Advances in analytical technologies to evaluate the quality of traditional Chinese medicines

Jing Jing, Wei Chao Ren, Si Bao Chen, Ming Wei, Harendra S. Parekh

Traditional Chinese medicines (TCMs) are in widespread use around the world, increasingly so in western nations as the complementary therapy of choice. Nonetheless, quality and safety of TCMs remain key concerns, hindering their wider popularity among the international healthcare fraternity.

Cutting-edge analytical technologies are urgently required to address these concerns, ensuring reproducible identification and verification of constituents within any given TCM. Recent improvements in engineering advanced analytical instrumentation with improved sensitivity and precision to allow greater resolution of multi-component mixtures are driving the quality-control standards of TCMs towards universally-acceptable standards.

We review recent applications of key analytical techniques in quality assurance and authentication of herbs and their extracts. We highlight the emerging role of chemical fingerprinting of TCMs and the latest regulatory requirements imposed on Chinese herbal medicines utilizing chromatographic fingerprinting.

Keywords: Analytical instrumentation; Chemical fingerprinting; Chinese herbal medicine; Chromatographic fingerprinting; High-performance liquid chromatography (HPLC); Liquid chromatography coupled to mass spectrometry (LC/MS); Multi-component mixture; Traditional Chinese medicine (TCM); Two-dimensional liquid chromatography (2DLC); Ultra-performance liquid chromatography (UPLC)

Jing Jing, Harendra S. Parekh*
School of Pharmacy & Pharmacy Australia, Centre of Excellence, The University of Queensland, 20 Cornwall Street, Wolloongabba, QLD 4072, Australia

Ming Wei, Wei Chao Ren
Griffith Institute for Health and Medical Research, Griffith University, Gold Coast Campus, Southport, QLD 4222, Australia

Si Bao Chen
State Key Laboratory of Chinese Medicine and Molecular Pharmacology, The Hong Kong Polytechnic University, Shenzhen 518057, China and Institute of Medicinal Plant Development, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100193, China

*Corresponding author.
Tel.: +61 7 3346 1887;
Fax: +61 7 3346 1999;
E-mail: h.parekh@uq.edu.au

1. Introduction

The popularity of Traditional Chinese medicines (TCMs) in the West is growing at a significant pace as recent credible evidence emerges indicating its real, untapped potential [1]. Unfortunately, considerable barriers still stand before TCM prior to it being accepted globally, in its own right, as an effective treatment for various acute and chronic conditions. The challenges stem primarily from a safety and efficacy perspective being distinctly different from orthodox western scientific medicine. The traditional prescription typically involves Chinese medicine practitioners prescribing a mixture of TCMs that the patient would most often take orally, as an aqueous decoction. In essence, a number of carefully-selected herbs (i.e. rulers and assistants) are mixed together and boiled in water (a decoction); each herbal medicine contains numerous (active) constituents and their relative concentrations are influenced by a range of factors including species, origin and processing technique

0165-9936/$ - see front matter © 2012 Elsevier Ltd. All rights reserved. doi:http://dx.doi.org/10.1016/j.trac.2012.11.006

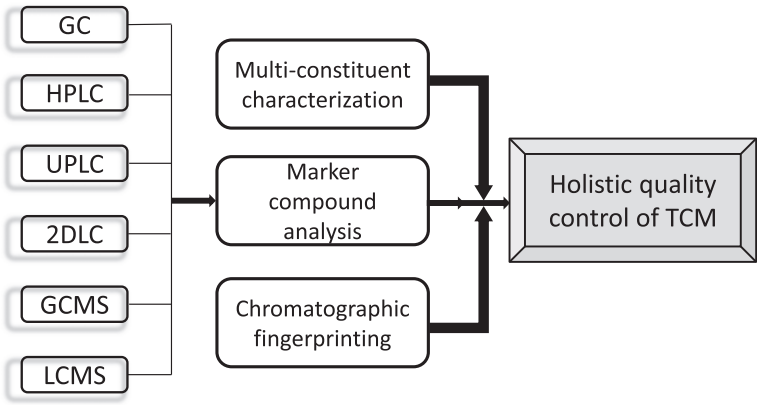

Figure 1. Primary analysis methodologies and their application in fingerprinting multiple traditional Chinese medicines (TCMs).

[2]. This inherent chemical diversity poses multiple challenges to analytical chemists in the search for robust and sensitive quality control (QC) methodologies for different batches of TCMs.

In recent years, rapid advances have been made towards the design of analytical instruments with improved sensitivity, delivering greater resolution in the analysis of multi-component mixtures. The key analytical techniques, namely UPLC (ultra-performance liquid chromatography), HPLC (high-performance liquid chromatography), 2DLC (two-dimensional liquid chromatography), GC (gas chromatography) and MS (mass spectrometry), may be used alone or, more commonly, in combination (Fig. 1) and significantly increase the QC capability of TCMs through a more integrated, comprehensive analytical approach (e.g., chemical fingerprinting) [3]. By routinely adopting these QC measures, we envisage that critical identification and verification of constituents within TCM will be achieved, allowing future TCM-based treatments to be assessed using similar stringent guidelines to conventional medicines. To this end, we review and highlight, using particular examples, the emerging role of key analytical techniques in analysis and authentication of TCMs.

2. Advanced chromatographic separation techniques

2.1. UPLC

UPLC recently proved to be one of the most promising developments in rapid chromatographic separations. A relatively new technique, it increases resolution of complex analytes, while experiments are performed in a fraction of the time using nominal amounts of solvent compared to conventional HPLC. The use of far higher operating pressures ($\leqslant$1000 bar, as opposed $\leqslant$400 bar for HPLC) in columns packed with sub-2 μm particles enables high linear velocities over the stationary phase, thus improving resolution while reducing analysis times [4]. Overall, UPLC presents the chemist with superior separation capabilities, high levels of system stability and the ability to combine it with highly-sensitive detection methods [e.g., diode-array detection (DAD) and evaporative light-scattering detection (ELSD)] that prove invaluable in scrutinizing key determinants within the complex mixtures in TCMs.

2.2. 2DLC

''Peak overlapping'' is widely recognized as an important source of error, as it is difficult to resolve and leads to ambiguous or problematic peak identification in complex matrices (e.g., herbs and herb-based products). Peak overlapping can be circumvented by employing consecutive, multiple detection methods, and, although effective, this can prove to be a very cumbersome and costly solution to the problem. Multi-dimensional separation techniques have emerged as alternative, more efficient approaches to address this common issue in the analysis of complex matrices.

Chromatographic techniques using this approach primarily comprise of MDGC (multi-dimensional GC), MDLC (multi-dimensional LC) and all their possible combinations [5]. Comprehensive 2DLC techniques can be considered as innovative, being only recently developed and adopted in the many available configurations [6]. A comprehensive 2DLC separation is one that employs multi-separation dimensions (columns) and draws on all of the available resolving power from each of the dimensions, from separate components in a given sample. This approach was demonstrated to have more advantages by providing enhanced peak capacity, good sensitivity and powerful resolution in the analysis of complex TCMs when combined with other detectors, most notably the MS detector [7].

3. Advanced coupled chromatographic techniques

MS is the most selective detector for identifying unknown compounds extracted from natural products. Various mass spectrometers have been embraced in the