BIOCHEMICAL ASPECTS OF PHARMACEUTICAL ANALYSIS

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Introduction. Pharmaceutical analysis is a discipline based on chemical, physical, biological, and information technologies. Chemical substances are the basis for drugs to exert their therapeutic effects, and chemical-based analytical methods were the first to receive attention. The physical properties of a drug can also affect its quality and have thus received attention. Nevertheless, biotechnology and latest information technology have not received enough attention from pharmacists.

Although chemical and physical methods show high accuracy, sensitivity, throughput, and robustness, some of the detected index components do not represent the efficacy or effectiveness of natural products, which is related to the complex action mechanism of natural products with complex composition. Biological analysis is the basis and an important part of life science, particularly medicine, and the development of biotechnology has advanced the field of medicine. Because of their advantages in reflecting the overall biological effects, function, or action mechanism of drugs and providing visual and intuitive results, some biotechnologies have been gradually applied to pharmaceutical analysis from raw material to manufacturing and final products. Biological detection methods are the core evaluation techniques used to study the effectiveness, safety, and quality of drugs.

The aim. Biochemical approaches can provide information on biological activity and even clinical efficacy and safety, which are important characteristics of drug quality.

Materials and methods. We used a literature search of articles included in Web of Science using the keywords "pharmaceutical analysis" in combination with "chemical analysis" or "biological analysis".

Results and their discussion. With the continuous upgradation of sequencing technology and the continuous decline in sequencing cost, the genetic information of many species has been obtained, and different databases have been established which lays the foundation for the development of molecular identification technology and the breeding of new varieties. Barcoding, molecular markers, and rapid detection are technologies based on DNA and can accurately identify raw materials. Molecular technology has been used for rapid and accurate identification of medicinal materials due to its rapid, trace, and strong specificity. However, these methods cannot identify the adulteration of non-pharmaceutical parts of medicinal materials and classify their quality grade.

Chip technology has been used to detect the authenticity of raw materials, heavy metals, and pesticide residues. Gene chips integrate oligonucleotide or cDNA in high density according to the preset nucleic acid molecule hybridization derivative array and then fix it on the surface of the support carrier. After the carrier surface hybridizes with the probe, the biological signal is captured by a special device comprising semiconductor sensors, and the content is recorded synchronously and sent back to the computer for analysis. Chip technology has the advantages of short detection cycle and high efficiency.

Biosensors use active substances, such as enzymes and microorganisms, as sensitive materials for recognition and convert biological information to electrical signals with high sensitivity, accuracy, and stability in real time. This technology has been used to detect the authenticity of raw materials, heavy metals, and pesticide residues. Shi designed a sequencing-free electrochemical herb sensor based on the ITS2 of Crocus sativus to identify the plant and its counterfeits. Lei explored an efficient and simple electrochemical sensor to prepare carbon-supported X-manganate for the detection of Pb^{2+} and Hg^{2+}. Enzyme biosensors can calculate the pesticide residue level in a sample by measuring the degree to which the enzyme activity (fixed on the electrode surface) is inhibited by pesticides. Hana Fourou fixed β-galactosidase from Aspergillus oryzae on the electrochemical sensor to detect Cr^{4+} and Cd^{2+}. Enzyme biosensors based on cholinesterase enzymes, organophosphorus hydrolase, and organophosphorus acid anhydrolase were used to detect organophosphorus pesticides. Whole-cell biosensors are based on microorganisms. Kim modified Escherichia coli strains to contain copA, zntA, and mer promoters and inserted the luciferase gene as the reporter gene into the plasmid to respond to the induction of copper, cadmium, and mercury, respectively, to detect heavy metals.

Immunoassay is based on specific antigen–antibody reaction and uses a detection method for antigen and labeled antigen competitive binding antibody. Immunoassay techniques used to detect harmful substances include enzyme-linked immunosorbent assay (ELISA), fluorescent immunoassay, chemiluminescent immunoassay, and gold immunochromatographic assay. ELISA uses enzymes as tracers to mark antigens or antibodies, and the enzyme catalyzes the substrate to develop color or emit light to establish the relationship between the developed color degree of the system and the content of the substance to be tested. Immunoassay is the most widely used method to detect pesticide residues. However, preparing pesticide antibodies is difficult and the development cost is high. It is only suitable to detect pesticide residues in a single product and not for multi-residue analysis. Therefore, establishing a high-throughput immunoassay technique is particularly important.

Conventional pharmaceutical manufacturing is usually accomplished using batch processing with laboratory testing conducted on collected samples to evaluate quality. This conventional approach has been successful in providing quality medicine to some extent. Although the quality of newly introduced products has increased, concerns over pharmaceutical product quality persist due to unacceptably high product recalls. Natural products are well-known for their complex multi-compound, multi-ingredient formulation and preparations, and large variation in the quality of products from different manufacturers or different batches by the same manufacturer.

Conclusions. Biochemistry approaches are as important as physical- and chemical-based detection techniques because they can provide information on biological activity and even clinical efficacy and safety of a drug. Chemical technology and biotechnology have their pros and cons: botanicals with identical chemical spectrum may display different biological activities when bioactive constituents cannot be detected under analytical conditions, and botanicals with different chemical profiles may have the same bioactivity when the phytochemicals responsible for the difference are biologically inert. In the future, biotechnology together with chemical and physical analyses should participate in the whole life cycle of drug quality control.