Future Perspectives of Chinese Medical Formulae: Chinmedomics as an Effector

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Abstract

Traditional Chinese medicine (TCM) has been used for thousands of years to treat or prevent disease. The health care paradigm has shifted from a focus on disease to TCM therapy with a holistic approach. However, the actual value of TCM has not been fully recognized worldwide due to a lack of scientific approaches to its study. Today omics has become practically available, and resembles TCM in many aspects, and can serve as a key driving force for the translation of the traditional Chinese medical formulae (chinmediformulae) into practice, and will develop and advance the concept of the metabolomics of chinmediformulae (chinmedomics). Chinmedomics seeks to elucidate the therapeutic and synergistic properties and metabolism of chinmediformulae and the involved metabolic pathways using modern analytical techniques. It is an integral part of top-down systems biology, which aims to improve understanding of chinmediformulae. This approach of combining chinmedomics with chinmediformulae with modern health care systems may lead to a revolution in TCM therapy. Although the scientific study of chinmedomics is at an early stage and requires further scrutiny and validation, the approach has major implications to improve the efficacy of chinmediformulae. This article introduces and reviews the concept of chinmedomics, and highlights recent examples of the approach, which are presented for description and discussion.

Introduction

TRADITIONAL CHINESE MEDICINE (TCM) has been practiced for thousands of years and is well integrated into the Chinese health care system as one of the mainstream medical practices, and is rapidly gaining attention for improving human health and preventing or healing disease (Xue and Roy, 2003; Normile, 2003). It attempts to bring the body, mind, and spirit into harmony, and promotes health with many of its features (Stone, 2008). To improve health, TCM applies multiple natural therapeutic approaches, including chinmediformulae, acupuncture, and Chinese herbal medicine. As one of the most important parts of TCM, chinmediformulae has been accepted by the academic community and patients for the treatment of multiple organ system disorders, in particular chronic diseases and metabolic syndromes. However, there are several obstacles to the advancement and application of chinmediformulae worldwide. The key issue is that the methodology basically follows the path of partitioned reductive analysis, which is unable to effectively capture the characteristics of TCM, such as its holistic and dynamic nature, as well as its interactions among various biological components (Wang et al., 2011a, 2012).

The increasing recognition of the value of chinmediformulae in the treatment of certain chronic diseases has dictated a new demand for novel insights into it. Unlike the single-component approach of Western pharmacology, chinmediformulae is a complex system consisting of multiple compounds, which makes scientific evaluation of TCM difficult (Wang et al., 2008a). Therefore, it is necessary to strengthen research on chinmediformulae, which undoubtedly will demand significant analytical resources. There have been many recent attempts to address these issues, but most of them were based on the “reductionism” philosophy, whereas chinmediformulae is based on a “holism” philosophy instead of reductionism. Fortunately, advances in metabolomics provide new tools and alternative approaches to the understanding of chinmediformulae (Zhang et al., 2010). As a systemic approach, metabolomics adopts a top-down strategy to reflect the function of organisms from terminal symptoms of metabolic networks, and seeks to understand the metabolic changes in a complete system caused by these interventions in a holistic context (Nicholson and Lindon, 2008; Sreekumar et al., 2009). This property acts in concert with the holistic efficacy of TCM, suggesting that metabolomics has the potential to impact our understanding of the theory behind

FIG. 1. The overall procedure of chinmedomics analysis. Chinmedomics technology consists of three sequential steps: (1) an experimental technique, based on MS or NMR spectroscopy, designed to profile endogenous low-weight metabolites, (2) multivariate data analysis using bioinformatic techniques, and (3) metabolites identification and quantification resulting in biomarkers (UPLC-ESI-MS, ultra-performance liquid chromatography/electrospray ionization/mass spectrometry; TIC, total ion chromatogram).

evidence-based TCM (Wang et al., 2011a; Zhang et al., 2010).

