CHAPTER 1

EXTRACTION TECHNIQUES FOR NATURAL PRODUCTS

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1.1 INTRODUCTION TO EXTRACTION TECHNOLOGY

For centuries, people have practiced natural product extraction to obtain important sources of ingredients for nutritional, aesthetic, and spiritual applications. The extraction of bioactive compounds from natural resources like fruits, vegetables, and herbs is in high demand. These extracted compounds are being formulated into a wide range of products across pharmaceutical, cosmetic, and food industries. These kinds of products that are enhanced with concentrated bioactive or target compounds have better functional benefits. This is mostly because the extracts contain a higher concentration of functional compounds. The popularity of naturally derived products continues to grow in the local and global market, partly because of reduced environmental impact. Moreover, Malaysia is rich in biodiversity and offers an abundant and high-quality supply of the valuable natural resources for further exploration.

Extraction is one of the important processing technologies used to recover compounds from natural products. Although extraction is a common unit operation in chemical engineering, it becomes more complex when dealing with natural products. Extracting bioactive compounds from highly complex natural resources for drug development is relatively challenging. Bioactive compounds in natural resources are often present in small amounts, which makes the extraction process relatively tedious and challenging. Traditional extraction methods such as maceration, percolation, distillation, solvent extraction, and soxhlet extraction are effective, but often time-consuming and less environmentally friendly. The mechanism of extraction involves stages such as solvent penetrating the sample matrix, compounds dissolving in the solvent media, compounds diffusing out of the sample matrix, and ultimately the extracted compounds being collected after solvent evaporation. Therefore, any factors enhancing the solubility and diffusivity of compounds will be facilitating the efficiency of extraction. Factors such as solvent type, stirring speed, solvent-to-solid ratio, temperature, and duration are the common variables for optimization (Popova & Bankova, 2023). Optimization is always integrated with extraction prior to operation. The process of extraction should be conducted using the optimal variables to save operating costs and processing time, while maintaining high efficiency and product quality. External energy could also be introduced to promote extraction efficiency. Nowadays, researchers and scientists prefer to introduce external energy like microwaves and ultrasound, accelerating the extraction process. Hence, high extraction efficiency, cost-effective operation, and more sustainable technologies would be of significant importance.

Recently, extraction technologies such as supercritical fluid extraction (SFE), especially use carbon dioxide as a solvent to extract compounds at lower temperatures, and subcritical water extraction (SWE) have been introduced in processing industries. Water is easily available, safe, non-toxic, non-flammable, and environmentally friendly, as well as the greenest solvent. Numerous studies revealed the possibility of subcritical water application for the extraction of compounds, particularly antioxidative polyphenols and flavonoids, under the temperature of 80–150 °C for 1 min to 60 min (Chemat et al., 2019). Ultrasound-assisted extraction (UAE) applies ultrasonic waves to create cavitation in the solvent to enhance mass transfer by disrupting plant cell walls for a faster and more efficient extraction. Microwave-assisted extraction (MAE) uses microwave energy to heat solvent and plant material simultaneously. These relatively modern extraction technologies promise a higher yield with lower energy and solvent requirements, as well as being considered a green extraction technique. The principle of work for each technique has been explained in detail, along with its application using local natural resources

1.2 APPLICATION OF MODERN EXTRACTION TECHNIQUES

Supercritical fluid extraction (SFE) has been considered an innovative and effective extraction method for thermolabile compounds from natural products. The following chapters report the use of SFE to extract chemically polar compounds from propolis and nonpolar oil from sirih. Often, carbon dioxide is a preferable apolar solvent in SFE due to several advantages. The gas is non-toxic, non-explosive, non-flammable, inert, and generally recognized as a safe solvent. It becomes supercritical at a relatively low temperature (31 °C) and moderate pressure (74 bar). It can extract sensitive bioactive compounds such as antioxidants and essential oils effectively. Since carbon dioxide is chemically non-reactive, it does not react with compounds during extraction. Hence, the extracted compounds could maintain their chemical integrity and biological activity. Most importantly, supercritical carbon dioxide is highly tunable because its density and solvent power can be easily controlled by adjusting temperature and pressure. This unique feature makes supercritical carbon dioxide have high selectivity in extracting desired compounds. Furthermore, reducing the pressure easily removes carbon dioxide. Therefore, there is no solvent residue left in the product, which would be an ideal choice for food industries.

Propolis is a natural substance with potent antioxidants, antibacterial, and antiviral properties. Resinous substance and wax are the major components in propolis, consisting of more than half of its composition. It is traditionally extracted using methods like soxhlet extraction, which is very time-consuming and high in solvent usage. Supercritical carbon dioxide-based extraction is proposed as an