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Short Communication

Development of Medical Herbarium

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Abstract

Collection of information on medicinally useful plants or organisms by creating publicly accessible herbaria 1) to explore and continue including medicinally important exotic and native species from various geographical locations on the earth 2) to communicate their role in health and nutrition, is useful for both agriculture diversification, and research 3) in training and educating future generations for awareness to keep up to date with valuable imprints of our ancient discoveries through digitization and 4) to encourage new and applied research in health science. A medical herbarium facility is necessary in every district or county and a small herbarium facility in every organization including elementary school to house the plants of their region. This action will help to protect our germplasm resources, maintain ecology and biodiversity, enhance the discovery research related to health and create employment to newly trained graduates and premedical students.

Keywords: Conservation; Herbal Garden; Biomedicine; Chromatography; Health

Introduction

Herbarium is a collection of preserved plant specimens of known and unknown origin to identify as well as to know and understand the plant taxonomy, anatomy, economical and ethnobotanical uses of regional and internationally important species. Before digitization, most herbaria are only pressed dried plant specimens and their parts stored in a cool, dry non-humid cabinets or glass jars containing fluid preserve (formaldehyde, ethanol or alcohol or isopropyl alcohol or methanol) for several hundred years. Currently, plant samples were stored as compressed specimens on herbaria sheets, digitized, or raised in herbal gardens with their essential details for domestic, public, private, research and industrial use.

There are many herbaria across the country and in many countries serving basic functions in research, education, outreach, and money-making ventures with several uses. There were 3240 herbaria in the world, and in USA more than 60 million specimens in 628 herbaria. At the US National Herbarium (National Museum of Natural History, Smithsonian Institution) there are nearly 5 million specimens containing about 500,000 United States' specimens in the family Composite (Vicki Funk, www.virtualherbarium.org).

Around 40,000 specimen collections of Carl V Linnaeus include those purchased from the estate of the Society's first President, Sir James Edward Smith, as well as Smith's own herbarium. These collections include correspondence, manuscripts, annotations of plants, algae, and fungi (14,000), fish (168), shells (1,564), insects (3,198) from Linnaean library and for plants, algae, and fungi (27,075) from James Edward Smith (1759 - 1828) library (http://linnean-online.org/).

Over 3 million plant specimens have been collected from southeastern USA from both Appalachian and the coastal plain regions over the past four centuries, and these specimens and the information they contain currently reside in museums, or herbaria, at universities across the area. It was made possible to retrieve information at broad geographic and taxonomic scales. The SERNEC group (South East Regional Network of Expertise and Collections) through an NSF-sponsored research coordination network (RCN) project deposited data of specimens using the latest photography and information capture tools and to engage citizen scientists and students to assist in transcribing and georeferencing this large dataset.

A preliminary effort was done in 2008 to collect specimens in the regions of Chesterfield and tri-city (Colonial Heights, Petersburg, and Hopewell) areas with an objective 1) to enhance botany or plant science courses to higher level (medical) botany courses in the department and 2) increase the enrolment of premedical science and agriculture students in the department of biology and 3) to digitize the plant specimens for creating virtual library to lead first digitally driven basic botany class tours and to fill the other online teaching or research needs of the plant science with the help of faculty in information technology expertise of the department and 4) to save expenditure on some class tours and divert the money for either building departmental herbaria facility and training needy students in biomedical science research.

These were the explorations and plant specimen collections initiated by previous faculty and post-doctoral researchers [1]. The botanists [2] restored 163 specimen records, 126 (77%) georeferenced, 143 (88%) identified to species, 53 families, 76 genera, 89 species and 91 total taxa including subspecies and varieties in the Department of Biology at Virginia State University Herbarium (VSUH) through NSF funding by SERNEC group.

The research generated through SERNEC-NSF project can help regional planners, land managers and communities to manage their natural resources in our ever-changing environment. This will represent a valuable data source for research on the response of vegetation to climate change, human development, and rapid migrations of introduced species. This region has been a biodiversity hotspot for 100 million years and this project should encourage research on changes over time to develop better predictive models as areas of biodiversity change [3].

Southern plant science herbarium has voucher specimen collections and extracts of medicinal plants from Australia, Europe, Asia, Americas and were registered with Index herbarium of New York housed with 3100 herbaria. Their herbal authentication has been done using pharmacogenetic techniques including botanical identification and microscopy. These specimens were also collated in a database for easy access (www.SCU.edu.au).

A resource herbarium from Williams and Mary has over 81,500 accessioned specimens representing most of our regional vascular plant species, also include gift exchanges from individuals and agencies with objectives of paleoethnobotany and digitization by linking to SERNEC portal (www.wm.edu). There was huge herbarium facility at Delaware State University and was engaged with lot of local and state level research and training programs by Arthur Tucker (www.dsu.edu). Likewise, each and every state in USA has a definite resource library of herbal plant species of native and non-native origin.