Chinmedomics, defined as “elucidating the therapeutic and synergistic properties and metabolism of chinmedifomulae and related metabolic pathways using modern analytical techniques,” has recently demonstrated significant potential in assessing TCM (Wang and Zhang, 2010). The overall procedure of chinmedomic analysis is shown in Figure 1, and its characteristics are shown in Table 1. The introduction of the concept of chinmedomics enables the study of living systems from a holistic perspective based on the profiling of multitude biochemical components, and opens up a unique opportunity to reinvestigate chinmedifomulae, and has developed in recent years from a technology-driven enterprise to a new strategic tool in TCM science. The adoption of the chinmedomics approach would aid in exploring the scientific mechanisms of TCM and the functions of chinmedifomulae (Chen et al., 2010; van Wietmarschen et al., 2009). It opens up the possibility of studying the effects of chinmedifomulae, and provides easily measured surrogate biomarkers. A chinmedomics approach may have the potential to revolutionize TCM research and to advance the development of chinmedifomulae. The value of chinmedomics in aiding our understanding of TCM is well recognized, and

may help in the increasing worldwide distribution of TCM. Chinmedomics holds the promise of a comprehensive, non-invasive analysis of metabolic biomarkers that could help to monitor treatment response and detect early treatment-related toxicity of chinmedifomulae. New molecular targets and signaling pathways can be identified through chinmedomic analysis, which would become a platform for the

TABLE 1. CHARACTERISTICS OF THE GLOBAL CHINMEDOMICS METHOD

Biofluids: Plasma, serum, urine, saliva, cerebrospinal fluid, synovial fluid, semen, and tissue homogenates
Experimental technology: GC, HPLC, UPLC, MS, and NMR spectroscopy
Multivariate data analysis: Unsupervised PCA, supervised PLS
Metabolites: Biochemical reaction products or intermediates
Application: Natural product discovery, gene functions, disease studies, toxicology, and nutrition

GC, gas chromatography; HPLC, high-performance liquid chromatography; UPLC, ultra-performance liquid chromatography; MS, mass spectrometry; NMR, nuclear magnetic resonance.

development of new therapies or drugs. The concept of chinmedomics will be presented here in detail by reviewing its scope and implications for the practice of TCM. With the increasing recognition of TCM, this review highlights new trends of TCM, and explores the role of chinmedomics as an aid to better understand this traditional Asian medicine.

Application and challenge of chinmedifomulae

TCM is considered as a complementary or alternative medical system in most Western countries, while remaining a form of primary care throughout most Asian countries (Gong et al., 2003; Normile, 2003). There are three major advantages of TCM treatments. One is holism (the concept of global and system-wide thinking), which considers the various parts of the human body as an organic whole, and in which the various organs closely relate to each other physiologically and pathologically, with emphasis on the close relationship between humans and their natural environment. The second is treatment based on the treatment of differential syndrome (TDS; diagnosis and treatment based on overall symptoms and signs). Third, TCM considers disease from various dynamic functional aspects as outlined from a nonlinear point of view. TCM is a comprehensive system for the assessment and treatment of acute and chronic disorders, as well as preventive health care and maintenance. The focus of the TCM system is on the patient rather than the disease, promoting health and enhancing quality of life, with therapeutic strategies used in a holistic fashion. Consistent with the modern view of homeostasis, clinical diagnosis and treatment in TCM is based primarily on the diagnosis and differentiation of syndromes (Zhang et al., 2012b). A syndrome is a certain stage of a comprehensive response of a patient's body condition, whereas chinmedifomulae is the primary means of TCM treatment. The combination of syndrome and chinmedifomulae will establish a bridge to explore the intrinsic link between clinical diagnosis and efficacy. Chinmedifomulae is one of the most commonly used complementary medicine therapies. Health concerns driving the use of chinmedifomulae therapies are primarily chronic pain, musculoskeletal problems, and mood disturbances, including back and neck pain, joint pain and stiffness, headaches, anxiety, and depression. However, compared with conventional medicine, the theory of TCM is complicated and is not thoroughly understood. Utilizing the frontier experience and up-to-date scientific knowledge, and trying to incorporate some key techniques into the comprehensive understanding of TCM in an effort to clarify difficult but important concepts and principles were essential. These works are important for understanding the essence of TCM, promoting the modernization of TCM theories, establishing the direction for future medicine with TCM characteristics, and exploiting a bright future for the health of humankind. TCM advocates combinatory therapeutic strategies by chinmedifomulae, which are comprised of several types of herbs and minerals, in which one represents the key component, and others serve as adjuvants to assist the effects or facilitate the delivery of the key component (Liu et al., 2010). The therapeutic efficacy of TCM is usually attributed to its synergistic property, which minimizes adverse reactions and improves therapeutic efficacy, by the use of multiple herbs and constituents, which is known as the "chinmedifomulae compatibility" of TCM (Zhang et al.,

2010). Chinmedifomulae can hit multiple targets and produce synergistic therapeutic effects. The scientific explanation of chinmedifomulae theory will further promote the reasonable, effective application of TCM.

