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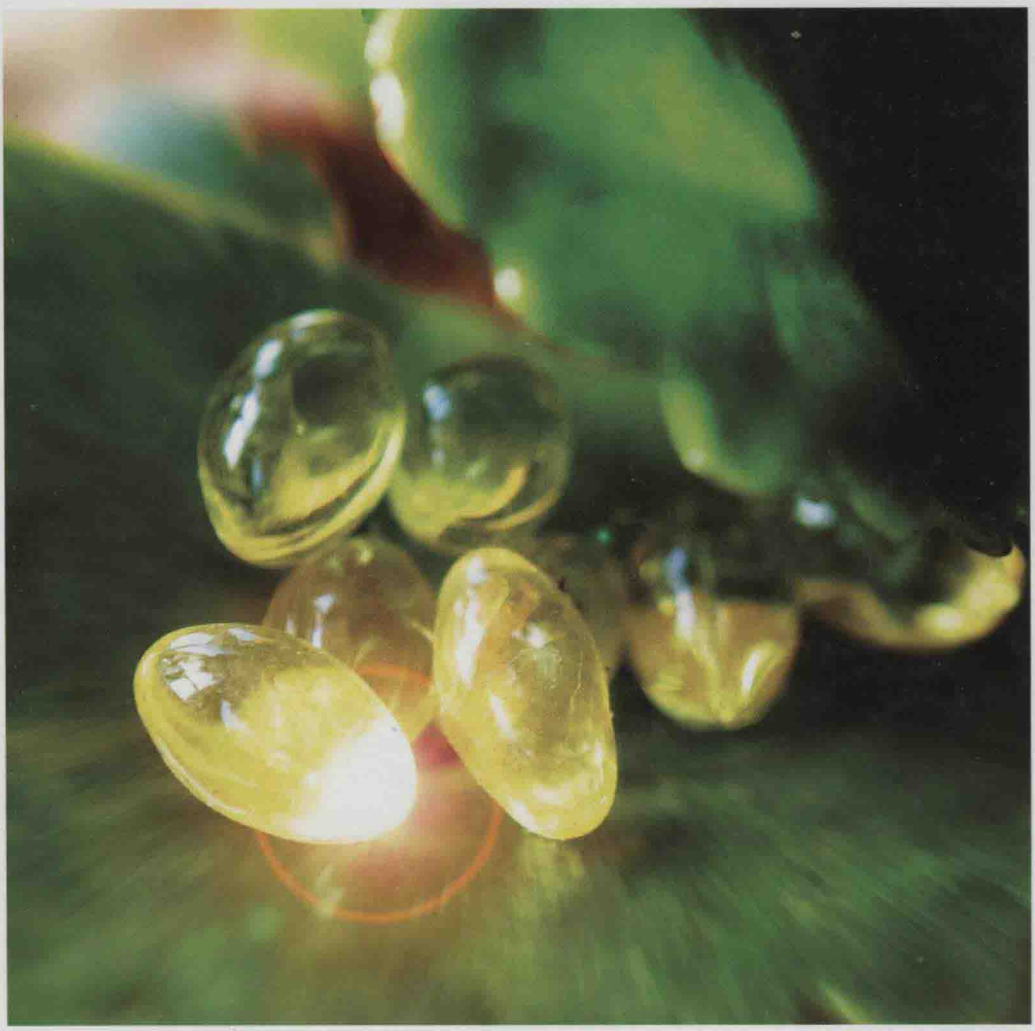
Natural Product Extraction

Principles and Applications



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Natural Product Extraction
Principles and Applications

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Preface

Natural products are a rich source of bioactive compounds with a wide range of potential applications. They have been used for centuries as popular medicines and in recent decades they have been a focus of the scientific community due to increasing evidence that associates them with health benefits and the prevention of several diseases. Their importance is also growing due to the concern of the negative effects of synthetic additives and their processing on human health and the environment. This makes natural products especially important to food, pharmaceutical and cosmetics industries. Several types of natural products are routinely used as functional foods, as components of products, as additives (colorants, antioxidants, etc.) or as final products (nutraceuticals and supplements). In several applications consumers are demanding the substitution of synthetic compounds by natural ones, since there is a popular belief that everything that is 'natural' is good. Thus, the importance of natural products has seen a progressive and steady increase in the last decades. Without doubt, consumer awareness, increasing quality demands and stricter regulations are driving the consolidation of natural products as part of productive processes of several industrial branches.

In general, the functional and/or technological properties of a natural product are associated with its components, their concentration and possible interactions. Many times, these bioactive components must be separated and/or concentrated from the raw material in order to be useable either as a sample or as a food or ingredient. Although analytical, semi-preparative and industrial separations of natural products have very different objectives and use different operational conditions and processes, all of these processes share the need of efficient extraction methods.