In the past only 1% of more than 10 million herbarium specimens that were housed in various universities/museums in Japan. Currently, a safe, fast, simple and inexpensive method was able to image 73,180 herbarium specimens (571 per day on average) to digitize completely [4].

There were 16 medicinal plants belonging to 11 families were provided with their botanical name, family name, vernacular name, part used, and the application of the plants from Alamut region [5]. There were huge nationally and internationally recognized organizations like Indian Council of Medical Research (ICMR), Centre of Biomedical Research (CBMB), Centre for Cellular and Biomedical Research (CCMB), and Bhabha atomic research center (BARC) were engaged in health-related research in India. There were several pharmaceutical industries and ancient literature helped in developing drugs from native germplasm since ancient Indian times throughout India. Likewise, every region has a unique load of plant species that were identified with medicinal use by humans.

The development of medical herbarium, like the one at Kew garden in England, helps to treat common health problems like hypertension, diabetes, asthma by using direct extracts of medicinal plants from the literature retrieved from Atharvana Vedam or Indians of Vedic period (2000 - 800BC). These herbal extracts are prepared without any contaminants or preservatives and use of such treatment completely eliminates our dependence on unknown composition of prescribed medicines for simple health problems.

There were 2000 items registered in medicinal herbarium in India [6].

Herbarium samples of *Salvia aethiopis, S. multicaulis, S. officinalis*, and *S. sclarea* collected over 150 years across the Mediterranean were compared to modern samples using both targeted and untargeted gas chromatography-mass spectrometry analysis of terpene profiles. There was no effect of collection year on chemical composition, although the total concentration of the 20 assessed standards and two individual standards significantly decreased over time. Geographic variation was a factor in regulating the untargeted chemical compositions, suggesting some underlying environmental effects [7].

In Bangladesh, 119 plant species belonging to 64 families were used by the traditional medical practitioners for treatment of various ailments. The most frequently used families were Asteraceae with six species followed by Moraceae, Solanaceae and Apocyanaceae with five species. Among the selected species the maximum contribution was recorded for herbs with 38% species followed by trees (32%), shrubs (21%), climbers (7%) and palm (2%). Assessments of reported ethno-medicinal activity indicate that these plant species can potentially be of pharmacological interest as well as for conservation of biodiversity [8].

In the newly formed state of Andhra Pradesh and many other states of India, due to the availability of several resources of native plants of medicinal use and due to the newly established universities in medicine and pharmacy, efforts are required to initiate a biomedical garden facility. Medical herbarium's main focus is to collect the native and foreign plant species that are having enumerable pharmaceutical uses.

The current review is written with the objectives of 1) establishing the essential requirements of a medical herbarium along with its benefits 2) methods to store them for long time use for research and teaching by the future generations, 3) conducting a case study to let the public know about the use of native useful plant species in health and nutrition.

Basic requirements to establish an herbarium facility

Men and Materials: Experienced professionals supervised by plant scientists and botanists for collection and curation are necessary to operate herbarium facility on daily basis for long term sustainability. The Curator or Lead herbarium specialist or the Director must be aware of practice, maintenance and preservation techniques. A carefully controlled operation plan, ideally maintaining the collections at temperatures between 60–65°F (15–18°C) and a relative humidity of about 50%, prevents the proliferation of pests. Open face shelves and tightly sealed cases were also used for herbarium specimens. Thermometers and hygrometers should be installed throughout the facility to monitor and record the facility's temperature and relative humidity [9].

Facilities for specimen curation, photography and storage, expertise and assistance available for preparation and mounting of voucher specimens (www.scu.edu.au). Access to high speed internet to access online data base resources on different herbaria including catalogue of Linnaean herbarium where images of the specimens from the herbarium collections of Carl Van Linnaeus (1707 - 1778) held at the Linnean Society of London to order and get the required information on identification or research (http://linnean-online.org/linnaean_herbarium.html).

Collection of plants and plant material, field book for field notes, drying and preserving of specimens, mounting the specimens, arrangements of plant specimen sheets, museum for display of the un-mountable material and periodic care and maintenance of pressed and displayed specimens is necessary. Indexing of preserved plants and preparation of a nomenclature index of botanical, Sanskrit, local name of cross indexing is essential last step to follow for establishing an herbarium. Other essential materials required for plant or sample collection is same except the season of collection with respect to collection of herbaria for herbal or medicinal plants [1,6].

Specific requirements to establish a medical herbarium facility (www.scu.edu)

Facilities for plant cultivation such as 1) specialist growth facilities with controlled environment, AQIS registered quarantine glasshouse, micro-propagation and tissue culture and a field plot, 2) Sample storage and curation rooms with freeze-drying, archiving reference material, low humidity storage facilities for seed, plant tissue and extracts as well as herbarium - voucher specimens are necessary.