The pharmaceutical industry has shifted from the search of disease treatments with a "1 disease-1 target-1 drug" and the "1-drug-fits-all" approaches, to the pursuit of combination therapy is comprised of more than one active ingredient (Hu et al., 2009; Li et al., 2011). Combination medicines that affect multiple pathways and targets have better efficacy than a single drug acting alone. Single drugs acting on individual molecular targets usually exert incomplete therapeutic effects when used to treat complicated diseases, such as tumors, diabetes, and inflammation. Modern medicine has long acknowledged the usefulness of the combination therapies of chinmedifomulae, which regulate multiple nodes of the disease network simultaneously, and have synergistic effects in the treatment of multifactorial diseases. The combination application of TCM can achieve a synergistic interaction capable of yielding a sufficient effect at low doses that has increased significantly in recent years (Zhang et al., 2009). Many Chinese therapeutic herbs traditionally used in the co-treatment, but not mono-treatment series, demonstrate significantly better pharmacological effects. On the basis of the characteristics of patients and guided by the TDS, chinmedifomulae contains a combination of different herbal or mineral medicines to improve efficacy. The essential law of the compatibility of chinmedifomulae is reflected in the changes of prescription medicine with the addition and subtraction according to syndrome. It is recognized that there are existing principles of prescription compatibility; these principles also must have the objective material basis that can be revealed by certain established methods. Chinmedifomulae, which depends on the relationship between the syndrome and the prescription, could have a role in the appropriate treatment of syndromes. TDS is the basis for Chinese medicine, and chinmedifomulae compatibility is the core of prescriptions; both are complementary and mutually dependent.

Increasing emphasis on the use of medicinal plants to search for new drugs is undoubtedly a correct strategy. Chinmedifomulae has gained interest from international medical, biomedical, and pharmaceutical institutions, as a potential source of valuable medicinal agents. Like most other traditional forms of medicine, at present chinmedifomulae is still being practiced in its original form, and although it has been effective in treating many conditions, especially chronic ones, it lacks the scientific research needed for more widespread use. There have been many recent attempts to address these issues, but most of them were based on the reductionism philosophy. The lack of a comprehensive understanding of the relationship between composition and therapeutic efficacy is another problem for the advancement of TCM (van der Greef et al., 2007, 2010). Fortunately, the chinmedomics approach may contribute to a TCM syndrome-type classification of disease, and will help explain individual differences in responses to treatment and adverse drug reactions. Chinmedomics adopts a top-down strategy to reflect the function of organisms from terminal symptoms of the metabolic network, and their treatment by holistic interventions, which may help explain the essence of chinmedifomulae.

Emerging trends and potential value of chinmedomics

Determining the mode of action of the chinmediformulae was previously difficult; however, information-rich chinmedomics technologies now allow for thorough mechanistic studies of the complex mixtures. Chinmedomics represents a global understanding of the metabolites of integrated living systems and dynamic responses to the changes of both endogenous and exogenous factors, and has many potential applications for TCM research. As a systemic approach, chinmedomics also reflects the function of organisms from terminal symptoms of metabolic changes of a complete system caused by chinmediformulae interventions in a holistic context. It is consistent with the holistic thinking of TCM, suggesting that chinmedomics has the potential to impact our understanding of the action of chinmediformulae. Consequently, the development of robust chinmedomics platforms will facilitate various applications for chinmediformulae. TCM, which has been used for thousands of years to treat disease, provides unique theoretical and practical methodologies for disease control. With the increasing accumulation of TCM data, it is imperative to study and analyze these resources with modern technologies, and to elucidate the molecular mechanisms behind TCM therapy (Li et al., 2010). The opportunities presented by chinmedomics will be revolutionary for chinmediformulae. Chinmedomics can be applied at any stage in the developmental processes of chinmediformulae, in one or more of the following settings: (1) predictive biomarkers for chinmediformulae-related effects in animal models; (2) understanding of the biochemical mechanisms of action that target organ pathologies; (3) developing biomarkers for chinmediformulae in non-clinical development; and (4) predictive biomarkers for the chinmediformulae-related effects seen during Phase II and III clinical trials. Chinmedomics performs studies focused on the complex interactions of the components of chinmediformulae, emphasizing the whole system rather than the individual parts.

