2.1.2.3 Plant Resources of Tropical Africa Database (PROTAbase)

PROTABase refers to an international documentation programme on the useful plants of Tropical Africa. The database synthesizes dispersed information on about 8000 species, makes it readily available in various forms, and stimulates its use for an extension, education, research, development, and governance. PROTABase was initiated by the University of Wageningen (Netherlands) and acted as a not-for-profit Foundation in the Netherlands and as an international NGO (non-governmental organization) in Kenya. Regional offices were created in Africa and national offices (Netherlands, United-Kingdom, and France) in Europe. The database has been active from 2000 to 2013, then stopped due to lack of funds. The databank aimed to comprise 6,000-8,000 newly made review articles on the useful plants of Tropical Africa following a standardized format: a unified literature list with an estimated 200,000 references; an estimated 30,000 photographs and drawings; and 6,000 geographic distribution maps [13]. In the last December 2013, PROTABase contained 1781 edited articles (in English and French) and 7400 starter kits (including

species mentioned in articles). It provides a synthesis of all the information available for about 8,000 plants used in tropical Africa, hence promoting opportunities for the sustainable use of plants information to the public and private sectors [14].

2.2 Diversity of African TM IK Systems

The creation of database depends on the diversity of life (Biodiversity) found in the Africa's natural heritage, known to be rich and wondrous with many languages, cultures, and people. The Indigenous Tradition Medicine Knowledge have to use the Biodiversity information that rely on chemical, biological diversity, and drug presentation to present Phytomedicines as part of the healthcare systems around the world [3]. Africa features a large number of biodiversity. Rasoanaivo [9] proposed a structure of translation for African Biodiversity (Figure 1).

Table 1. List of African Traditional Medicine Databases

SN	Database Name	Compiler/publisher	Country	Language	Year of launch	Website	Active	References
1	Botanica Ethiopia	Elizabeth d'Avigdor	Ethiopia	English/Amharic	2014	https://botanicaethiopia.com/herbs	Y	[11]
2	CESRIKI	University of Botswana	Botswana	English	2012	http://www.ub.bw/home/ac/1/fac/8/dep/47/Centre-for-Scientific-Reseach.-Indigenous-Knowledge-&-Innovation	Y	
3	Francophone	Madagascan Council for Higher Education	Madagascar +18 French Speaking countries	French/English	NA	http://www.ulb.ac.be/sciences/bota/pharmel.htm	N	
4	Ghanaian indigenous knowledge of medicinal plants	Forest Research Institute of Ghana	Ghana	English/Akan	2017	http://csir-forig.org.gh/tikfom	Y	[12]
5	IMRA		Madagascar	French	NA	http://imra-ratsimamanga.org	Y	
6	NTRAP	Dr. Richard E. Ford	Sub-Saharan East Africa	English	NA	http://www.ippc.orst.edu/ipmafrica/db/index.html	N	
7	PlantZAfrica	South African National Biodiversity Institute (SANBI)	South Africa	English	2015	http://pza.sanbi.org	Y	[13]
8	PRELUDE	Jean Lehmann Université de Louvain	Belgium/sub-Saharan Africa	English/French	2012	http://www.africamuseum.be/collections/external/prelude	Y	
9	PROTABase	Wageningen University (WU)	International	English	2000	https://www.prota4u.org/database/	Y	[14]
10	TRAMED (Traditional Medicine Database)	University of Cape Town	South Africa	English	NA	http://www.mrc.ac.za/Tramed3	N	

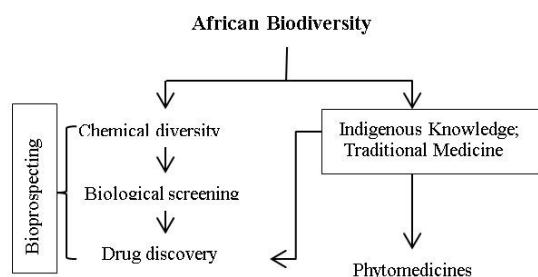


Figure 1. The structure of Biodiversity translation

Since the development of Internet as a powerful medium for health, the chance of applying online information as a guide for personal healthcare has been successful. Following the suggested method of Biodiversity Translation, drugs information using proper information from traditional medical prescription has become more reliable. Presentation of data in databases defines different mixtures. The combinations of African Traditional databases are discussed according to the thematic presentation.