In the case of analytical applications, it is necessary to isolate target compounds to be later analyzed and they must be in sufficient concentration to allow their detection, identification and/or quantitation. When dealing with

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quantitative analysis, it is critical to achieve an exhaustive and complete extraction of the target compounds from the sample. Usually in semi-preparative separations, the process is designed to produce small amounts of a highly purified extract containing only a few components. Purity is commonly considered a priority factor to the detriment of extraction efficiency. This type of separation may employ several additional steps when compared to analytical applications. In contrast, in industrial applications, the process is designed to manufacture a specific product with determined characteristics at a reasonable cost. The product may range from a very pure mixture of a few compounds (>98%) to a product that is commercialized as an extract with undefined concentration of bioactives present. As an example, a 1:10 extract indicates that it yielded 10% in relation to the raw material used, without any composition specifications. In most cases the final quality and the manufacturing cost of the product will assume decisive roles on determining the operational conditions.

Independently to the strategy adopted, the selective separation of specific components from such complex matrices is a difficult task that involves multiple steps and procedures. Obviously, the complexity of the process will depend on the raw material's natural characteristics, as the solute location, the characteristics of the target components, the desired concentration of target compounds in the final product, etc. Techniques for achieving these goals may range from the simple soaking of the ground-up material in a given solvent followed by filtration and evaporation, to a complex series of extraction and post-extraction processes using a combination of techniques on-line. Nevertheless, the technology currently in use by the natural product industry and most analytical laboratories is based on highly inefficient processes and outdated techniques. Without doubt, the technology used by the industry needs to be updated in order to increase the competitiveness of natural products. It is evident there is a need for more efficient processes that can increase yields and the overall quality of natural products at a feasible cost. Moreover, new products can be developed using the new extraction processes that allow controlling more variables than in conventional techniques, thus tuning the selectivity of the process.

Analytical and semi-preparative separations play a decisive role on the development of these extraction techniques. This development is fueled by a constant increase in the demand of higher sample throughout, higher selectivity and lower solvent consumption derived from the increasing performance of instrumental methods of analysis. For example, considering that a high-performance liquid chromatography separation can be achieved in a few minutes, it is likely that it will take longer to extract the sample than to analyze it! Furthermore, most semi-preparative and industrial processes are basically scaled-up from the processes developed at analytical scale. In this sense, several new technologies developed in the last decades have an enormous potential to be explored by the natural product industry and by analytical and semi-preparative laboratories in this field.

With these issues in mind, this book is intended to give a holistic, in-depth view of the state-of-the-art techniques for the extraction and processing of

natural products and the factors influencing the process performance. Each chapter was written by leading scientists in the specific field. Besides conventional extraction techniques, the use of ultrasound, microwaves, pressurized liquids and supercritical fluids are discussed in detail in specific chapters devoted to them. Each chapter gives a balanced outline of each technique's potential for the extraction of natural products. The principles and fundamentals of each extraction process are addressed and the factors influencing them are further discussed, including specific aspects of each technique. Each chapter will provide the reader with comprehensive information about the fundamentals of each technique, the parameters that affect the process and how to explore this knowledge to maximize the efficiency of the extraction method in order to obtain the products intended. The characteristics, advantages and disadvantages, and applications of these techniques are contextualized in maximizing their potential as an attractive alternative for the production of natural extracts. Examples and case studies are used to illustrate the application of each extraction method and to give a balanced outline of recent applications and potential uses of each technique for obtaining extracts from natural sources.

Chapter 1 presents the uses and potential applications of natural products. The following chapters (chapters 2–6) present both conventional and modern extraction techniques used to obtain them. Furthermore, in Chapters 7 and 8, the most recent trends on the extraction of natural products are discussed, including the combination and coupling of different techniques to maximize the production process and their applications for natural products purification, isolation and stabilization. Other relevant subjects, such as the elimination of the extraction solvent, the modification of the physicochemical characteristics and the improvement of functional characteristics of extracts using advanced techniques will be covered, including techniques for particle formation and encapsulation of the extracts. The isolation and purification techniques which may be used for further processing of the extracts are discussed in Chapter 9, giving special attention to chromatographic and non-chromatographic techniques. Further process design and optimization can be used to employ resources more effectively and to minimize costs. Chapter 10 is dedicated to the coupling of pressurized fluids to other post-extraction processes, assessing the interactions between different operations and units that can be used to optimize the overall process and which are used to illustrate that using a holistic approach leads to higher overall process efficiency.

Additionally, specific implications of scaling-up the process to industrial level are the focus of Chapter 11. Finally, in Chapter 12, we intend to provide the reader with a critical view about the economic aspects of the whole process and of scaling-up separations and why they are important as individual steps and procedures. These aspects are discussed in detail in terms of the factors involved in the cost of manufacturing natural products extracts and how to explore them to maximize extract production while minimizing costs. All this information will help when considering new less polluting extraction technologies when the decision comes to choosing the appropriate method for determined raw material, including scale-up to industrial level.

In general, this book is directed to researchers working both in academic and industrial sectors of chemistry, chemical and food engineering, food science and nutrition, among others. The information presented may be useful in a variety of fields, from the investigation about phytochemical composition to assisting in the assessment of biological activities of compounds present in natural products. Furthermore, the same principles also apply to large-scale separations and therefore this knowledge can be explored for industrial applications, especially by the food and pharmaceutical industries.

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