Recent advances in the analytical platforms of mass spectrometry (MS) and nuclear magnetic resonance (NMR) have driven the discipline of omics (Beckonert et al., 2010; Geier et al., 2011; Halama et al., 2011; Hrydziuszko et al., 2011; Jäger et al., 2011; Kim et al., 2011; Kronthaler et al., 2012; Wu et al., 2009; Villas-Bôas and Bruheim, 2007; Zhang et al., 2012a). Technological advances have opened a new chapter in TCM by using chinmedomics as an approach to study the metabolomics of chinmediformulae. NMR is one of the most commonly used technologies in omics research, providing detailed information by probing metabolites. The high selectivity of MS with low-detection limits makes MS an ideal tool for metabolomic applications. It requires separation of the metabolic components using either gas chromatography (GC) or ultra-performance liquid chromatography (UPLC). UPLC/MS is often used to obtain the largest possible biochemical profile information subset. It is a sensitive tool that can be used to characterize, identify, and quantify a large number of compounds in a biological sample in which metabolite concentrations might cover a broad range of information about disease pathophysiology (König, 2011; Manna et al., 2011; Wang et al., 2011b). All chinmedomics studies result in complex multivariate datasets that require visualization software and chemometric and bioinformatic methods for interpretation. The application of software tools to the analysis of the

information contained in a database can identify the signature of a disease and help predict disease outcomes.

One of the major benefits of chinmedomics in the study of disease and drug therapy is that metabolic profiling can usually be achieved using urine or plasma samples (Manna et al., 2010; Twohig et al., 2010). The uniqueness and effectiveness of TCM in the treatment of some chronic diseases and metabolic syndromes would have a significant impact on people's health worldwide. The application of a chinmedomics approach, constituting a novel platform of TCM study, will provide novel insights into the mechanisms of action of TCM. This process will not only improve our understanding of TCM, but will further explore the application of chinmediformulae in the discovery and development of new drugs and therapies for diseases responsive to TCM treatment. Chinmedomics would thus provide a novel tool for the validation of the therapeutic efficacy of TCM and the enrichment of modern medicine. There is a need to modernize chinmediformulae to gain greater acceptance by medical and regulatory agencies internationally so that its benefits can be realized. Robust chinmedomics techniques can be used to resolve the key issues and challenges in TCM research. To conduct a systemic strategic reductive analysis of the human body and disease under the guidance of a holistic view will be an important way to foster the use of TCM in the future of health care. It is believed that chinmedomics will greatly promote Chinese medicine research and lead to the modernization of chinmediformulae and the extension of its application in modern health care. In a holistic and systemic context, chinmedomics has a convergence with TCM, which could help overcome the one-sidedness of TCM and lead to its acceptance. Chinese medicine has a wealth of experience and chinmedomics has substantial research potential, and the integration of the two will enhance our knowledge of disease.

Analysis of chinmediformulae using chinmedomics

TCM often uses chinmediformulae tailored to an individual's condition based on subjective diagnostic methods. With the popularity of the return to natural medicines, people all over the world are becoming more and more interested in the magical effects of chinmediformulae. Increasing evidence demonstrates that treatment regimens containing multiple herbs with distinct but related mechanisms can amplify the therapeutic efficacy of each agent, leading to maximal therapeutic efficacy with minimal adverse effects (Wang et al., 2011c; Zhang et al., 2011). In the past few years, the pharmaceutical industry has seen a shift from the search for "magic bullets" that specifically target a single disease-causing molecule, to the pursuit of combination therapies that comprise more than one active ingredient. Interestingly, combinatory therapeutic strategies have been advocated for thousands of years in the form of the prescriptions of chinmediformulae in TCM. Typically, chinmediformulae consist of several types of medicinal herbs or minerals, in which one represents the principal component, and others serve as adjuvants to assist the effects or facilitate the delivery of the principal component. The rapid development of chinmedomics, especially the advances in high-throughput and comprehensive research technologies, provide new strategies for the analysis of the active components of chinmediformulae.