2.2.1 Thematic Database

Many African Indigenous Systems provide attention to specialized area and content [15]. Databases themes which focus on a specialized area such as traditional medicine system, country or region feature, disease-specific, and phytochemical information have some advantages [8], including a focus on the comprehensive information. For example, medicinal plant databases can contain information based on botanical aspects, ethnopharmacological aspects, chemical aspects, agro-technological aspects, chemotaxonomic aspects, market aspects, and other relevant aspects [16]. In a real situation, indigenous knowledge systems should have the capability to present ethnographic information and associated traditional knowledge [5]. The ethnographic information include plant detailed information, other related plants, possible diseases the plant can heal, dosage outline, possible effects of the TM after being used and list of human gene in relation to disease and mentioned medicine. The available databases provide the information (such as the plant detailed information with picture, disease that the plant can heal, dosage outline) on the Graphical User Interface of the database. The content and quality of the database aim to present African Traditional Medicine to African and International.

2.2.2 Regional level databases

Information of the databases has been exclusively based on traditional usage confined to a particular geographical area (for example, PRELUDE Database presents the data based on the country, NTRAP for East African only, Botanica Ethiopia for Ethiopian), though the information is accessed globally. Several attempts have been made to develop an information system for collecting and managing ethnomedicinal plant knowledge in different geographical areas. From the viewpoint of scientific knowledge sharing, sharing of information in the regional database is of the utmost importance for the purpose of saving the database space [15]. This approach allows the detailed information about the plant, dosage usage, and presentation to be presented according to the given region effectively. Because countries possess different languages, cultural values, and norms of conduct, the presentation of knowledge systems based in the region has been found as the best option.

3. DISCUSSION

3.1 Challenges of African Traditional Medicine Databases

3.1.1 Language Translation

Biodiversity Translation to new therapy process has been found as a big challenge in the preparation of African Traditional Databases [9]. Translation is more than just transporting words or sentences from one language to another. Traditional indigenous knowledge of medicinal plant in many groups is yet to be explored. A large number of Biodiversity is known in local languages of the particular region and the same plant can have several undocumented local names. This is due to the diversity of population with different languages within the country. Identification and documentation of Chemical diversity and Biological screening names in comparison with the local languages seems to take a long process. Ghana Indigenous system reported the challenge when collecting and translating plant names from a vernacular language into English and in the process of identifying the appropriate scientific names for the local plant species to enable preservation [12]. Misidentification of the plant can lead to an error during the translation. Data accuracy and validation process may need more time and effort. Botanica Ethiopia reported the scarce of translators and interpreters who can work on translating from local language to English. PROTAbase needed donations for the translation and interpretation process. Therefore, the process of translation requires professional translators. This will be useful in preserving the Indigenous Knowledge of Traditional Medicine from Oral to digital documentation.

3.1.2 Need for Global Unique Identifier

A greater number of the available databases lack the unified system for recording ethnopharmacological data in the databases. For making data interoperability and sharing of information with the large scientific community, development of regional database needs to adhere to the common unified standard. The globally unique identifier is used for unique identification and sharing of resources between primary data and secondary data. Application of globally unique identifiers is one of the methods for integration of biological information from the diverse source. These identifiers are valuable because they expose information in a standard way to other software. Unique identifier of information to the Available indigenous systems is still a challenge. For example, PRELUDE Medicinal Plants Database contains the information of herbs plant for all countries in Africa. Most of the created databases cited PRELUDE, meaning that the database integrates primary data that can be used as secondary data in other databases. If the data could be integrated according to globally unique identifier, some databases, such as PlantZAfrica, with over 3850 plants herbs from South Africa could have the same information as that found in PRELUDE containing 1303 plants from 116 references; similarly, Botanica Ethiopia has 9 registered herbs plants whereas PRELUDE contains 935 plants found in 80 references; Ghanaian indigenous knowledge of medicinal plants registered 60 herbs whereas PRELUDE contains 248 plants found in 13 references.