A living laboratory and a herbal garden are necessary for an university campus or research industry with access to public and student community for both teaching and research separately in providing information on every detail of each specimen or sample for commercial and non-commercial purposes.

Facilities for herbal authentication such as macroscopic and microscopic examination, and chromatography are necessary. In addition, some pharmacopoeial monographs (Example: Indian Ayurvedic Pharmacopoeia, the Pharmacopoeia of the People's Republic of China) are crucial to authenticate herbal material, define a botanical drug and provide information that allows for its proper identification including chemical identification tests.

Macroscopic examination involves the comparison of morphological characters that are visible with the naked eye or under low magnification with descriptions of the plant or botanical drug in floras or monographs. Characters such as size, shape and colour of leaves (or leaf fragments), flowers or fruits are commonly used in macroscopic identification.

Microscopic examination focuses on anatomical structures in the plant material that are visible only with the help of a microscope. Features such as pollen mother cells in an anther, trichome (hair) shape and structure, the arrangement of stomata in the epidermis, the presence or absence of compounds such as mucilage, starch or lignin, or the presence of tissues with characteristic cells might be used in the microscopic identifications.

Chromatography is the separation of chemical compounds in a mixture. A number of chromatographic techniques exist, but all are based on the same basic principles. Thin-layer chromatography (TLC) is widely employed in herbal authentication, and the majority of pharmacopoeial monographs for herbs include a TLC identification test. TLC separates mixtures of compounds to leave a 'fingerprint' of separated compounds on a plate coated with silica gel. This fingerprint can be compared with that of an authentic sample or pure reference compound. High-performance liquid chromatography (HPLC) is widely used in the authentication and analysis of herbal substances and gas chromatography (GC) is used in particular for essential oils and fatty acids.

Facilities for large scale extraction and new product development starting from grind, extract, filter, concentrate and dry large quantities of plant material to temperature-controlled percolation, accelerated solvent extraction, steam and vacuum distillation, sterile filtration, solvent recovery, concentration to specification, spray drying/freeze drying. The new product development should be facilitated with registration support and with nutraceutical, pharmaceutical, veterinary and biotechnological applications. Building collaborative support from other organizations of related research interests will help to strengthen the medical herbarium facility and taking it to higher level of teaching and research facility to fulfil the needs of graduates and postgraduates in any organization or industry.

Benefits of medical herbarium

When a herbarium facility is available in the reach of a community, the beneficiaries can utilize the resource 1) to protect plant germplasm without any deterioration in quality and biochemical constituents in plant and plant parts 2) to access the literature instantly either physically or digitally pertaining to the usefulness of various locally available plant species (flowers, fruits, vegetables) or organism of pharmaceutical importance (herbs), 3) to treat the health related problems of humans and animals 4) to educate the young and future generations through research and training 5) to know the information on the new drug developed in the market or the treatment they are getting from known or unknown physicians for different health conditions starting from the most important organ of the body brain and eye to skin diseases 6) to let the public know about the usefulness of the nutritive roles of the species and make them part of their culinary dishes 7) to eliminate the unnecessary dependence on the heavy doses of medicines for simple health problems that can be cured at home 8) to protect the innocent humans indirectly from dangerous humans in a community that kill others or make them non-functional for their unknown benefits, for research or money or selfish reasons or to completely demolish a specific community in a society 9) to improve local agricultural cultivation, business, small scale industries and family income by incorporating new crops with health and nutritional value 10) to earn money and create jobs for educated people in this subject area in a community.

A sample study to explore the use of native plant resources

A sample case study done by Satya SS Narina during 2019 in three remote villages in East Godavari District of Andhra Pradesh in India, to explore the value of local plant species in food, nutrition and health. The study reviewed 10 families of average income living in a village by taking data on incidence of health problems in a family with age group, the crops cultivated in the region, the fresh fruits and vegetables consumed by their families and the number of dependable medications on regular basis. The data included the fresh produce from their backyard gardens as well. This study revealed no one in the modern society were dependent on the herbal plant species for the cure of their simple health problems like cough, body pain, natural cuts, rashes or skin diseases due to industrialization and development of herbal based drugs in pharmaceutical stores. This achievement of pharmacy made them ignorant of what they consume and forget the useful plants those were existing in their surroundings in the past. These plants were not only providing fresh healthy breeze besides healthy food and natural cure for their simple health problems at home.