The integrative approach of chinmedomics is in line with the holistic concept and practices of TCM. The promise of chinmedomics to validate the effect of Chinese medicines and the compatibility of chinmedifomulae has been verified. A UPLC-MS-based chinmedomics study was conducted to assess the holistic efficacy of TCM Shuanglong Formula (SLF), a classic chinmedifomulae composed of *Panax ginseng* and *Salvia miltiorrhiza* for myocardial infarction in rats (Liang et al., 2011). Urinary samples for chinmedomics study, serum samples for biochemical measurements, and heart samples for histopathology were collected. The results showed that SLF exerted synergistic therapeutic efficacies to exhibit better effects on myocardial infarction compared to either *Panax ginseng* or *Salvia miltiorrhiza* used alone. The shifts in the urinary TCA cycle, as well as the pentose phosphate pathway, suggested that SLF may diminish the cardiac injury of myocardial infarction through its potential pharmacological effect in the regulation of myocardial energy metabolism. Using UPLC-MS chinmedomics, coupled with partial least squares discriminate analysis, Lu and associates studied the therapeutic and synergistic effects of TSG (a combination of tanshinone IIA, salvianolic acid B, and ginsenoside Rb1), which are the three major active ingredients of Compound Danshen Formulae (CDF), for its protective effects on myocardial ischemia (Lu et al., 2011). The results suggested that chinmedomics offers a new idea for Chinese medicine research. Wang and colleagues evaluated the chinmedomic effects of Yin Chen Hao Tang (YCHT), a classic chinmedifomulae, for the treatment of jaundice and liver disorders (Wang et al., 2008b). Recently, the promise of chinmedomics to validate the effectiveness of the chinmedifomulae Liu Wei Di Huang Wan (LW) for treating kidney yin deficiency was evaluated with UPLC-MS (Wang et al., 2010b). The results indicated that LW could restore the disturbed metabolite network to baseline values. Since urine contains thousands of metabolites, there are no universal analytical techniques to analyze these compounds simultaneously. There were different phenotypes of metabolites based on high-performance liquid chromatography (HPLC)-UV urinary profiling after administration of Liuwei Dihuang Pills (LWPs) or a carrageenan-stimulated inflammation model, and they could be discriminated by principal component analysis (PCA) (Xie et al., 2009). The results also showed that LWPs could restore the metabolite network that was disturbed by inflammation, which was proof of the therapeutic efficacy of LWPs for inflammation in a chinmedomic study. The effect of tang-shen-fang (TSF) on the treatment of diabetic nephropathy was evaluated by UPLC-MS-based chinmedomic analysis (Yu et al., 2011). It is helpful to assess the changes in global metabolism networks during treatment with TSF, and to evaluate its clinical efficacy and understand its mechanism of action. Xiaoyaosan (XYS), a famous Chinese prescription composed of *Radix bupleuri*, *Radix angelicae sinensis*, *Radix paeoniae alba*, *Rhizoma atractylodis Macrocephalae*, *Poria*, *Radix glycyrrhizae*, *Herba menthae*, and *Rhizoma zingiberis recens*, has been widely used in the clinic for treating depression, but its mechanism of action is not well understood. The therapeutic effect of YYS in treating depression was studied using chinmedomics-based GC-MS (Gao et al., 2011). Significant changes were seen in metabolites that are related to disturbances in amino acid metabolism, energy metabolism, and glycometabolism. A chinmedomics approach is helpful to further understand the pathophysi-

ology of depression, and to assist in the clinical diagnosis of depression, and it is also a valuable tool for studying the Chinese medicine syndrome theory, and the therapeutic mechanism of this Chinese prescription.

Chinmediolomics is the comprehensive assessment of endogenous metabolites of a biological system in a holistic context, and is consistent with the global view of TCM. Suanzaoren decoction (SZRD), an ancient TCM prescription, has been used for treating insomnia for centuries, and its mechanism of action remains unclear. Bo and associates explored the chinmediolomic characteristics of insomnia and the therapeutic effects of SZRD (Bo et al., 2011). UPLC-MS combined with pattern recognition approaches were integrated to approximate the comprehensive metabolic signature and to discover 20 differentiating metabolites. The alterations in these metabolites were associated with perturbations in amino acid and fatty acid metabolism, in response to insomnia via the immune and nervous systems. Of note, they found that SZRD increases sleep activity and exhibits binding affinity for serotonin receptors. The results indicate the therapeutic effects of SZRD may be mediated through serotonergic activation. These findings also show that ultra-performance liquid chromatography/electrospray ionization synapt high-definition mass spectrometry (UPLC/ESI-SYNAPT-HDMS) is promising for the metabolite profiling analysis of TCM, and be a new way to use chinmediolomics to resolve some chinmedifomulae issues. Danshen tablets, an herbal (*Salvia miltiorrhiza* Bge.) compound preparation, has shown protective effects on myocardial ischemia by reversing some biomarkers to sham levels, especially four metabolites in the pathway of purine metabolism (Lv et al., 2010). Based on the symptoms and characteristics of patients, and guided by the theories of TCM, chinmedifomulae are designed to contain a combination of different plants and minerals to improve clinical efficacy. Siwutang, a classic chinmedifomulae, used to treat mice in a cyclophosphamide-induced "blood deficiency" model, was assessed by NMR chinmedomics (Wang et al., 2011a). When the mice were dosed with Siwutang for 7 days, cyclophosphamide-caused "blood deficiency" was reversed according to PCA results. It is possible that Siwutang may have therapeutic and pharmacological effects in humans. An integrated chinmedomics study using high-resolution NMR spectroscopy has been used to discover the changes in metabolic profiles in mice with blood deficiency and the effect of Siwutang. Damage to mitochondria and disorders of energy metabolism and osmoregulation are observed in a cyclophosphamide-caused blood deficiency model using NMR chinmedomics, and Siwutang can improve these effects. Luo and associates provided a scientific basis for systematic research on the mechanism behind chronic immobilization stress (CIS)-induced metabolic network changes in rats, by detecting the changes in endogenous metabolites during CIS after treatment with Xiaoyao powder (XYP). They determined the small molecule marker compounds that were closely associated with the metabolomic specificity of CIS, and the mechanism of action of XYP (Luo et al., 2008). The metabolic phenotype in CIS rats includes increases in lactic acid, choline, NAC, and saturated fatty acids, and decreases in blood sugar, unsaturated fatty acid, and HDL. These may be the markers of the metabolites. The final metabolic changes induced by CIS are primarily seen in lipid substances. XYP regulates the contents of the final metabolites, but which metabolites or