Table 2: Summary of registered plants herbs

Database	Registered herbs	PRELUDE
Botanica Ethiopia	9	935
Ghanaian indigenous knowledge of medicinal plants	60	248
PlantZAfrica	3850	1303
Others	NA	4042
Total	3919	6528

Furthermore, Integration of biological data is often most valuable when are integrated with other types of related biological data, analyses all datasets and builds a joint model that captures all datasets. The main goal of any data integration methodology is to extract additional biological knowledge from multiple databases that cannot be gained from any single database alone. The ambiguity of information can be eliminated through data integration, for example, the plant *Acacia kamerunensis*, when searched from different database, gives different diseases that can be healed by the same plant: Ghanaian indigenous knowledge shows that the plant can be used for cleaning teeth; PlantZAfrica shows that the same plant treats eye and backpains, and that its roots can be used to make a yellow dye and leaves to attract lightning. Although it is believed that one plant can heal many diseases, if the information is unified, the standard unit can be used and if necessary more information can be added from the existing one—hence resulting in uniformity to all knowledge base. WHO presented some guidelines reinforcing the systems to consider the consumers. It is important to create the conditions for the correct and appropriate use of TM/CAM methods which, if used correctly, can contribute to the protection and the enhancement of patients' health and well-being. One such condition is the need to make sure that systems provide detailed information to create awareness of strategies and treatments so as to enable them to make appropriate decisions on how to improve their health.

3.1.3 Funding

Funding is a significant factor in the collection, processing, digitization, and storage of indigenous knowledge systems. One of the major difficulty reported by some of the developers of the databases is the lack of fund to sustain the whole process of development and maintenance of the systems [12]. Although Botanica Ethiopia is supported by Blackmores, more funds are needed for developing and researching; PROTABase stopped due to lack of funds. Ghana Indigenous Knowledge system has very low collected data due to lack of fund that limited the process of data collection. Funding is also an important factor in the recruitment and training of staffs and users who are going to use the system. In fact, is the fund is important for staff to receive proper training when executing a digitization project and for them to have access to the right high-end equipment. The creation of a database, which has to be made available online, also needs fund since there is the need to pay for the services of a web/database developer, pay for Internet hosting, and also subscribe to high-speed Internet access. Botanica Ethiopia reported the scarce of translators and interpreters who can work on translating from local language to English. PROTABase needed donations for the translation and interpretation process. The required professional translators will be useful in preserving the Indigenous Knowledge

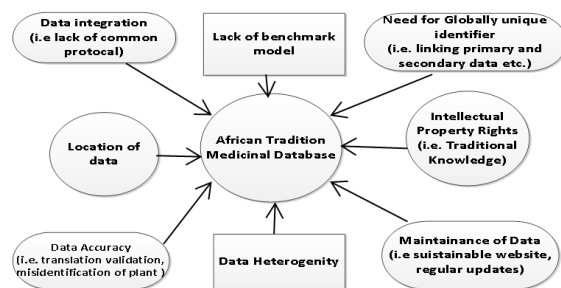
of Traditional Medicine from Oral to digital documentation. The support given by South African policy on indigenous knowledge systems and South Africa National Biodiversity Institute to PlantZAfrica database leads the database to be updated weekly. Lack of fund has made a large number of Indigenous Knowledge Systems to be less updated or/and inactive online.

