Quality Assessment of Medicinal Plants

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Since ancient times, herbal medicines (HM) have played a vital role in worldwide healthcare systems. It is therefore critical that a thorough evaluation of the quality and control of its complicated chemical makeup be conducted, in order to ensure its efficacy and safety.

herbal medicines Herbal Extracts NMR chemical prints

1. Introduction

It is difficult to undertake spectroscopic investigations of chemical mixes that contain several components [1]. These difficulties are worsened in systems with individual components that are uncertain or difficult to isolate and analyze. These systems are mixtures of compounds in many states of order and disorder, multiphase materials, interfaces, dopants, biological systems that respond differently when isolated, and metabolomes [2]. NMR spectroscopy is a good tool for examining these complicated mixtures since it can quantitatively evaluate the specification of a bulk sample while also revealing information regarding the atomic environment, the ordering within the sample, and the electronic structure [3]. Even the statistically based algorithms, such as principal component analysis and free component examination, can also be used to separate spectra components into successive sections without having comprehensive knowledge of the source signals associated with these components. These techniques are useful tools; however, due to implementation concerns, such as software challenges, a lack of understanding, and a lack of literature examples, they are not commonly employed.

2. Herbal Extracts as Therapeutic Agents

For millennia, traditional herbal therapy has been used in a variety of ways, and it is still mostly used as a primary form of healthcare in a number of developing and disadvantaged nations [4]. Traditional medicines (TMs) were used by nearly 80% of the world's population in impoverished nations for basic healthcare due to their cheap cost and accessibility. According to the WHO, aborigines residing in rural villages are not served by contemporary treatment facilities [5]. Early explorers' plant collections, as well as ethnobotany, have played a significant role in the discovery of novel pharmaceuticals for many centuries. Plants and their derivatives account for 25% of all medications in developed countries [6]. In many African and Asian nations, medicinal plants are still used in basic healthcare by up to 80% of the population [7]. These herbal medicines (HMs) are also gaining prominence in developed countries, particularly the United States and Germany.

Despite its existence and continued use over many centuries, traditional medicine has not been officially recognized in most countries. Therefore, due attention and support has been paid to education, training, and research in this area. The quantity and quality of the safety and efficacy data on traditional medicine seem to be insufficient to meet the criteria needed to support its use worldwide. The reasons for the lack of research data are primarily healthcare policies as well as the lack of adequate or accepted research methodology for analyzing TMs [8]. To analyze the quality and authenticity of HMs, the identification of specific herbs and their main components is essential. However, this examination does not provide the whole picture for HMs because multiple factors are often responsible for their therapeutic advantages. The majority of phytochemical constituents of herbal products must be established in order to ensure the reproducibility and reliability of pharmacological and clinical research on these products, to better understand their bioactivities and potential side effects, and to improve product quality control [9].

It is crucial that researchers identify the variation between conventional medicines and HMs when comparing these two types of therapeutic agent and how they are supplied. The administration of a pure chemical in comparison to a plant extract containing the same chemical entity is quite different. The distinction is mostly due to the intricacy of a plant extract, which introduces a flood of variables into conventional phytomedicinal research, all of which could influence its chemical complexity and bioactivity. Weathers et al. (2011) found that when a plant sample (e.g., *Artemisia annua*) was administered vs. a pure medicine (e.g., artemisinin), the bioavailability of the bioactive substance through the leaves was 45 times higher than in the case of the pure drug [10]. As a result, the plant extract's complexity may have contributed to the higher bioavailability of the bioactive substances, and consequently their bioactivity.

Herbal therapy may be critical since science is only beginning to appreciate the numerous complex, diverse, and sophisticated mechanisms that operate in a wide variety of biochemical systems found in organisms [11].

HMs have shown a wide range of success in treating infections, particularly in recurring and chronic illnesses. Additionally, it is worth noting that a variety of plant extracts, having a variety of bioactive compounds, can be used to achieve clinical efficacies that are typically not possible with single-compound-based drugs, not to mention to provide critical combination therapies that affect several pharmacological targets [12][13].

3. Quality Control and Quality Assurance (QC/QA) of Herbal Medicine

The presence of active components with medicinal benefits in HMs depends on various factors, such as the period and place of harvest of the medicinal plants, the type of soil in which they are planted, the quality of water used for their irrigation, and the way the HMs are prepared [14]. HMs and the included treatments are part of a broader field of complementary and alternative medicine [15]. The quality control of traditional medicines is a crucial problem attracting a lot of research attention, since the safety and efficiency of TMs are intimately linked to their quality [16]. Over the last few decades, the quality requirements for HMs, herbal drug (HD) preparations, and herbal therapeutic items have advanced dramatically [17].

High-performance liquid chromatography with diode array detection (HPLC-DAD), liquid chromatography with mass spectrometry detection (LC-MS/MS), and gas chromatography with mass spectrometry detection (GC-MS) are the commonly reported methods for detecting unlawful adulterations in HMs [18][19][20][21]. Recently, the local straight line screening (LSLS) technique was devised for resolving complicated IR spectra of potentially contaminated HMs [22]. Chromatographic and electrophoretic methods in combination with various detectors, such as IR-LSLS, and nuclear magnetic resonance (NMR) [23][24][25], have been documented in relation to the adulteration of herbal formulations advertised for weight loss [26][27][28].

All parts that contribute to the superiority of HDs should be considered in standardization methods, including sample identity, organoleptic assessment, pharmacognostic assessment, volatile matter assessment, quantitative assessment (ash values, extractive values), xenobiotics assessment, microbial load assessment, phytochemical assessment, toxicity assessment, and biological activity assessment [29]. Researchers have used chromatographic fingerprinting methods to assess the quality of herbal samples and the products developed from them. To protect the safety of the consumer, sample identification must be conducted with extreme caution. It is accomplished by removing adulterations (plants mixed together) or full misidentifications (wrong plants), as well as samples of low quality (low quantities of active chemicals) or possessing excessive concentrations of pollutants (e.g., pesticides) [30]. Chemometric techniques are now being utilized in conjunction with chromatographic data to generate even more accurate data for determining the integrity of HMs as well as for observations on the comparisons and differences between HMs data. The strength of chemometrics is in the multidimensional remarks that are used to describe the data's similarities and contrasts, which are then presented in a graphical manner that is user-friendly.

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