metabolic pathways it affects to alter the final metabolites needs to be confirmed by further studies. Furthermore, chinmedomics may represent a new way to evaluate chinmedic formulae's effects, and could contribute to the establishment of a new technique for evaluating the efficacy of chinmedic formulae. The anti-osteoporosis effect of *Rhizoma drynariae* has been confirmed by a plasma chinmedomics method (Liu et al., 2012). The results showed that osteoporosis was prevented by *Rhizoma drynariae* by intervening in the antioxidant-oxidant balance, tryptophan metabolism, and phenylalanine metabolism *in vivo*. The protective effect of the TCM agent *Sini-decoction* was systematically analyzed (Tan et al., 2011). It was found that *Sini-decoction* provided therapeutic effects on cardiomyopathy by regulating perturbed metabolic pathways. Chinmedomic analysis has facilitated and provided useful information to better understand the pharmacological activity and potential toxicity of processed *Aconite* roots in the clinic (Wang et al., 2011d). Recently, the difference in the metabolic profiles between the root *Aconitum carmichaelii* *Debx* and its processed preparations was analyzed by PCA of the MS spectra (Sun et al., 2012). Significant changes in 19 metabolite biomarkers were detected in the *Aconitum carmichaelii* *Debx* samples and its preparations. UPLC-MS chinmedomics was used to profile the metabolic fingerprints of *Chaihu-Shu-Gan-San* (CSGS), which has been effectively used for the treatment of depression in the clinic (Su et al., 2011). Through partial least squares discriminant analysis, it was observed that chinmedomic perturbations induced by chronic variable stress were restored in a time-dependent fashion after treatment with CSGS. The effects of many biomarkers can be regulated by CSGS treatment, which suggests that the therapeutic effect of CSGS on depression may involve effects on dysfunctional energy metabolism, tryptophan metabolism, bone loss, and liver detoxification. The results indicate that a rapid noninvasive urinary chinmedomics approach may be a powerful tool to study the efficacy and mechanism of action of complex chinmedic formulae.

Future Perspectives

Although many TCM agents have been recognized for the treatment of various diseases, more information is needed, including preparation, standardization, identification of active ingredients, and toxicological evaluation. Further experimental investigations will allow a better understanding of the mechanisms of action, therapeutic effects, and the safety profile of TCM. As the post-genome era approaches, omics has become a hot topic in the research field of the life sciences, and is also widely used in TCM research. As a new research approach, chinmedomics is the best fit to the holistic concept of TCM. It can not only interpret the essence of TDS, but it also elucidates the modern scientific applications of chinmedic formulae. With the global application of chinmedomics, more and more natural resources and products from chinmedic formulae are being studied and recognized. The resources of TCM will continue to play an important role in the fight against disease. Chinmedomics approaches represent a bridge that may influence and provide opportunities to explain the theoretical meaning of evidence-based TCM. Progress in chinmedomics has opened new gateways in therapeutics and drug discovery and development. These efforts require further exploration and validation, and the use

and development of chinmedomics in the future will substantially contribute to our knowledge of the life sciences. Chinese medicine represents a wealth of experience, and chinmedomics has substantial research potential, and their integration in a systemic context will lead to a better understanding of chinmedic formulae.

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