3.1.4 Data Sharing

Researchers should consider the issue of data sharing from the very beginning of their research projects, by including for example a data sharing plan in the study protocol. Create a safe environment for data sharing; that means create an environment where people can be reassured that they will not be at risk for the knowledge and data that shared [17]. Consideration of open accessibility of traditional knowledge is usually encountered in sharing medicinal plant data. Restriction on using biodiversity data is common mainly in developing countries including African Countries, based on interpretations of Convention on Biological Diversity with regard to access and benefit-sharing [15]. The situation can be foreseen to delay development of new regional databases using the similar information available in the created database. If developers for the available databases can share data with the new developers, we may simplify the work of developing and modifying the databases. Also, data redundancy will be eliminated from the new databases.

3.1.5 Intellectual property right

Intellectual property right issues are other challenges, particularly if indigenous knowledge leads to profit for transnational corporations. Documenting and publicizing Indigenous Knowledge could immediately lead to their appropriation by others without return to innovators. The intellectual property rights of the individuals and communities have to be protected and benefits have to be generated for the innovators as well as local communities. Community structures such as telecenters are increasingly becoming as the most important platforms for capturing, transfer and exchange of indigenous knowledge.

**Figure 2: Challenges of African Traditional medicines.**

3.2 Future Directions of Traditional Medicine Databases

African institutes have made a great effort in establishing bioinformatics as a subject in the undergraduate core curriculum and as a postgraduate research field [18]. Significantly, the establishment of Africa Society for Bioinformatics and Computational Biology (ASBCB) and Pan African Bioinformatics Network for H3Africa (ABioNet, www.h3abionet.org) has played a crucial role in providing a critical mass of expertise that

facilitated the establishment and nurturing of such training programs. These efforts can increase the number of experts who can manage and maintain the software related to bioinformatics. However, there is still a significant shortage of trained bioinformaticians in Africa. This is partly because of insufficient infrastructure but, critically, also because of the absence of suitably qualified lecturers and academic mentors. The few African experts in bioinformatics are trying their best to develop the best knowledge base for traditional medicines.

The direction towards the best databases in comparison to developed countries is not as fast as it is reported in [16]. With the help of fund from Georg Forster Fellowship from the Alexander von Humboldt Foundation, Germany, The Development of a database of chemical components of African Traditional Medicine: Focusing on Northern Africa is under construction [19]. With these efforts, in the future, experts who are now gaining knowledge based on bioinformatics will cover the gap. The knowledge systems will be developed using semantic programming skills.

My colleagues and I are working on the construction of Tanzanian Traditional Medicine Knowledge Base. We are now in the collection of available known medicine from Institute of Tradition Medicine at the Muhimbili University of Health Sciences; then planning to visit some villages to collect the medicines which are not found in the institute. The creation of the Knowledge Base will capture the design of Chinese Traditional Medicine Knowledge Base. To satisfy and reach large numbers of users, the bilingual (English and Swahili) will be used.

4. CONCLUSION

In this survey, electronic databases on medicinal plants have been identified and categorized according to different criteria. Most of the databases focus on a particular region especially country, although some databases like PRELUDE focus on the continent. The optimization of data and development of a common minimum standard for sharing digital resources has been the best option for documenting indigenous knowledge systems and sharing them internationally. Due to different biodiversity, the development of international data in a single indigenous knowledge system for African traditional medicine may be impossible. More efforts should be put to specific regions such as East, north, or South African countries and the Africa Museum can act as a center of all knowledge bases created. Furthermore, the database programmer, data analyst and database developer should address the issues of authenticity and validity of the data, multilingual and semantic issues, as well as the applicability of the data for further medicinal plant research. Adopting and incorporating similar methods already implemented in allied and interrelated disciplines can provide a dimension in the medicinal plant research. For the integrative and scalable potential of the database, a thorough understanding of the discipline of ethnopharmacology along with its current scenario and future vision becomes relevant. A continuous critical assessment in this field and dialogue among the academicians, bioinformaticians, and programmers will contribute immensely in knowledge sharing and scientific development of Traditional Medicines Indigenous Knowledge Systems in Africa.

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