There were so many plant species that were disappeared or at the edge of extintion in this region that include but not limited to 1) Vegetables: climbing wool plant (thelaga pindi aaku, *Achyranthes-sanguinolenta*), drumstick (munaga aku, *Moringa oleifera*), ponnaganti aaku (*Alternanthera sessilis*), tamarind (chinthaaku, *Tamarindus indica*), Amla (Indian goosberry, *Phyllanthus emblica*), elaka jigudu koora; 2) Herbal/medicinal plant species: Nattulaaku (cures cuts, minor skin problems), nalleru kada (*Cissus quadrangula*), Ocimum species, jilledu aaku (Crown flower, *Calotropis gigantea*) 3) Fruit crops: Neredu pandu or malabar plum or black plum or java plum (*Syzygium cumini*), tati pandu or toddy palm or palmyra palm (*Borassus flabellifer*), and eetha pandu or date palm (*Phoenix dactylifera*). Currently, some fruit crops are at the last stage of ruin with very limited population and full of diseases producing less quality produce. These fruit crops include cashew (*Anacardium occidentale*), coconut (*Cocos nucifera*), jackfruit (*Artocarpus integrefolia*), custard apple (*Annona reticulata*), cherimoya (Ramaphal, *Annona cherimola*), soursop (lakshmanaphal, *Annona muricata*) 4) Flowering / Ornamental plants: kurubaka [blue Decembaraalu (*Barleria cristata*), yellow gobbi puvvulu (*Barleria prionitis*), white Decembaraalu (*Barleria grandiflora*)], Parijatham (*Nyctanthus arbor-tristis*), laxmikantham plant (*Stachytarpheta indica*, *Stachytarpheta jamaicensis*), kariveru puvvulu (*Nerium oleander*), ashoka tree (*Polyalthia longifolia*), kada malli (*Millingtonia hortensis*), bogadabanthi, centumalli, bougainvillea, bogada puvvu chettu (bullet wood tree, *Mimusops ellengi*) etc., 5) Commerically valuable agriculture crops: Pigeonpea (*Cajanus cajan*), sesame (*Sesamum indicum*), sugar cane (*Saccharam officinarum*), pesalu (mungbean, *Vigna radiata*), fodder legume crops with organic farming value like janumu or sunhemp, pillipesara as well as fibre value crops like jute (Corchorus sp.).

Most of the above stated plants have nutritionally valuable in providing health, healthy environment with a fresh unpolluted breeze to humans when they were in the backyards of every household. Because agriculture is commercialized depending on the ease in processing and marketing of the farmers produce, and the money or benefits for middlemen in selling this produce, a lot of nutritionally rich crops cease to disappear from their native origin of cultivation. Most of the vegetables or flowers produced in the farm were graded and the least quality is consumed by the producers due to less family income. Slowly, the valuable crops missing from the mainland and were replaced with less quality, worthless plant population either due to shift in cultivation, cultivation practices, change in culture, income or other domestic or international business reasons.

More than 80 per cent people buy groceries, medicines and vegetables from stores and none were consuming any freshly grown herbs or spices from their backyard. This was commonly observed in present day society even in the remote villages where agriculture is their primary income. Imagine about the situation of population in cosmopolitan cities and towns in the modern world. Thus, in summary, a day should never come to any human child to look for a definition of a plant when someone asks "what is a plant and define it?". The modern society, through urbanization and increased population, not only made the environmentally safe plants completely disappear from their natural habitat, but also making our young generation illiterate of even known cures off from their backyard garden.

Thus, developing an herbarium facility housed with plant specimens including locally grown cultivated crop, garden herbs, flower and vegetables plants with medicinal, food and ornamental use is a necessity for the present modernized, fast paced, industrialized society operated by information technology. It is useful to build a healthy community by providing enormous amount of information for our young, growing and curious generations through training by involving kids and adults to earn knowledge on our native plant resources to reach out in close proximity for agriculture, gardening, research and experimentation and feel good for their golden reserves from their ancestors. Last but not least, a medical herbarium is a potential resource for the long time to protect humans and in the times of medical warfare where physician prescribed medicines would never work to cure diseases of humans. The “Charaka Samhita” is one of such resources with ancient Ayurvedic writings available for the public.

Conclusion

The efforts of so many botanists served in both teaching and research sessions using paper-based herbaria, hybrids from cross breeding efforts in cultivated crops by agriculture scientists and other traditionally stored specimens of value must be restored. Due to advances in information technology, expensive botanical tours can be replaced with the use of community's or on campus small medical herbarium facility when training biomedical science students. If we do not know what we have, we never know what we want. Therefore, saving our naturally available potential plant resources of nutrition and health and utilizing advanced technology to protect those resources is a viable goal for long periods of time to protect humans, create awareness to young generation and utilize resources in a developing community. This will not only strengthen maintenance of native plant species of pharmaceutical importance forever but also preserves biodiversity, creates employment on a continuous basis for lot of trained graduates.

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