CHAPTER

14

Use of microfluidic organ-on-a-chip systems for the screening and development of phytopharmaceuticals and herbal drugs

Fahimeh Shahabipour[1,2], *Abdullah Aldhaher*[3], *Andrea I. Doseff*[4], *Seyed Ehsan Alavian*[5], *Ahmed A.M. Elnour*[6,7] *and Nureddin Ashammakhi*[8]

[1]Skin Research Center, Shahid Beheshti University of Medical Science, Tehran, Iran; [2]Orthopedic Research Center, Mashhad University of Medical Sciences, Mashhad, Iran; [3]Department of Chemistry, Faculty of Chemistry, Sharif University of Technology, Tehran, Iran; [4]Department of Physiology and Department of Pharmacology and Toxicology, Michigan State University, East Lansing, MI, United States; [5]Middle East Liver Diseases (MELD) Virology Laboratory, MELD Center, Tehran, Iran; [6]Faculty of Chemical and Process Engineering Technology, University of Malaysia Pahang-UMP, Pekan, Pahang, Malaysia; [7]International Institute for Halal Research and Training, International Islamic University Malaysia (IIUM), Gombak. Kuala Lumpur, Malaysia; [8]Department of Biomedical Engineering, College of Engineering, College of Human Medicine and Institute for Quantitative Health Science and Engineering, Michigan State University, East Lansing, MI, United States

1. Introduction

Natural products (NPs) and their derivatives are the most broadly found metabolites or byproducts that originate from animals, plants, or microorganisms [1,2]. The large diversity

https://doi.org/10.1016/B978-0-323-99125-4.00013-5

in chemical structure and biological activities of NPs has made them a promising source for pharmaceutical agents used in the prevention and treatment of disease conditions, as antiviral [3], antimicrobial [4], antioxidant [5], anticancer [6,7], antiinflammatory, and immunoregulatory agents [8,9].

Plant-derived NPs or phytochemicals have historically been used in different cultures to ameliorate pathological conditions [10], such as infections and pain. Additionally, phytochemicals are used as dietary supplements, or as antiinflammatory and anticarcinogenic compounds [11]. Plant extracts were used as concoctions, which were composed of a mixture of different bioactive ingredients. The bioactivity of NPs stem from their receptor-binding activities, and finding these interactive receptors is considered an important issue; while some of the components do not have therapeutic activity, their synergistic effects are important [12,13].

Recently, the World Health Organization (WHO) reported that almost 60% of the world population relies on traditional medicine, and the Chinese are pioneers in the use of NPs to treat disease conditions in which the Shen Nung Pen 'Ts'ao predated the oldest Chinese herbs, which mentioned 1898 herbal drugs and described about 8160 [14–17]. In the United States, NP application has a long history, though not as long as the Chinese [18]. Although the application of traditional remedies is very limited compared to modern medications, they are considered as a source for the development of potential drugs [19].

Since 1980, ~51% of new drugs that have been derived from NPs comprise 65% of antibacterial and 73% of all anticancer compounds [20]. In fact, nearly 80% of all drugs with antimicrobial, cardiovascular, immunosuppressive, and anticancer activities are derived from NPs or derivatives [21]. The global market of these drugs accounted for US$ 65 billion in 2003 [22]. In spite of the success in the application of NPs in the past, many pharmaceutical companies have reduced the use of NPs in drug discovery screening due to some defects in NP application such as complexities of NP chemistry, difficulties in access and supply, and slow process in working with NPs [23]. Hence, only a few herbal drugs have been documented in drug discovery programs due to the complexity of herbal plant extractions. This is in part due to the complex composition of herbal mixtures and the lack of enough understanding of the compounds present in NPs. Additionally, methodologies to simplify screening for the active compounds responsible for the beneficial health effects remain laborious and expensive [24].

Several technologies are currently used for monitoring NPs nutraceuticals, such as targeted purification, drug discovery, molecular tracking, food science, and biomechanics [25]. The gold standard in the last two decades for drug discovery has been relying on the use of macroscopic systems. These systems incorporate automatic analysis and robotics to provide high-throughput screening (HTS) methods. However, these methods suffer from some limitations, including cost, processing time, and the need to use expensive equipment [26]. Thus, the development of microfluidic devices will potentially contribute to overcome these limitations in future.

Microfluidic devices provide unique systems to perform potentially high-throughput experiments with minimal reagent consumption and attain fast reaction times [27–30]. Moreover, microfluidic devices have small microchannels, thus facilitating the study of a small